Engström Carestation
Technical Reference Manual

Datex-Ohmeda products have unit serial numbers with coded logic which indicates a product group code, the year of manufacture, and a sequential unit number for identification. The serial number can be in one of two formats.

AAA**X**11111	AAA**XX**111111AA
The **X** represents an alpha character indicating the year the product was manufactured; **H** = 2004, **J** = 2005, etc. **I** and **O** are not used.	The **XX** represents a number indicating the year the product was manufactured; **04** = 2004, **05** = 2005, etc.

Engström Carestation

Important

The information contained in this Technical Reference manual pertains only to those models of products which are marketed by Datex-Ohmeda as of the effective date of this manual or the latest revision thereof. This Technical Reference manual was prepared for exclusive use by Datex-Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Datex-Ohmeda provides this Technical Reference manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from Datex-Ohmeda does not imply in anyway that Datex-Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Technical Communications, Datex-Ohmeda, Ohmeda Drive, PO Box 7550, Madison, Wisconsin 53707.

⚠ CAUTION Servicing of this product in accordance with this Technical Reference manual should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.

Technical Competence

The procedures described in this Technical Reference manual should be performed by trained and authorized personnel only. Maintenance should only be undertaken by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

Datex-Ohmeda strongly recommends using only genuine replacement parts, manufactured or sold by Datex-Ohmeda for all repair parts replacements.

Read completely through each step in every procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

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Appendix A 1

1 Introduction

In this section This section provides a general overview of the Engström Ventilator.

1.1 What this manual includes

This manual covers the service information for the Engström Carestation.

It covers the following components:

- Display Unit (DU/HPDU)
- Integral electronics
- Gas delivery components
- Frame component

Other equipment

Other equipment may be attached to the system. Consult separate documentation relative to these items for details.

1.2 User's Reference manuals

Some sections of this manual refer you to the User's Reference manual for the Engström Carestation. To expedite repairs, you must have, and be familiar with, the User's Reference manual for this product.

Refer to the Engström Carestation User's Reference manual if you need further information about the operation of the system.

1.3 Conventions used

Hard keys

Names of the hard keys on the display and modules are written in bold typeface; for example, **Normal Screen**.

Menu selections

Menu selections are written in bold italic typeface; for example, ***Patient Setup***.

Messages

Messages that are displayed on the screen are enclosed in single quotes; for example, 'Check sample gas out.'

Sections and headings

When referring to different sections or headings in the User's Technical Reference manual, the name is written in italic typeface and is enclosed in double quotes; for example, *"System Controls and Menus."*

1.4 What is an Engström Carestation?

The Engström Carestation (EC) is a critical care ventilator that is flexible and physically adaptable to a variety of work environments. It has an intuitive user interface that is common to many Datex-Ohmeda products. A wide selection of performance options gives the user full control of the system configuration. The Engström Carestation is a complete system featuring patient monitoring, patient ventilation, and the capability of interfacing with central monitoring.

Note Photos and drawings shown in this manual may not be identical to all variants of the product. Some photos and drawings show accessories and options that may not be present or available on all variants. This manual does not cover the operation of every accessory; refer to the accessory documentation for further information.

The EC must only be operated by authorized medical personnel well trained in the use of this product, for patient ventilation in the intensive care environment. It must be operated according to the instructions in the User's Reference manual. The ventilator is designed to be used with infant through adult patients with a body weight of 5 kg or greater. If the neonatal option is installed on the ventilator, patients weighing down to 0.5 kg may be ventilated by the EC. The EC is designed to maintain lung ventilation in the absence of spontaneous breathing effort as well as in support of the patient's existing spontaneous breathing effort.

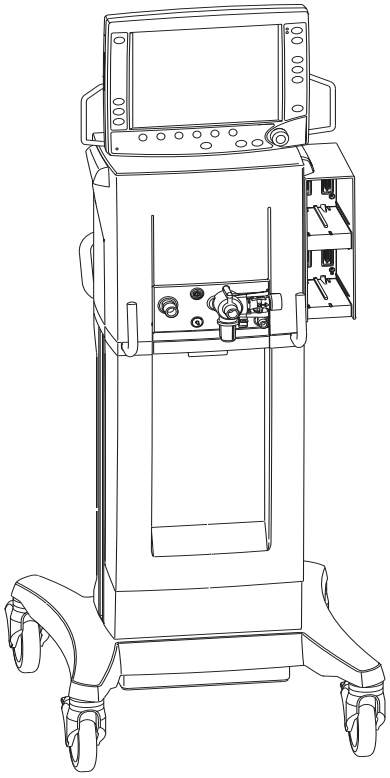


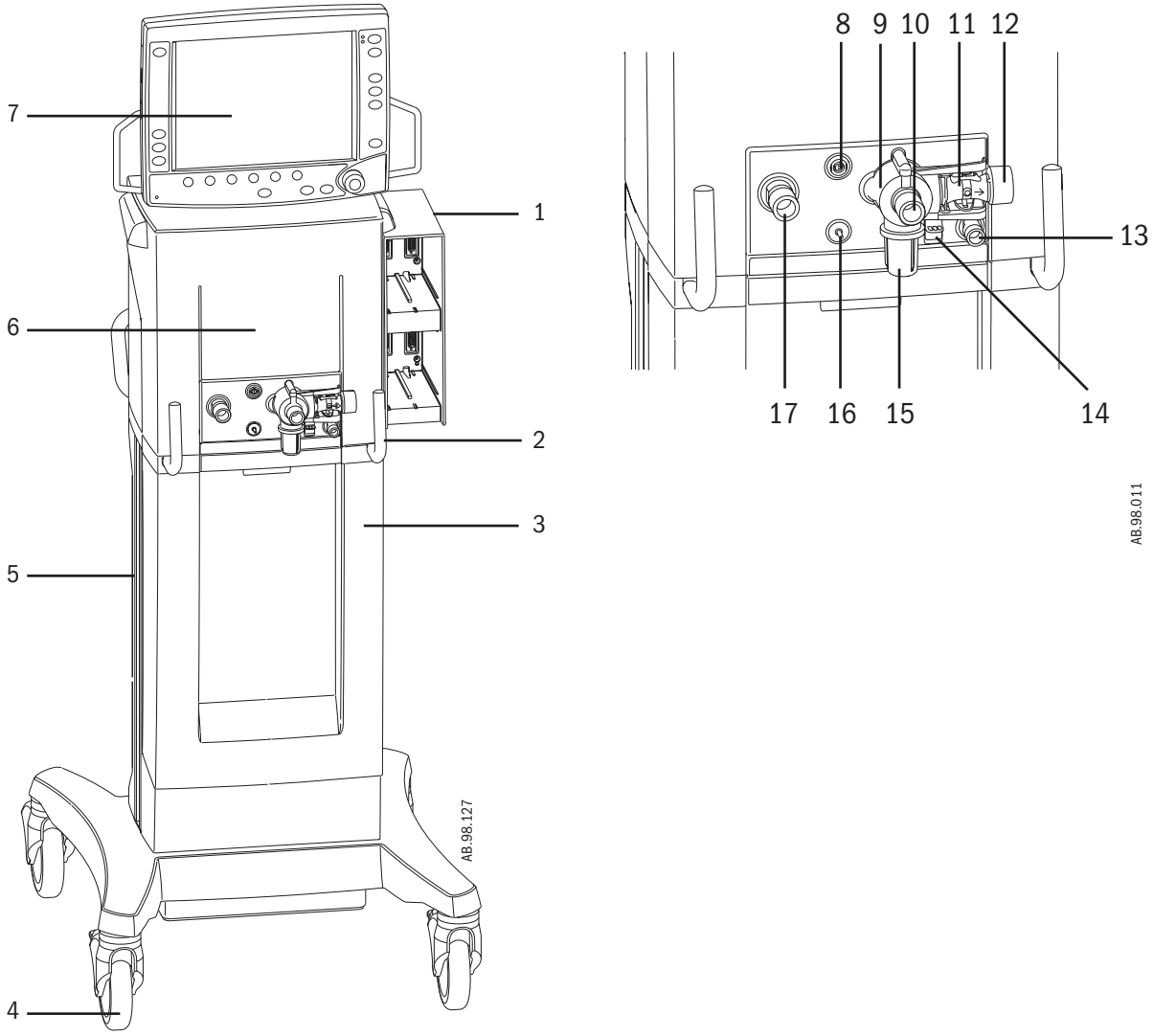
Figure 1-1 • Engström Carestation (EC)

The system is designed for facility use, including within-facility transport, and should only be used under the orders of a clinician. It is designed to be operated on medical-grade gases only and should never be connected to gasses that do not meet the medical-grade requirements listed in Appendix A.

The Engström Carestation consists of three main components: a display, a ventilator unit, and an optional module bay. The display allows the user to interface with the system and control settings. The ventilator unit controls electrical power, nebulization, and pneumatic gas flow to and from the patient. The module bay allows the integration of various patient monitoring modules with the ventilator.

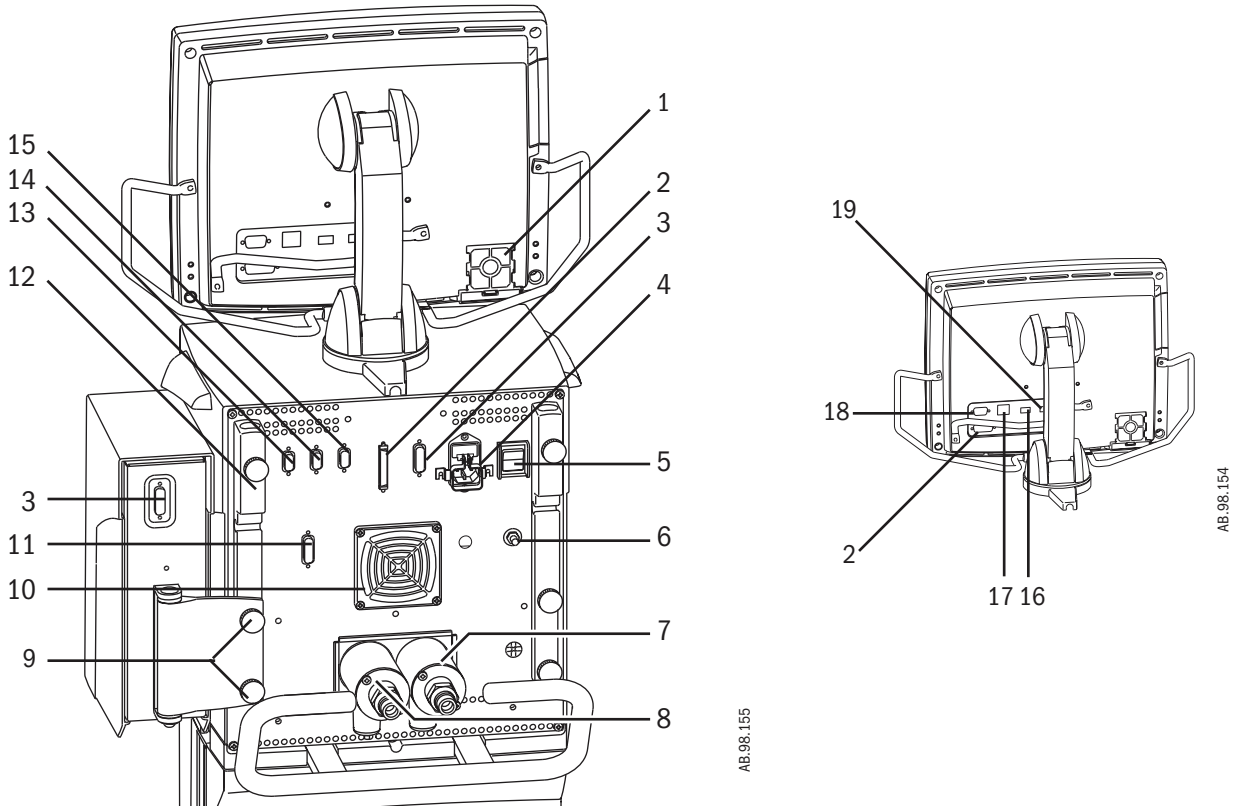
Optional accessories include an air compressor, airway modules, module bay, support arm, humidifier and water trap mounting brackets, auxiliary electrical outlets, and a neonatal flow sensor.

1.5 Ventilator overview



1. Module bay (optional)
2. Ventilator lock [locks Ventilator unit (item 6) to Cart (item 3)]
3. Cart
4. Caster
5. Dovetail rails
6. Ventilator unit
7. Display
8. Nebulizer connection
9. Exhalation valve housing
10. Expiratory inlet
11. Expiratory flow sensor
12. Gas exhaust port
13. Leak test plug
14. Exhalation valve housing latch
15. Water trap
16. Auxiliary pressure port
17. Inspiratory outlet

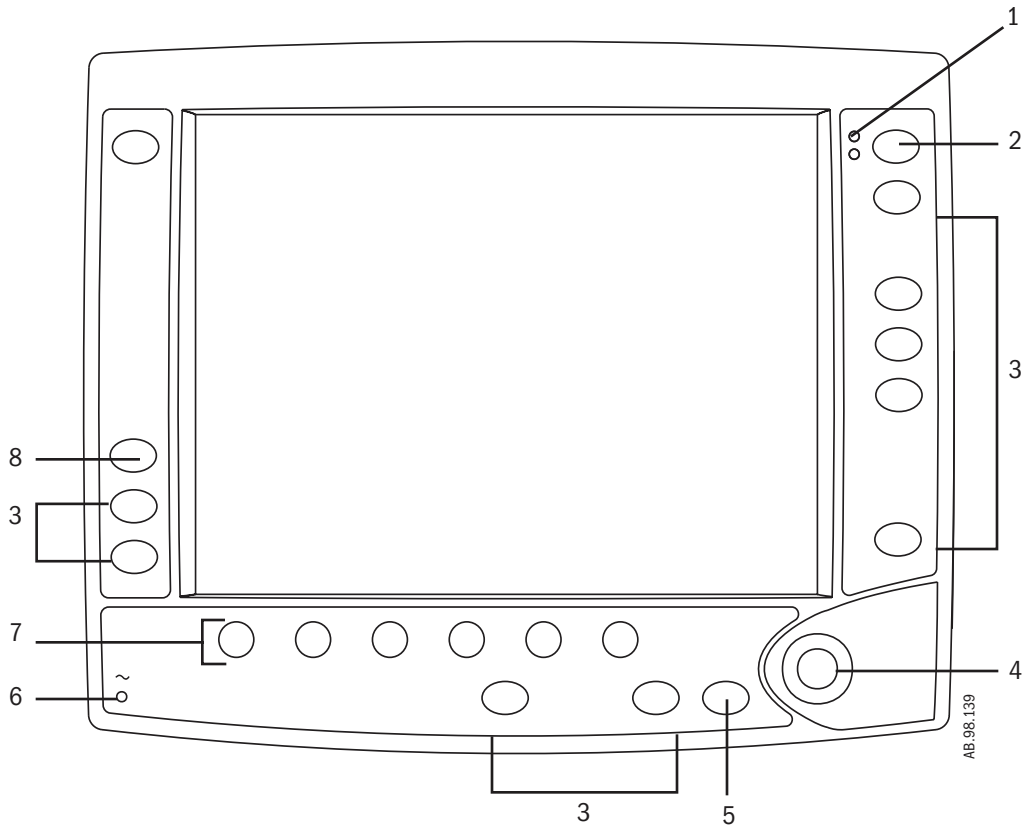
Figure 1-2 • Front view of the EC



1. Display fan filter
2. Display connection
3. Module bay connection
4. AC mains inlet
5. System switch
6. Equipotential connector
7. Oxygen supply connection (pipeline)
8. Air supply connection (pipeline or compressor)
9. Module bay mounting thumbscrews
10. Ventilator unit fan filter
11. Serial communication port (Nurse call - Port 4)
12. Arm holder
13. Port 1 (Neonatal Flow Sensor)
14. Port 2 (Not currently supported)
15. Port 3 (Used to communicate with PC based Service Application — Refer to Section 8.5)
16. Communication port (Refer to Section 2.3)
17. Communication port (Refer to Section 2.3)
18. Communication port (Refer to Section 2.3)
19. Communication port (Refer to Section 2.3)

Figure 1-3 • Back view of the E V

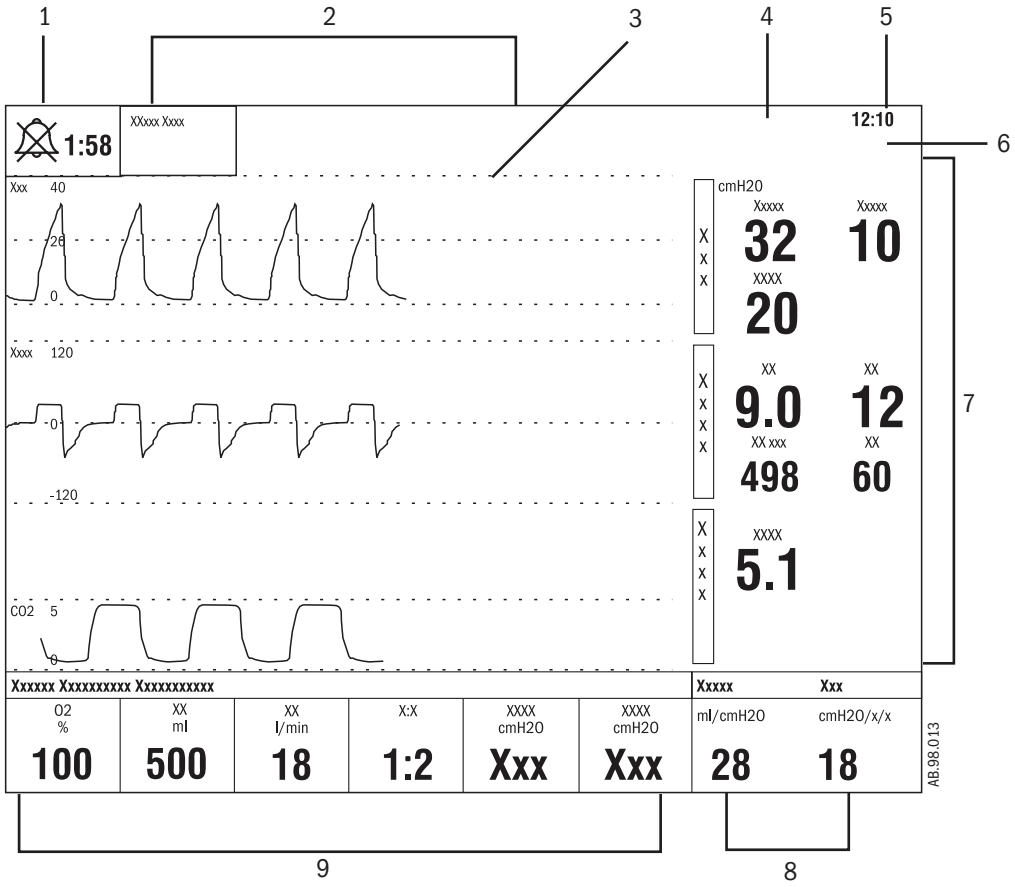
1.6 Display controls and indicators



1	Alarm LEDs	The red and yellow LEDs indicate the priority of active alarms.
2	Silence Alarm key	Push to silence any active, silenceable high and medium priority alarms or to suspend any non-active high or medium priority alarms. Alarm audio is silenced or suspended for 120 seconds for Adult and Pediatric patient types, and for 30 seconds for Neonatal patient types. Push to clear resolved alarms.
3	Menu keys	Push to show corresponding menu.
4	ComWheel	Push to select a menu item or confirm a setting. Turn clockwise or counterclockwise to scroll menu items or change settings.
5	Normal Screen key	Push to remove all menus from the screen.
6	AC mains indicator	The green LED lights continuously when the EC is connected to an AC mains source. The internal batteries are charging when the LED is lit.
7	Quick keys	Push to change corresponding ventilator setting. Turn the ComWheel to make a change. Push the Quick key or ComWheel to activate the change.
8	↑ O2 key	Push to deliver 100% O_2 (Adult or Ped) or 25% above current setting (Neo) for 2 minutes.

Figure 1-4 • Controls and indicators

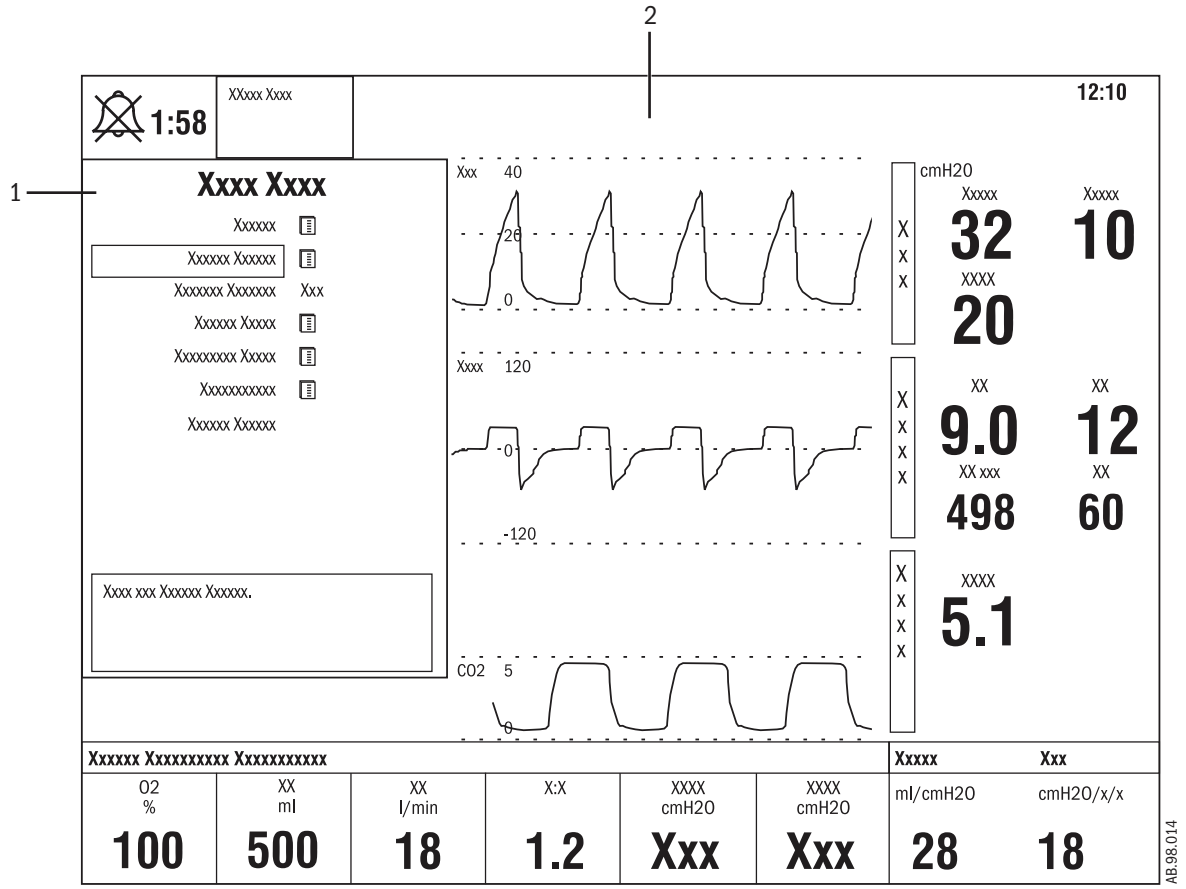
1.7 Ventilator display



1	Alarm silence symbol and countdown	Displays the time remaining during an alarm silence or alarm suspend period.
2	Alarm message fields	Alarms will appear in order of priority. Refer to *"Alarms and Troubleshooting"* for more information on alarm behavior.
3	Waveform fields	The top two waveforms are permanently set to Paw and Flow. The third waveform may be selected as CO_2, O_2, Vol, Paux, or Off.
4	General message field	Displays informational messages.
5	Clock	The time may be set in 12 or 24 hour format in the Time and Date menu.
6	Patient type icon	Displays Neonatal, Pediatric, or Adult patient type mode.
7	Measured value fields	Displays current measured values corresponding to the waveforms.
8	Digit field	Displays information related to Volume, CO_2, O_2, Compliance, Metabolics, Spirometry, or Volume per weight.
9	Ventilator settings	Displays several of the settings for the current mode of ventilation.

Figure 1-5 • Normal Screen view

When a menu key is selected the waveform fields start at the right edge of the menu. The entire waveform is always displayed.

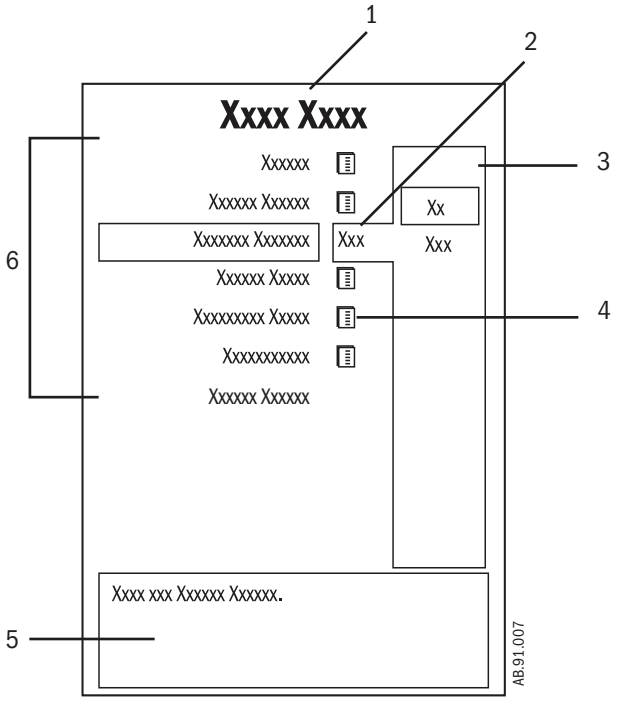


1. Menu
2. Waveform fields

Figure 1-6 • Menu view

1.7.1 Using menus

Push a menu key to display the corresponding menu. Use the ComWheel to navigate through the menu.



1. Menu title
2. Present selection
3. Adjustment window
4. Indicates submenu
5. Short instructions
6. Menu selections

Figure 1-7 • Example menu

1. Push the menu key to display the corresponding menu.
2. Turn the ComWheel counterclockwise to highlight the next menu item. (Turn the ComWheel clockwise to highlight the previous menu item.)
3. Push the ComWheel to enter the adjustment window or a submenu.
4. Turn the ComWheel clockwise or counterclockwise to highlight the desired selection.
5. Push the ComWheel to confirm the selection.
6. Select ***Normal Screen*** or push the **Normal Screen** key to exit the menu and return to the normal monitoring display. (Select ***Previous Menu*** to return to the last displayed menu, if available.)

1.8 Symbols used in the manual or on the equipment

Symbols replace words on the equipment, on the display, or in Datex-Ohmeda manuals.

Warnings and Cautions tell about the dangerous conditions that can occur if the instructions in the manual are not followed.

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

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

	On (power)		Off (power)
	On for part of the equipment		Off for part of the equipment
	Standby		Type B protection against electrical shock
	Attention, refer to product instructions IEC 60601-1		Caution, ISO 7000-0434
REF	Stock number	SN	Serial number
	Direct current		Alternating current
	Earth ground		Protective earth ground
	Equipotential connector		Fuse
	Lock		Unlock
	Variability		Variability in steps
+	Plus, positive polarity	-	Minus, negative polarity
	Movement in one direction		Movement in both directions
	This way up		Warning, dangerous voltage

Pneumatic inlet

Pneumatic outlet

Electrical input

Electrical output

Inspiratory port

Expiratory port

Electrical testing certification

Inspiratory breath identifier

Serial port

Module data indicator

Module bay port

Electronic micropump nebulizer

Auxiliary pressure port

Display signal input/output

No battery/battery failure

Battery in use. Bar indicates amount of battery power remaining.

Silence alarms

Submenu

Hourmeter

Drain outlet

Air

Pump

Heavy object

USB port

Ethernet connection

Network ID connection
(Datex-Ohmeda proprietary port)

Autoclavable

Not autoclavable

Authorized representative in the European Community

Systems with this mark agree with the European Council Directive (93/42/EEC) for Medical Devices when they are used as specified in their User's Reference Manuals. The xxxx is the certification number of the Notified Body used by Datex-Ohmeda's Quality Systems.

Date of Manufacture

Maximum

Neonatal option in installed

Functional Residual Capacity option is installed

SpiroDynamics option is installed

Neonatal patient type

Pediatric patient type

Adult patient type

Manufacturer

GOST R Russian certification

Indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of equipment.

2 Theory of Operation

In this section

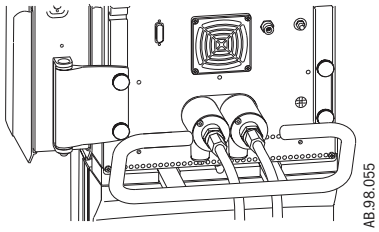
2.1 Pneumatic Operation

For a complete diagram of the pneumatic system, refer to Figure 11-3, "*Vent Engine manifold flow diagram*" in Section11.

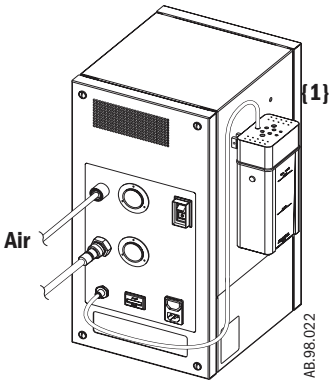
The EC requires medical-grade oxygen (O_2) and medical-grade Air sources ranging from 2.4 to 6.5 bar (35 to 94 psi). Refer to Appendix For additional information regarding medical-grade gasses. Additional filtering will not be necessary if supplied gasses are medical grade. If gas supply does not meet specifications refer to Appendix A for information regarding risks and recommendations on filters.

The system includes two separate channels (O_2 and Air) to provide dynamic mixture control of the delivered O_2 percentage.

The Air supply may include an optional compressor unit {1} for applications where pipeline Air is not available or to provide a continued Air supply if the pipeline supply goes down.



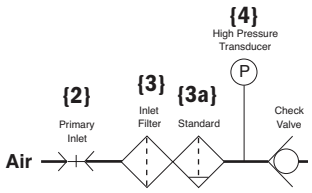
Air 02

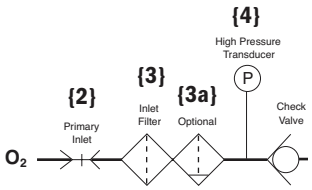


2.1.1 Primary Gas Inlet

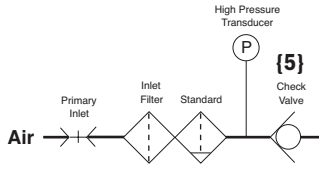
Compressed gas enters the EC through an inlet fitting {2} that is particular to the institution's supply system. The gas is filtered through a 2-micron particulate filter {3} and then a 0.5-micron coalescing particulate filter {3a} as it enters the ventilator's "pneumatic engine" manifold. The Air Pipeline Inlet filter assembly {3a} is standard on all configurations. The O2 Pipeline Inlet Filter assembly does not come standard, but is an orderable option. The 0.5-micron filter protects the EC from pipeline particle and liquid aerosol contamination.

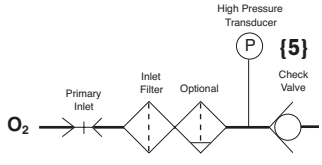
A high-pressure transducer {4} having a dynamic range of 0 to 8.3 bar (0 to 120 psi) is tapped at the outlet of the filter. This transducer monitors the adequacy of the supply pressure. Failures of supply gas, coupling hoses or an occluded filter are identified by the supply pressure transducer.



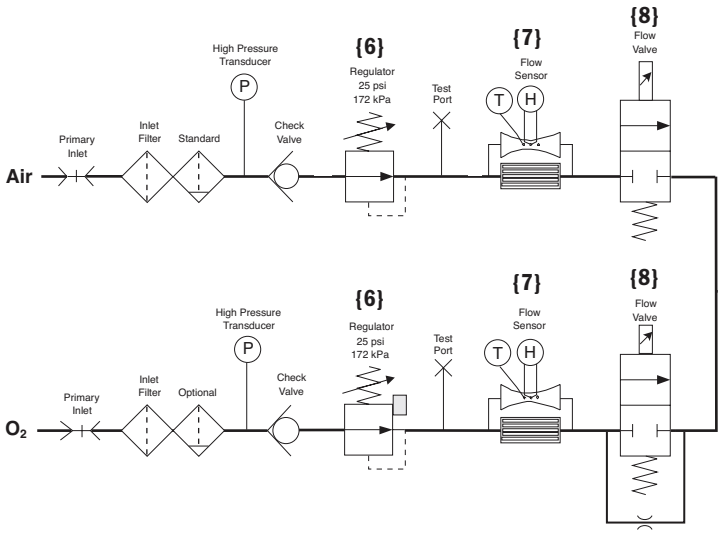


Next in the downstream path of flow is a check valve {5}. The check valve prevents backflow from the EC that would possibly contaminate the supply pressure lines. For example; if the O_2 supply were to be lost, the check valve in the O_2 channel will prevent Air from moving back into the O_2 supply lines.





Downstream from the check valve is a 172 kPa (25 psi) pressure regulator {6}. (The regulator is a non-relieving type that does not bleed gas into the ventilator's enclosure.) The regulator ensures a constant pressure supply to the flow valve {8}. The regulated supply is flow rate dependant, which is compensated for in the flow valve's on-site calibration.

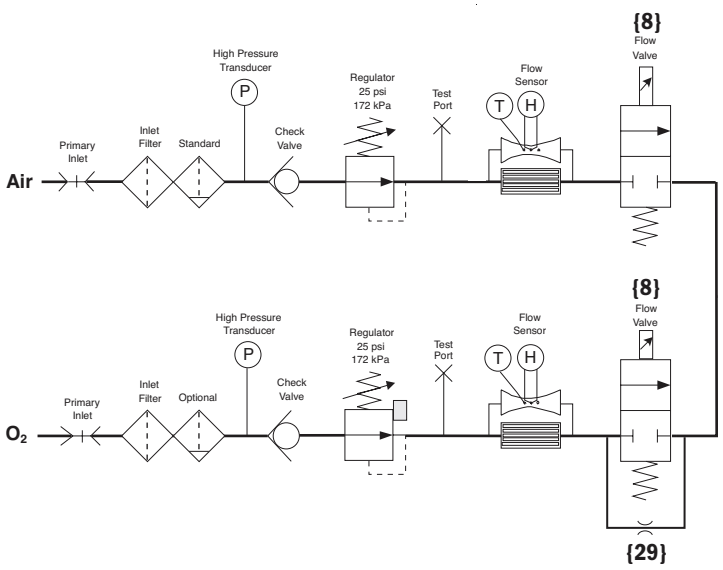


Between the regulator and the flow valves is the inspiratory flow sensor {7}. The sensor is a thermal mass-flow type that injects heat into the flow stream and monitors the associated temperature rise at a downstream location. The temperature change is dependent on the mass flow of the flow stream and the specific heat of the gas moving through the sensor. Since the composition of gas in the sensor is known, a conversion of mass-flow rate to volumetric flow at ambient conditions can be made using the ambient density of the gas. The sensor uses a laminar (two channel) flow element to split a portion of the flow through the sensor past the heat injection and temperature sensing elements. The sensor is pre-calibrated and includes an electronic PCB that produces direct digital output of mass flow through an RS-232 interface.

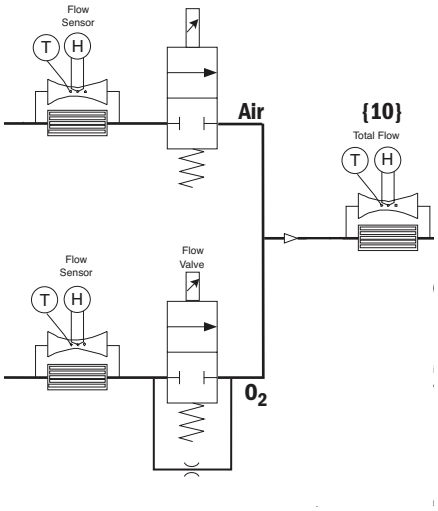
Individual flow sensors measure the volume of gas dispensed from the O_2 and Air channels during inspiration and expiration. The relative proportion of gas dispensed from each channel is continuously adjusted to precisely control the percentage of O_2 delivered to the patient.

Downstream of the flow sensor is a flow valve {8} that meters flows from approximately 0.05 l/min (leakage level) to a full flow value of 160 l/min. The valve is a normally- closed proportional solenoid that is powered by a current feedback loop. When calibrated on-site, the flow valve uses both sensors during calibration. Data comes from the Total Flow Sensor and is verified again by the Air or O2 Flow Sensors. Using data from the inspiratory flow sensor, a precise volumetric flow versus input current profile is developed that includes both the valve and regulator characteristics.

A Bleed Resistor {29} is located in parallel with the O2 Flow Control Valve to prevent pressure build-up between the O2 regulator and the Flow Control Valve. This Bleed Resistor has a 35 ml/min nominal flow.



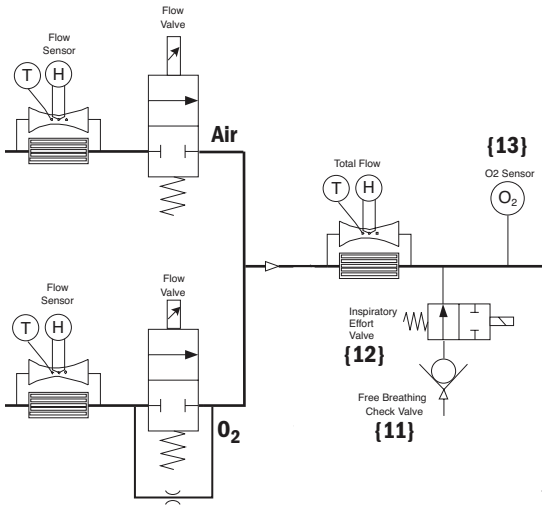
Following the two individual flow valves is the total flow sensor {10}. This sensor is the same type as the individual flow sensors and is used to measure the combined inspiratory flow being dispensed from the system. Using the known mixture composition along with atmospheric pressure and gas temperature information, mass-flow data from the sensor is converted to delivered volumetric flow towards the patient. During calibration, the sensor is checked against the output of the O_2 and Air flow sensors to ensure proper operation.



Following the total flow sensor are the free-breathing check valve {11} and the inspiratory effort valve {12}.

During normal operation, the inspiratory effort valve is open, allowing the free-breathing check valve to admit flow if the patient draws a significant amount of inspiratory pressure, causing the airway pressure to become more negative than -0.5 cm H_2O. The free-breathing check valve allows the patient to spontaneously breathe in case of a ventilation delivery failure.

On occasion, to assess the patient's tolerance to be weaned from the ventilator, clinicians can determine the amplitude of inspiratory effort that the patient can create. During this "procedure", the inspiratory effort valve is closed, effectively locking out the free breathing valve from the patient circuit.

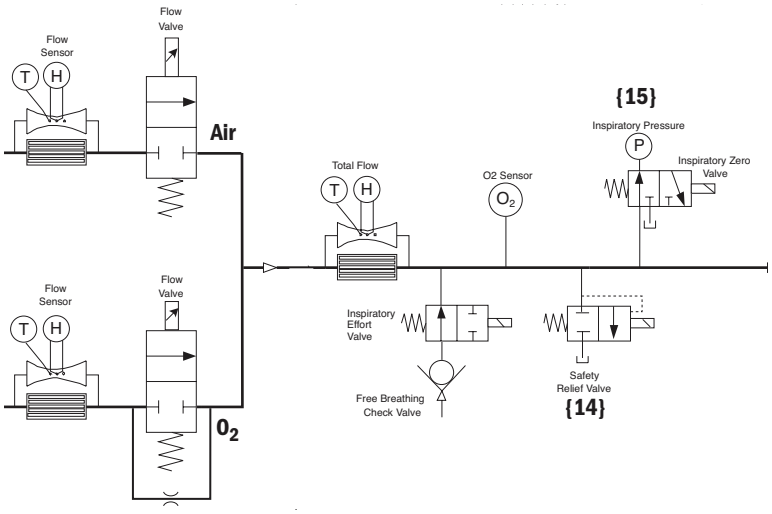


Next in the flow path is the O_2 sensor {13}. The sensor is used to monitor the O_2 concentration produced by the combined O_2 and Air flows.

The O_2 sensor uses the paramagnetic principle (oxygen molecules are attracted in magnetic fields) to measure the oxygen concentration. The sensor includes two nitrogen-filled glass spheres mounted on a suspension containing a conductive coil that is located in a non-uniform magnetic field. When the system is disturbed by an impulse of current, the suspension begins to oscillate, inducing an EMF into the coil. The oscillation period of the induced EMF is dependent on the partial pressure of oxygen surrounding the suspension.

As sample gas fills the sensor, oxygen that is present in the sample is attracted into the strongest part of the magnetic field. This congregation of O_2 molecules alters the natural oscillation frequency of the suspension. Calculations based on the difference between the oscillation period for an oxygen sample and that for nitrogen, and readings from the absolute pressure transducer, determine the measured O_2 percentage.

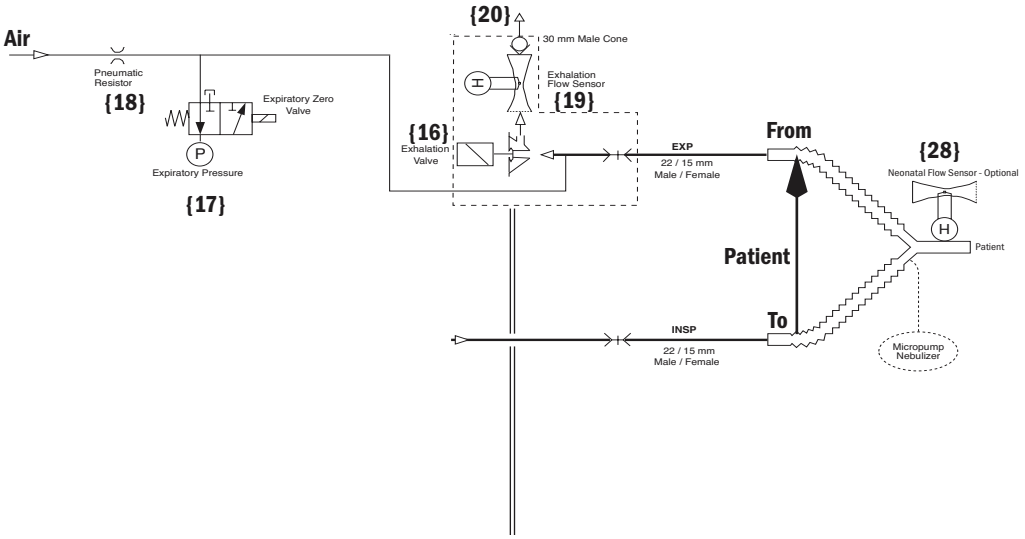
As a safety measure, a relief valve {14}, located downstream from the O_2 sensor, can be energized to vent the full flow rate of the inspiratory delivery side of the system. If an overpressure condition is detected, the valve can be opened by either of the EC's two control processors. To provide redundant safety (independent of the electronic circuits), the valve begins to mechanically relieve pressure at a nominal 115 cm H_2O.



The inspiratory airway pressure transducer {15}, along with its associated zeroing valve, is located just prior to the inspiratory outlet port. This transducer has a range of –20 to 120 cm H_2O and serves as one of three airway pressure measuring devices in the EC.

2.1.2 Expiratory circuit

At the expiratory side of the ventilator, a solenoid powered exhalation valve {16} controls exhaust from the breathing circuit. The valve contains an elastomer diaphragm that is held against a rigid seat by a solenoid (voice coil) driven piston. The valve achieves a balance between the pressure generated within its 21-mm diameter seat area and the force applied by the piston, releasing exhalation flow as necessary to maintain balance. The proportional solenoid controls the exhalation sealing pressure within a range of 0 to 100 cm H_2O. Software control provides continuous oscillatory movement (dithering) of the exhalation valve to minimize static friction effects.



Immediately upstream of the exhalation valve is a tap for the expiratory pressure transducer {17} and its associated zeroing valve. The expiratory pressure tap is continuously purged with 35 ml/min of air to ensure that exhaled condensate does not occlude the tap. The air flow is established from the regulated Air supply using a fixed orifice (pneumatic resistor) {18}.

Downstream of the exhalation valve is the expiratory flow transducer {19}. In principle, the transducer is similar to a hot-wire anemometer. A wire having a large “temperature to electrical resistance” relationship is placed in the flowstream. The wire is kept at a constant temperature using a Wheatstone bridge circuit. The current necessary to maintain the resistance of the sensor portion of the bridge is a function of the flow through the sensor.

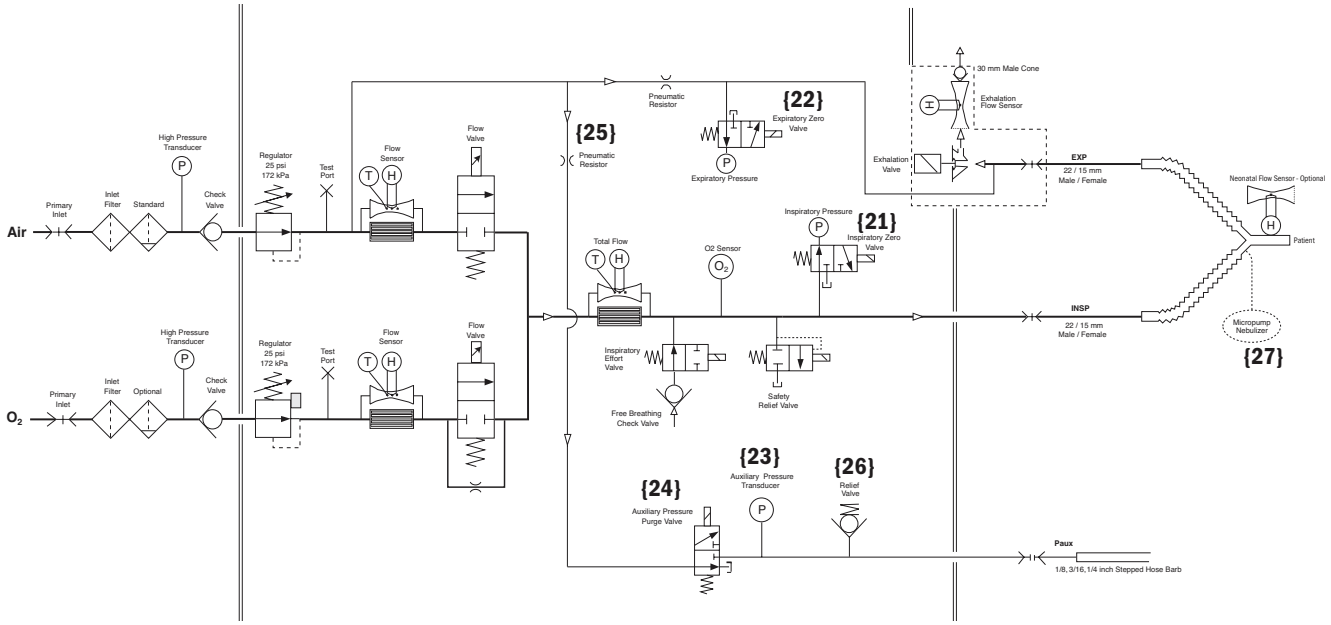
At the output of the flow sensor is a flapper type check valve {20} that prevents gas from being drawn in through the expiratory valve and minimizes patient rebreathing in the event of a ventilator failure.

Located downstream on the patient wye is an optional Neonatal Flow Sensor {28}. The sensing elements for the Neonatal Flow Sensor Subsystem consist of two hot wires each with its own drive circuitry and Wheatstone bridge. The hot wires reside off-board in a flow tube situated at the patient wye and

electrically act as variable resistors in each of the bridges. The sensors hold a constant temperature at all times as they contain a linear resistance change with temperature. The Neonatal Flow sensor is connected to the Ventilator Monitoring Board (VMB) through the Motherboard via Port 1 and a 2^{+} meter long shielded cable, detachable at both ends. The other Wheatstone bridge resistors and all associated drive circuitry reside on the VMB. As gas (Air and Oxygen) flows, current through the hot wire elements increases. These currents are converted to a voltage, amplified, offset with a voltage reference and converted to a digital value by the 12-bit ADC. Because of the bidirectional nature of gas flow at the patient wye, a post that is situated between the elements serves to shadow the downstream element and reduce the downstream signal. By comparison of the individual signal levels of the two hot wire elements, flow direction can be ascertained.

2.1.3 Associated circuits

Associated with the inspiratory and expiratory pressure transducers are two “zeroing” solenoid valves {21} and {22}. These valves are used to disconnect the pressure transducers from circuit pressure and vent them to atmosphere during zero bias calibration. This zeroing procedure is conducted routinely (every 12 hours) under the control of the Vent Engine software.



A third (auxiliary) pressure channel {23} is used to measure additional patient “airway” pressures at the discretion of the clinician. This port could be used to measure circuit pressure directly at the airway, laryngeal cuff pressures or pressures lower in the airway tract. The transducer circuit includes a valve {24} to provide a 35 ml/min purge flow as required by the particular clinical application. For example, in measuring airway pressure at the endotracheal tube the purge would most likely be turned on, but for measuring laryngeal cuff pressures (closed system) the purge would be turned off. The purge flow is established from the regulated Air supply using a fixed orifice (pneumatic resistor) {25}. The relief valve {26} limits pressure in the auxiliary channel to less than 230 cm H_2O.

2.1.4 Electronic micropump nebulizer

The Aeroneb Professional Nebulizer System (Aeroneb Pro) by Aerogen, Inc. {27} is integrated into the EC. This nebulizer is electrically connected to the EC and uses proprietary technology to produce a fine-droplet, low-velocity aerosolized drug delivered into the breathing circuit.

The Aeroneb Pro is designed to operate in-line with standard ventilator circuits and mechanical ventilators. It operates without changing the patient ventilator parameters.

2.2 Electrical Operation

For a complete diagram of the electrical system, refer to Figure 11-5, "*Electrical architecture*" in Section11.

The EC includes 5 major processor control boards:

- Display Unit: DU (1009-8289-000) or HPDU (1009-5933-000)
- Ventilator Control Board (1505-5500-000)
- Ventilation Monitoring Board: Original VMB (1505-5501-000) or Current VMB (M1052980)
- Expiratory Flow Sensor Board (1505-5507-000)
- Power Management Board (1505-5502-000)

The EC includes 5 analog boards:

- Motherboard/backplane: Original Motherboard (1505-5504-000) or Current Motherboard (M1053184)
- Monitoring Module Power Supply Board (M1052831)
- 3 Airway Pressure Transducer boards (1505-5506-000)

2.2.1 Display Unit overview

The Engström Carestation can use one of two display units:

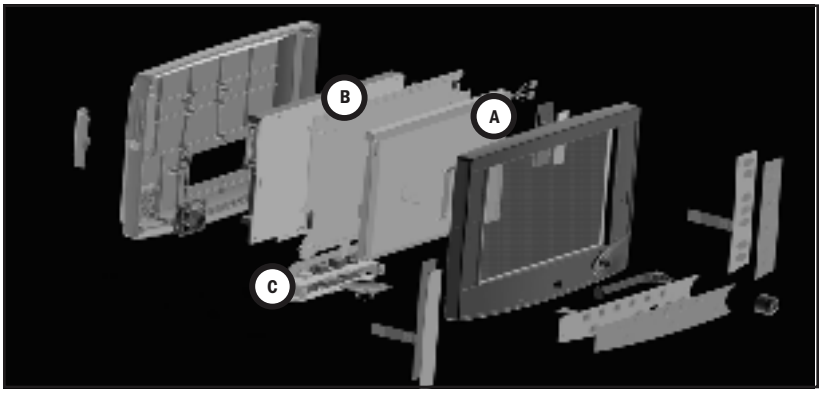
- the original Display Unit (DU)
- or the High Performance Display Unit (HPDU)

The display unit handles most of the machine's user interface functions through the front panel controls and the LCD screen. It is the primary interface to external peripherals

The main components of the display include:

- An active matrix thin film transistor liquid crystal display **(A)**
- The CPU board **(B)**
- The System Interconnect assembly **(C)**

The CPU board includes a host processor and three coprocessors to handle display, front panel, and monitoring interfaces.



2.2.2 Software requirements

The DU uses a PCMCIA interface to handle software upgrades and to load the diagnostics Service Application. The DU is compatible with system software versions 3.X and lower.

The HPDU uses a Compact Flash interface to handle software upgrades and to load the diagnostics Service Application. The HPDU requires system software version 4.X or greater.

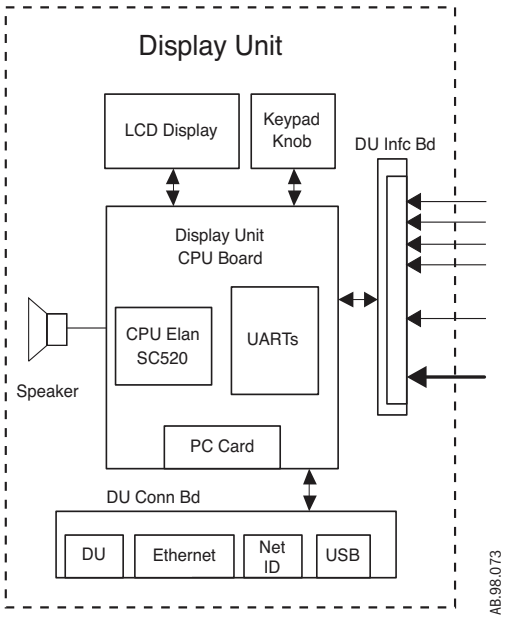
2.2.3 DU system connections

The display unit is physically separate from the ventilator chassis (connected through a single cable running through the display arm). The display unit contains a CPU board based on the Elan SC520 processor. A small daughter board (DU Interface board), provides a communications interface between the DU's CPU and the remainder of the EC system. A second daughter board (DU Connector board), provides hardware connector interfaces for the USB, Network ID, Ethernet, and Display Unit connector ports.

The CPU board includes a PCMCIA (PC Card) interface.

The DU's CPU board provides power and signals for operating the main audio speaker and a 12 inch (30 cm) backlit color LCD display, providing an interactive video interface. Membrane keys from three front-panel keypads and a rotary encoder (ComWheel) complete the loop for acquiring user inputs.

The DU housing contains a continuously operating fan for temperature reduction.

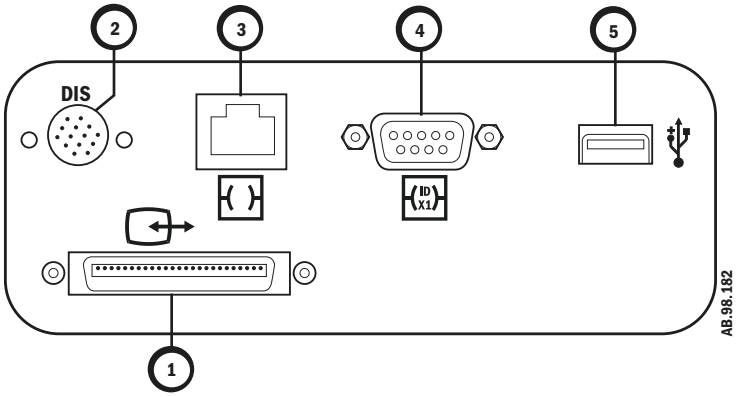


2.3 System Connections

2.3.1 Display Unit

The DU accommodates the following connections:

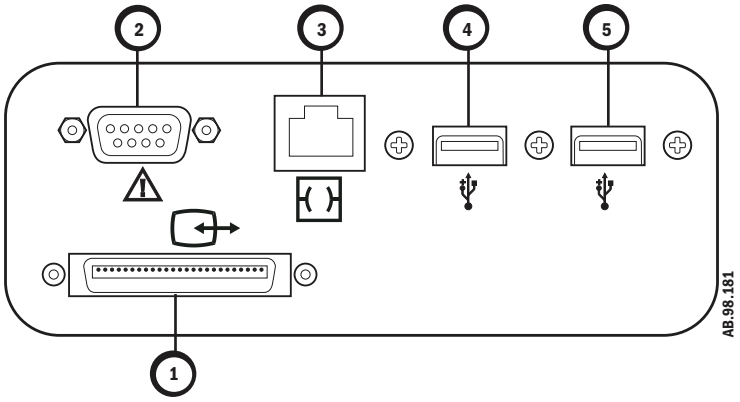
- Display connection (**1**).
- DIS connector - supports D-O Device Interface Solution (DIS) (**2**).
- Network connection - Standard Ethernet port for network connectivity (**3**).
- Network ID - accepts D-O proprietary network identification plug (**4**).
- USB port - standard USB interface for external communication (**5**).



2.3.2 High Performance Display Unit

The HPDU accommodates the following connections:

- Display connection (**1**).
- Future expansion(**2**).
- Future expansion (**3**).
- Future expansion (**4**).
- Future expansion (**5**).



2.3.3 Communication channels

The DU communicates to the remainder of the EC system through the Motherboard using 5 digital channels.

[1] A 500 Kbaud, RS-485 interface (Mod Bus: Datex-Ohmeda proprietary module communication protocol), to external monitoring modules. This link runs through the Monitoring Module Power supply board which forms the physical interface to the M-Gas (and ultimately other) monitoring modules.

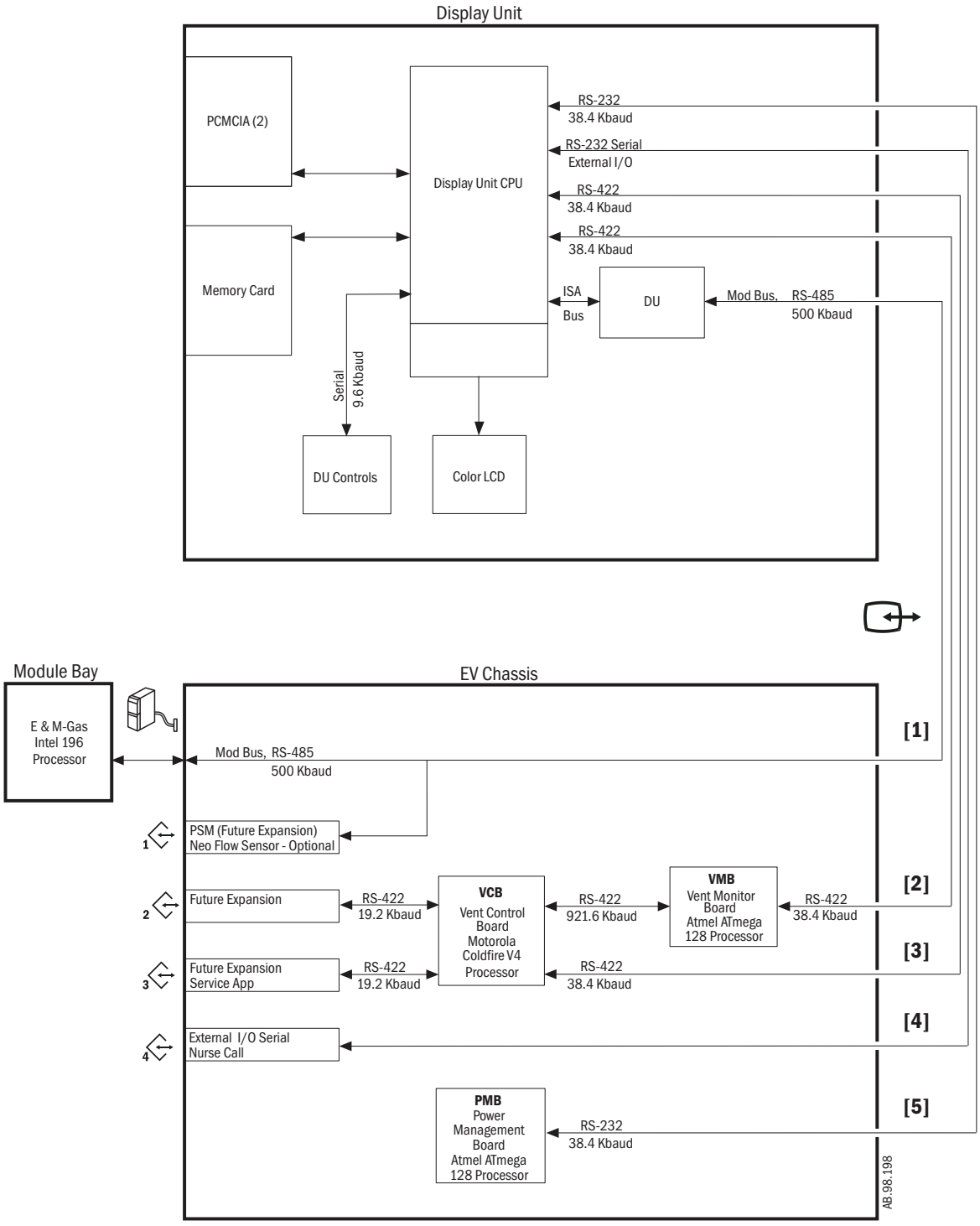
Additionally, the Mod Bus interfaces with the PSM (Patient Side Module) support circuitry (future expansion).

[2] A 38.4 Kbaud, RS-422 interface relays setting and alarm annunciation information from the VMB, and receives alarm commands and data.

[3] A 38.4 Kbaud, RS-422 interface relays setting and alarm annunciation information from the VCB, and receives sensor data for presentation to the user as well as alarm commands. As described later, the VMB also communicates directly to the VCB, thus there exists a triangle of bi-directional communication paths between the DU, VCB and VMB.

An RS-232 Serial port that routes to an external connector directly on the motherboard. This link ports data from the DU to other compatible equipment via the Ohmeda Com 1.X protocol.

[4] A 38.4 Kbaud, RS-232 link to the PMB. Provides display signal input/output, battery and power information to the DU. This link is located internally on the Motherboard and is used to confirm a “hard” power down of the EC with user inputs to the DU being relayed to the PMB for power down action.


Display Unit
PCMCIA (2)
Display Unit CPU
Memory Card
RS-232
38.4 Kbaud
RS-232 Serial
External I/O
RS-422
38.4 Kbaud
RS-422
38.4 Kbaud
ISA
Bus
DU
Mod Bus, RS-485
500 Kbaud
Serial
9.6 Kbaud
DU Controls
Color LCD
Module Bay
EV Chassis
E & M-Gas
Intel 196
Processor
Mod Bus, RS-485
500 Kbaud
[1]
1
PSM (Future Expansion)
Neo Flow Sensor - Optional
2
Future Expansion
RS-422
19.2 Kbaud
VCB
Vent Control
Board
Motorola
Coldfire V4
Processor
RS-422
921.6 Kbaud
VMB
Vent Monitor
Board
Atmel ATmega
128 Processor
RS-422
38.4 Kbaud
[2]
3
Future Expansion
Service App
RS-422
19.2 Kbaud
RS-422
38.4 Kbaud
[3]
4
External I/O Serial
Nurse Call
[4]
PMB
Power
Management
Board
Atmel ATmega
128 Processor
RS-232
38.4 Kbaud
[5]
AB.98.198

2.3.4 Ventilator Control Board - VCB

The VCB is a Motorola Coldfire V4 CPU powered assembly that:

- collects information from all EC system sensors (some indirectly from the VMB),
- and controls all actuators necessary to effect ventilation delivery.

The VCB computes and supplies all ventilation sensor monitoring data for display on the DU. If there are alarms to be generated based on this monitoring data, the VCB notifies the DU to post the appropriate alarm message and audio sequence. The VCB observes the DU's response to ensure that the alarm is adequately presented.

To control ventilation, the VCB accepts ventilation parameters from the DU. Measured data (waveform and numeric) is also sent to the DU from the VCB. This data flow occurs on the 38.4 Kbaud, RS-422 communications link (VCB - DU Data I/O).

The VCB also communicates directly with the VMB every 1 ms, receiving expiratory flow, expiratory pressure and O_2 sensor data on the 921.6 Kbaud, RS-422 interface (VMB Sensor Data I/O). Barometric pressure data is also received from the VMB, but at a lower data rate.

The following sensor information is acquired directly by the VCB:

- Air Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- O2 Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- Total Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- Inspiratory Pressure sensor via a differential analog signal – 12 bits @ 1000 Hz.
- Auxiliary Pressure sensor via a differential analog signal – 12 bits @ 1000 Hz.

The VCB contains actuator drive circuits for the following:

- the Air and O2 Flow Valves,
- the Exhalation Valve,
- the Inspiratory Pressure Sensor zeroing valve
- and the Auxiliary Pressure Sensor purge flow valve.

The Flow Valve and Exhalation valve actuators are driven using current drive circuits and feedback controlled using current sense resistors. The VCB contains digital control signals for activating the inspiratory effort and safety relief valves (through the VMB) and the Piezo-Electric Nebulizer.

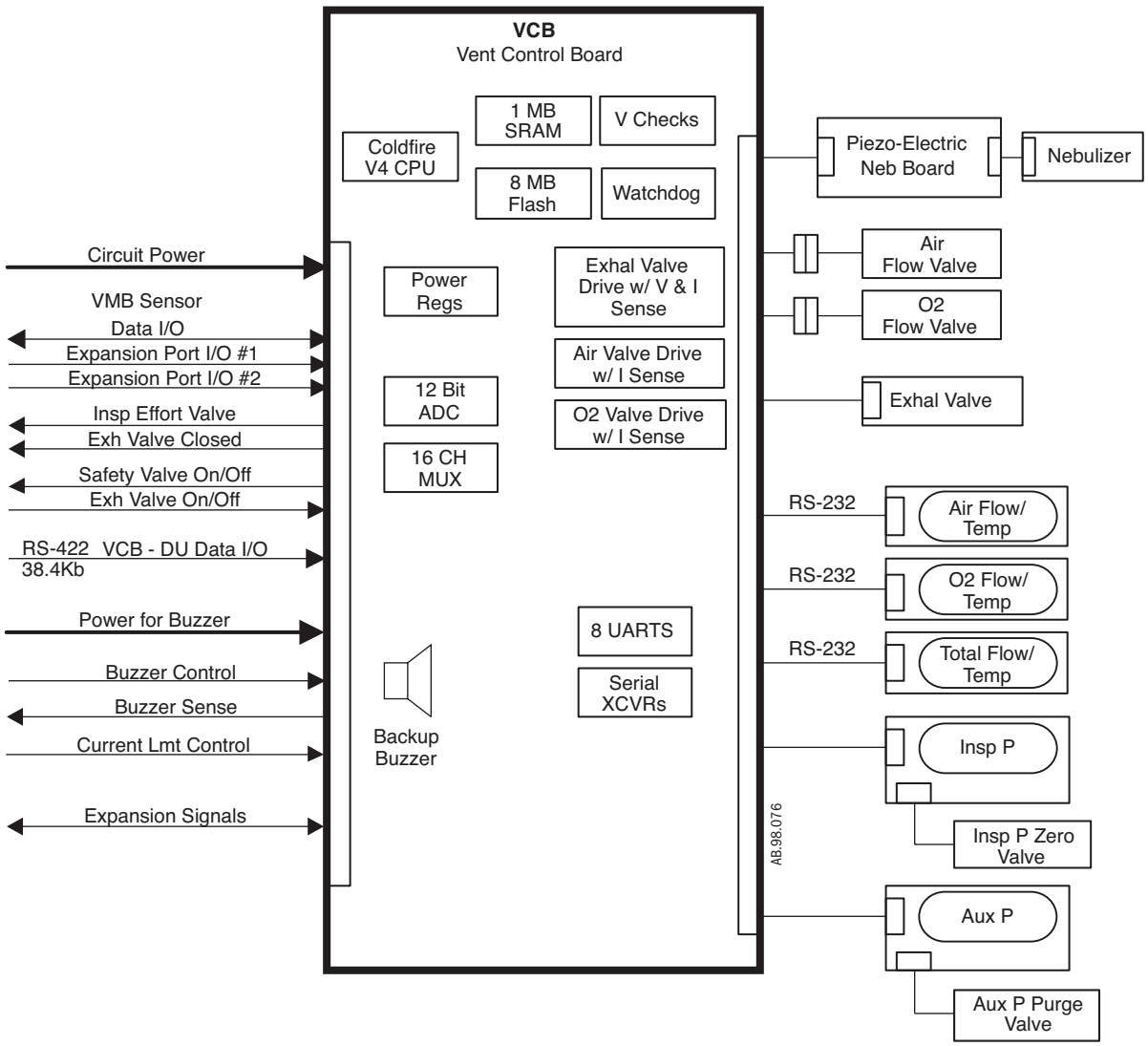
The VCB receives 12.5 Vdc from the PMB, which it regulates down to various voltages for use by the board's digital circuits and analog drivers. These voltage IECels are self-tested on the VCB.

An additional 12.5 Vdc power line is separately connected to an auxiliary buzzer on the VCB that provides a backup audio alarm source. The buzzer is normally on and must be kept silent by both the VCB and through a dedicated digital line coming from the VMB. A reset or failure of either the VCB or VMB is regarded as a system fault and the buzzer is activated.

The VCB includes 1 MB of SRAM and 8 MB of Flash memory. The CPU is connected to a digital watchdog circuit to monitor continuous and properly sequenced execution of software code.

As the core processor unit for the EC, the VCB includes two external serial I/O channels: one 19.2 Kbaud RS-422 channel (Expansion Port I/O #1 to External Connector 3) and one 19.2 Kbaud RS-422 channel (Expansion Port I/O #2 to External Connector 2).

For further details, refer to Figure 11-13, "*VCB block diagram*" in Section 11.



2.3.5 Ventilator Monitoring Board - VMB

The Engström Carestation can use one of two Ventilator Monitoring Boards:

- Original VMB, PN 1505-5501-000
  (Original VMB units do not support the Neonatal option) **or**
- Current VMB, PN M1052980
  (Current VMB units support Neonatal hardware and expansion capability; Port 2 (RS-422) via the Motherboard.)

Note: If replacement of the original VMB with a current VMB is required, it is necessary to replace the original Motherboard (1505-5504-000) with the current Motherboard (M1053184).

The VMB is based on an Atmel Atmega 128 CPU. The VMB performs as an independent monitoring system that provides computational and oversight redundancy to the DU and VCB.

The VMB independently acquires sensor data relating to the ventilator's three safety parameters:

- airway pressure (expiratory),
- delivered O_2 percentage,
- and exhaled minute/tidal volume.

In addition, the VMB monitors the air and oxygen supply pressures:

- Air High Pressure Supply via analog cable –10 bits @ 11 Hz,
- O2 High Pressure Supply via analog cable – 10 bits @ 11 Hz,
- Expiratory flow sensor data via an I^2C cable interface @ 200 Hz,
- O_2 Concentration via a serial cable @ 5 Hz,
- Expiratory Airway Pressure via analog signal – 12 bits @ 1000 Hz,
- Barometric Pressure onboard VMB – 10 bits @ 11 Hz.

The VMB controls a safety valve actuator that enables it to unilaterally relieve pressure in the breathing circuit. This allows the barotrauma hazard with its 50 ms reaction time to be independently controlled by either action of the VCB or VMB. The hazards associated with O_2 concentration (improper mixture) and low exhaled minute volume (hypoventilation) have much slower reaction times (on the order of minutes) and are controlled under fault conditions by the VMB's ability to unilaterally activate the backup buzzer.

The VMB receives 12.5 Vdc from the PMB, which it regulates down to various voltages for use by the board's digital circuits and analog drivers. These voltage levels are self-tested on the VMB.

The VMB communicates directly to the DU via the bi-directional 38.4 Kbaud RS-422 channel (VCD - DU Data I/O). A separate 921.6 Kb RS-422 link (VMB Sensor Data I/O) is used to transmit the VMB's sensor data to the VCB.

Neonatal Option

For Neonatal patients, the VMB provides circuitry designed to interface with the VCB and VMB and a remote bidirectional gas flow sensor. The analog sensor signals are routed from outside of the Engström housing to the VMB via an electrical harness to the back of the machine and are filtered on the Motherboard before entering the VMB through the Motherboard internal connector. This circuitry is provided 12.5V power via the Motherboard and regulates this down to 5V and 3.3V, independent of other VMB circuitry.

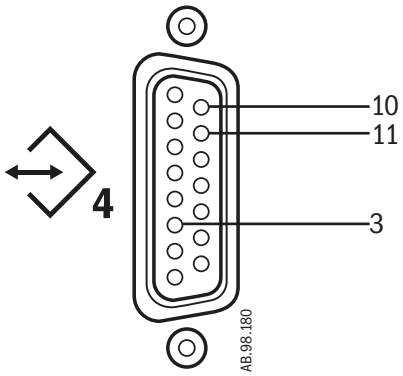
Nurse Call

Nurse Call functionality is supported on units with Serial Numbers greater than CBK00356 and units updated with Motherboard M1053184 and VMB M1052980.

Port 4 (15 pin) may be used to output alarm signals to a nurse call system. The ventilator will signal an alarm with a normally open or normally closed signal. The nurse call will be triggered by all medium and high priority alarms. When alarms are suspended, the nurse call will not be signalled. If an alarm is silenced, the nurse call signal will turn off.

Note: Motherboard M1053184 and VMB 1052980 are included in the following kits:

Item	Description	Stock Number
Neonatal	Upgrade kit (with hardware components)	M1061589
FRC and Neonatal	Upgrade kit (with hardware components)	M10792676
SpiroDynamics and Neonatal	Upgrade kit (with hardware components)	M1079272
FRC, SpiroDynamics, and Neonatal	Upgrade kit (with hardware components)	M1079274

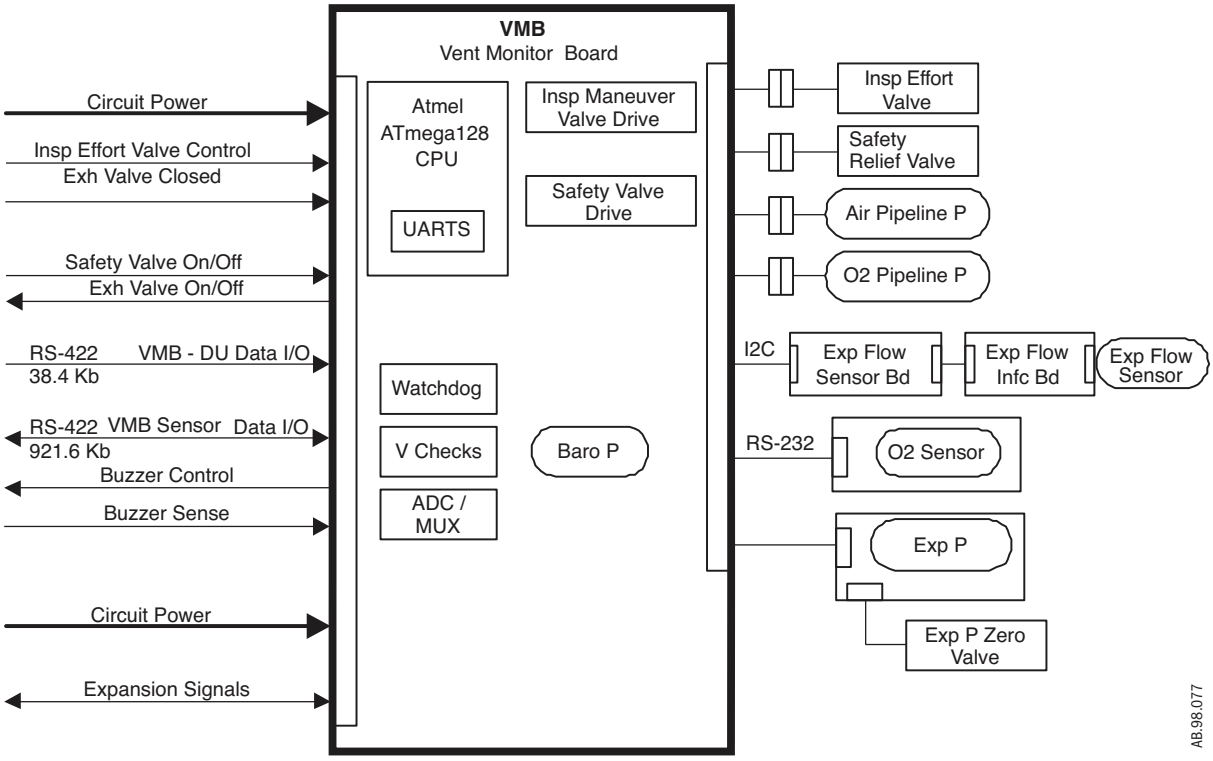


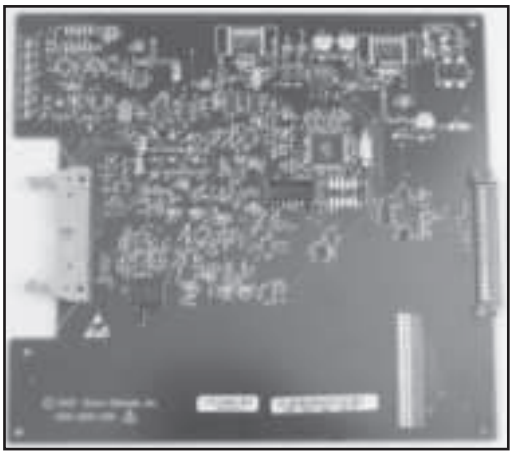
The 15-pin female D connector configuration:

- Pin 3 - relay common
- Pin 10 - normally open
- Pin 11 - normally closed

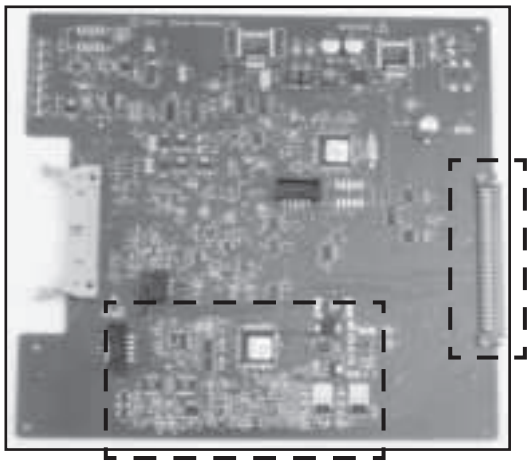
Load current:

- Minimum: 100 uA at 100 mVdc
- Maximum: 1 A at 30 Vdc
- Relay isolated





Original VMB
505-5501-000



Current VMB
M1052980

2.3.6 Power Management Board – PMB

The PMB is based on an Atmel Atmega 128 CPU. The PMB performs power selection between power sources in the following order:

- AC power mains,
- Internal battery.

The PMB regulates the 24 Vdc power supply output down to raw 16 V and 12.5 V power rails that are used throughout the system (all boards locally regulate from these power rails).

The PMB controls the charging operation of the internal battery, selecting trickle, bulk, or float charge status.

The PMB communicates with the DU through the 9.6 Kbaud, RS-232 link (PMB Data I/O). It sends status commands to the DU concerning the charge status of the internal 24 V battery.

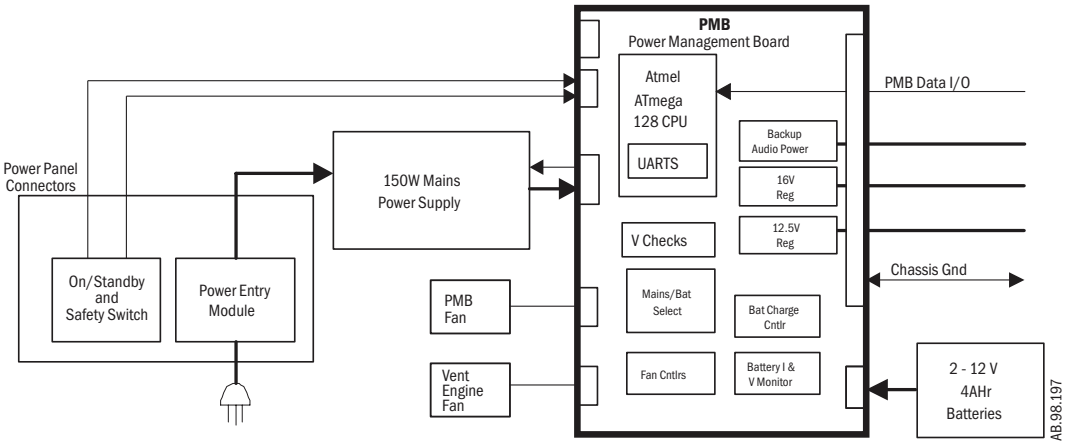
The PMB uses this link as a communication interlock to handle the unit shutdown sequence. Once a signal is received by the PMB from the mechanical On/Standby switch, the PMB prompts the DU for a confirmation signal that shutdown is appropriate (unit is not in a ventilation therapy state). Once the DU relays this confirmation to the PMB, the power-off sequence is initiated.

The PMB supports the operation of the EC chassis fan and the fan on the PMB heatsink.

2.3.7 Other Electronic Items

The EC employs a separate AC to DC switching power supply for providing a nominal 24v voltage level to the PMB. The power supply is capable of regulating 150 W of power output. A power entry module contains fuses and filters for Mains AC input cables. Finally, two internal 12v batteries are connected in series to provide an internal backup 24v power source for the system.

For further details, refer to Figure 11-9, "*PMB block diagram*" in Section11.



2.3.8 Motherboard (backplane)

The Engström Carestation can use one of two Motherboards:

- Original Motherboard - 1505-5504 (Port 2 - 15 pin) **or**
- Current Motherboard - M1053184 (Port 2 - 9 pin)

Note: If replacement of the original Motherboard with a current Motherboard is required, it is necessary to replace the original VMB (1505-5501-000) with the current VMB (M1052980).

The EC motherboard provides backplane connectivity for the VCB, VMB and PMB assemblies in the EC chassis.

Analog circuits on the board provide current limiting for external peripheral connections to ensure that the EC's primary ventilation and monitoring functions are not compromised by excessive power draw. In addition, 10VA energy limit circuitry is provided for power connections within 20 cm of O_2 exhaust outlets, in order to mitigate the risk of an oxygen enriched fire.

The board features 6 external connectors that exit through a rear sheet metal interface. Refer to section 2.3.3.

- Patient Side Module (PSM) support connector, Neonatal Flow Sensor, (future expansion)

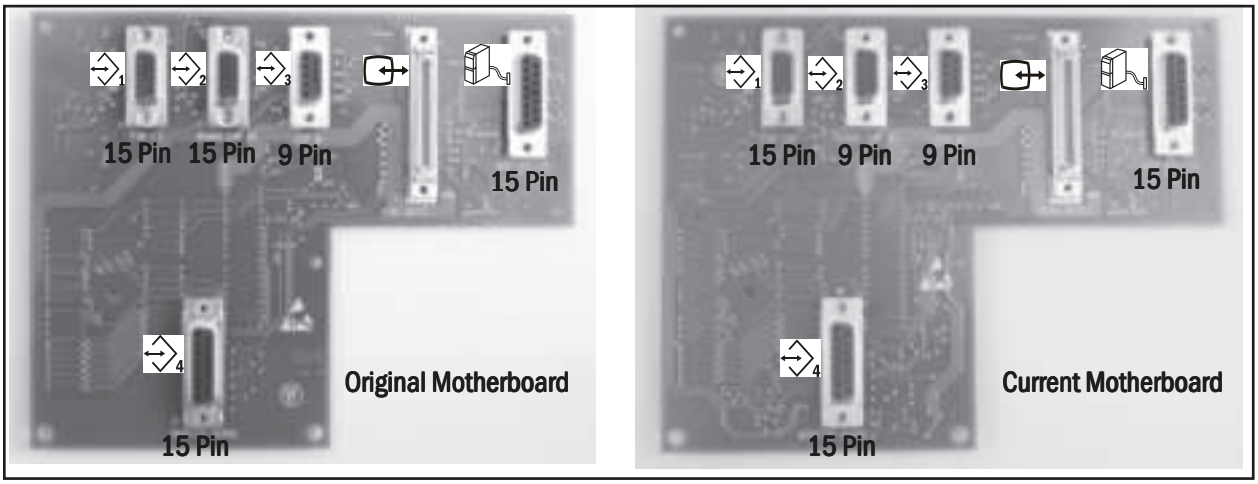
- Serial (future expansion) connector

- Service Application, Serial (future expansion) connector

- External Serial I/O connector, Nurse call

- Main DU connector (communication channel between DU and EC)

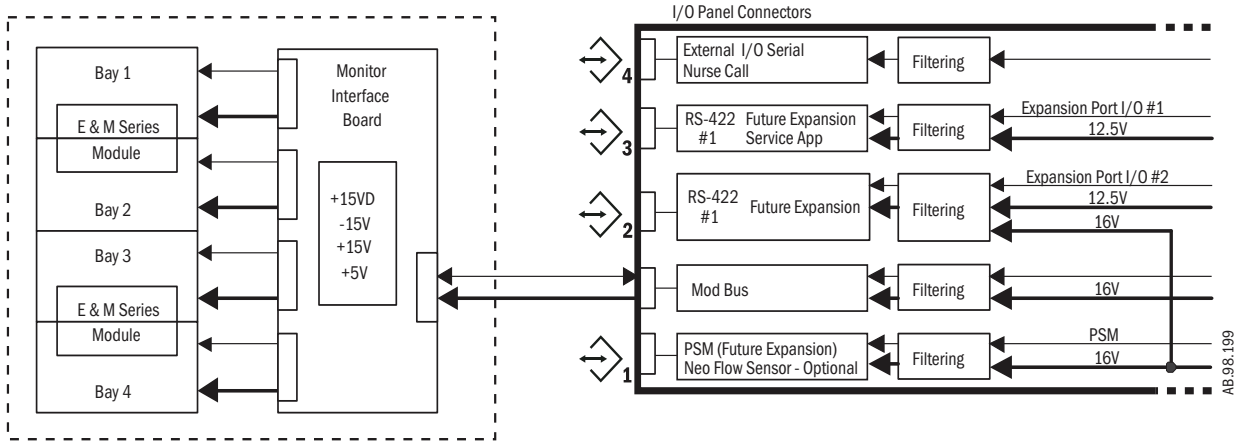
- Monitoring Module, Mod Bus connector



2.3.9 Monitoring Interface Board – Monitoring Module Bays

The EC accommodates an optional four-bay module assembly that supports compatible Datex-Ohmeda M-series modules.

The assembly includes a Monitoring Interface Board (MIB) that communicates with the DU through the Mod Bus connector. The MIB includes circuitry that regulates the raw 16 V power down to +15 V (unregulated), ±15 V (regulated), and +5 V levels required by the M series monitoring modules.



3 Checkout Procedure

In this section

⚠ WARNINGS After any repair or service of the Engström Ventilator, complete all tests in this section.

Before you do the tests in this section:

- Complete all necessary calibrations and subassembly tests. Refer to the individual procedures for a list of necessary calibrations.
- Completely reassemble the system.

If a test failure occurs, make appropriate repairs and test for correct operation.

3.1 Inspect the system

Before testing the system, ensure that:

- The equipment is not damaged.
- Components are correctly attached.
- Pipeline gas supplies are connected.
- The casters are not loose and the brakes are set and prevent movement.
- The power cord is connected to a wall outlet. The mains indicator comes on when AC Power is connected.

3.2 Automated Checkout

The EC is equipped with an automated checkout.

Note If any of the Checks fail, refer to Section 7.1, “Troubleshooting Checkout Failures”, to troubleshoot a specific failure.

To file a quality report or request technical assistance regarding a checkout failure, create and include a Checkout log using the EC Service application (Section 8.6.8).

Run the Checkout while the EC Service Application is running and select ***Log Calibration Results***.

When in Standby, the ***Patient Setup*** menu is displayed on the normal screen.

1. Select ***Checkout***.
2. Attach the patient circuit.
3. Occlude the patient wye.
4. Select ***Start Check***.
   - The results appear next to each check as they are completed. When the entire checkout is finished ‘Checkout complete’ will appear and the highlight will move to ***Delete Trends***.
   - If one or more checks fail, select ***Check Help*** for troubleshooting tips.

5. Select ***Previous Menu***.

Checkout includes the following checks:

- Paw Transducer Check
- Barometric Pressure Check
- Relief Valve Check
- Exhalation Valve Check
- Expiratory Flow Sensor Check
- Air Flow Sensor Check
- O2 Flow Sensor Check
- O2 Concentration Sensor Check
- Neonatal Flow Sensor Check (if applicable)
- Circuit Leak, Compliance, and Resistance

3.3 Backlight test

1. Access the Calibration menu.
   - In the standby mode, push the **System Setup** key.
   - On the System Setup menu, select ***Install/Service*** (23-17-21).
   - On the Install/Service menu, select ***Calibration***.
2. On the Calibration menu, select ***Backlight Test***.
3. Select ***Start Test***.
4. The display will show the test running on light 1 and then on light 2. If the display goes completely blank or flickers during the test, one of the lights has failed.

3.4 Power failure test

1. Connect the power cord to a wall outlet. The mains indicator on the front panel of the Display Unit comes on when AC Power is connected.
2. Set the system switch to On and Start a case.
3. Unplug the power cord with the system turned on.
4. Make sure the following message is displayed:
   - 'On battery'
5. Connect the power cable again.
6. Make sure the alarm cancels.

3.5 Electrical safety tests

⚠ WARNING Make sure the system is completely assembled and that the power cords are connected as illustrated in Section 10.15. Make sure all accessory devices are connected to electrical outlets.

1. Connect an approved test device (for example: UL, CSA, or AAMI) and verify that the leakage current is less than:

Voltage	Max. Leakage Current
120/100 Vac	300 □Amps
220/240 Vac	500 □Amps

2. Make sure that the resistance to ground is less than 0.2Ω between the equipotential stud and the ground pin on the power cord.

4 Installation and Service Menus

In this section

4.1 Service and Installation menu structure

This section describes the Service level functions that are part of the main software installed in the ventilator.

Section 8, "*Service Diagnostics and Software Download*," covers a separate service application that loads from a PCMCIA card and is used to download system software and run service diagnostics and other service tests.

Menu structure

The Service menu structure has two levels which are password protected:

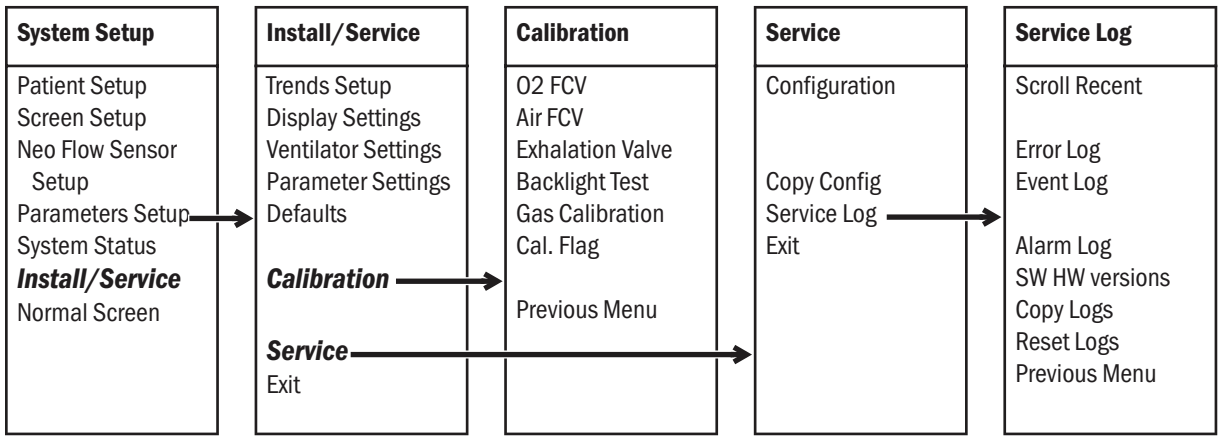
- Install/Service (super-user)
- Service

The **Install/Service** level (with super-user password) supports standard hospital preferences such as colors, units, ventilator settings and alarm defaults, and access to the **Calibration** and **Service** menus.

The **Service** level (with service password) supports system configuration and provides access to the Service Log menu.

Follow the menu structure to access the various service screens:

- On the front panel of the Display Unit, press the **System Setup** key to access the System Setup menu.
- On the **System Setup** menu, select **Install/Service** to access (with super-user password) the Install/Service menu;
  - select **Calibration** to access the Calibration menu.
  - select **Service** to access (with service password) the Service menus.



4.2 Install/Service Menu (Super User)

Use the super-user password to access the Install/Service menu: "23-17-21".

Menu Item	Message text	Comments
Trends Setup	Configure graphical trend pages.	Refer to section 4.2.1
Display Settings	Set colors, units of parameter, and time and date. Show alarm limits in digit fields.	Refer to section 4.2.2
Ventilator Settings	Configure ventilator settings: breath timing, flow, and modes using backup ventilation.	Default is Yes
Parameter Settings	Set volume conditions and CO2 humidity compensation.	Refer to section 4.2.4
Defaults	Set or change default settings.	Refer to section 4.2.5
Calibration	Calibrate airway gas, calibrate gas valves, and test backlights.	Refer to section 4.3
Service	Set and copy configuration and show technical data. Note: The system will have to be turned off to exit this menu.	Refer to section 4.4
Exit	Turn power off to exit menu.	

4.2.1 Trends Setup

Menu Item	Message text	Values
Default Trend	Change default trend type: graphical, numerical, or settings.	Num (default), Graph, or Set
Graphical Trends	Configure graphical trend pages	Pages 1-5
Previous Menu	Return to previous menu.	

Graphical Trends

Menu Item	Message text
Page 1 (Page 2 to Page 5)	Configure first graphical trend page (Second, third, fourth, fifth)
Previous Menu	Return to previous menu.

Page Menus Use the Pull Aside list to select options for each menu item and page. Options are shown below:

Menu Item	Options	Page 1 Default	Page 2 Default	Page 3 Default	Page 4 Default	Page 5 Default
Field 1	**Off**—Select Off to clear trend field **rr+co2**—respiration rate and CO2 **Pres**—Ppeak, Pplat **Pmean**—Pmean **PEEP**—Peepe and Peepi **MVexp**—expired minute volume **Spont**—spontaneous MVexp and respiration rate **Compl**—compliance and Raw **Spiro**—static compliance **Paux**—auxiliary pressure **VO2**—VO2 and VCO2 **VO2/m2**—VO2 and VCO2 weighted by body surface area **VO2/kg**—VO2 and VCO2 weighted by body kg **EE/RQ**—energy expenditure and respiratory quotient					
Field 2						
Field 3						
Previous Menu	Return to previous menu.					

4.2.2 Display Settings

The ***Display Settings*** menu can be accessed here in the super-user level to change individual preferences, or if required during installation, in the service level Installation menu.

Menu Item	Message text	Values
Colors	Set colors of parameters.	
Units	Set units of Paw, Flow, CO2, height, weight, and EE.	
Show Alarm Limits	Select yes/No to show alarm limits in digit fields.	Yes/No
Time and Date	Change clock and calendar functions.	
Previous Menu	Return to previous menu.	

Colors Menu

Menu Item	Message text	Values
Paw	Change color of Paw waveform, digits and trend.	Yellow, White, Green, Red, or Blue
Flow	Change color of Flow waveform, Flow and Volume digits and trend.	Yellow, White, Green, Red, or Blue
O2	Change color of O2 waveform, digits and trend.	Yellow, White, Green, Red, or Blue
CO2	Change color of CO2 waveform, digits and trend.	Yellow, White, Green, Red, or Blue
Volume	Change color of Volume waveform, digits and trend.	Yellow, White, Green, Red, or Blue
Paux	Change color of Paux waveform, digits and trend.	Yellow, White, Green, Red, or Blue
Previous Menu	Return to previous menu.	

Units Menu

Menu Item	Message text	Values
Paw	Change Paw unit	kPa, cmH2O
Flow	Change Flow unit	l/min or l/s
CO2	Change CO2 unit	%, kPa, or mmHg
Height	Change height unit	cm or in
Weight	Change weight unit	kg or lb
Energy Expenditure	Change EE unit	kcal/d or kJ/d
Altitude	Change altitude unit	m or ft
Gas Supply Pressure	Change gas supply pressure unit	psi, kPa, or bar
Exit	Turn power off to exit menu and save settings.	

Show Alarm Limits

Menu Item	Message text	Values
Show Alarm Limits	Select Yes to show alarm limits in digit fields.	Yes or No

Time and Date

Menu Item	Message text	Values
Hour	Set Hour.	a (am) p (pm)
Minutes	Set Minutes.	0-59
Zero seconds	Set seconds to zero.	
Day	Set Day.	1-31
Month	Set Month.	Month
Year	Set Year.	XXXX
Clock Format	Set Clock Format: 12 or 24 hours.	12 or 24
Previous Menu	Return to previous menu.	

4.2.3 Ventilator Settings

Menu Item	Message text	Values
Timing	Change timing setting: I:E, Tinsp, or Tpause. Tpause is only available when Flow is set to On.	I:E, Tinsp, Tpause
Flow	Select to use Flow settings or Insp Pause. Tpause Timing is available when Flow is set to On.	On, Off
Modes with Backup	Select Modes that will allow backup ventilation.	SIMV-VC (Yes, No) SIMV-PC (Yes, No) Bi-Level (Yes, No) CPAP/PSV (Yes, No) SIMV/PCVG (Yes, No)
Previous Menu		

4.2.4 Parameter Settings

Menu Item	Message text	Values
TV Based on	Change value calculations: ATPD (no humidifier) or BTPS (heated humidifier).	ATPD, BTPS
CO2 Numbers	Change humidity compensation type in CO2 partial pressure values.	Dry, Wet
Previous Menu	Return to previous menu.	

4.2.5 Defaults

Menu Item	Message text	Comments
Scroll Settings	Push ComWheel to scroll default settings.	
Default Type	Select default patient type.	The selected type (Adult, Pediatric, or Neonatal) determines the Patient Type in the Select Patient Menu on power up. The corresponding Adult, Pediatric, Neonatal, or facility defaults are displayed for the settings on power up. If the setting is changed within a power cycle, those settings remain for a specific Patient Type until they are changed by the user or the ventilator is turned off.
View		Not selectable: Heading for the following mutually exclusive lists — Adult, Pediatric, Neonatal, or Factory.
Adult	Show Adult facility defaults and settings.	The “Adult Settings” page contains a list of parameters or settings and the corresponding “Saved” and “Current” values for the Adult patient type. The “Current” values reflect the settings in the Vent Setup and Alarms Setup menus. Any setting that does not have a value shows three dashes.
Pediatric	Show Pediatric facility defaults and settings.	The “Pediatric Settings” page contains a list of parameters or settings and the corresponding “Saved” and “Current” values for the Pediatric patient type. The “Current” values reflect the settings in the Vent Setup and Alarms Setup menus. Any setting that does not have a value shows three dashes.
Factory	Show adult and pediatric Factory defaults.	Refer to section 4.2.6
Neonatal	Show Neonatal defaults and settings.	The "Neonatal Settings" page contains a list of parameters or settings and the corresponding "Saved" and "Current" values for the Neonatal patient type. The "Current" values reflect the setting in the Vent Setup and Alarms Setup menus. Any setting that does not have a value shows three dashes.
Neo Factory	Show neonatal factory defaults.	Refer to section 4.2.6
Backup	Set defaults for backup ventilation.	

Menu Item	Message text	Comments
Save Current	Save current settings as facility defaults.	The default selection is No. Common values in the saved defaults are overridden if another ventilation mode is set up and saved.
Factory Reset	Save factory settings as facility defaults.	The default selection is No. If Yes is selected, “Reset machine for defaults to take effect.”
Previous Menu	Return to previous menu.	

4.2.6 Factory Defaults

The following table lists the factory defaults for parameters and alarm limits:

Setting	Adult	Pediatric	Neonatal	Backup Defaults
Vent Mode	BiLevel	BiLevel	PCV	PCV
FiO2	50	50	50	Current FiO2 setting
TV	500	100	10	
Pinsp	10 cmH2O (10 mbar, 1.0 kPa, 10 hPa, 8 mmHg)	7 cmH2O (7 mbar, 0.7 kPa, 7 hPa, 5 mmHg)	5 cm H2O (5 mbar, 0.5 kPa, 5 hPa, 3 mmHg)	10 cmH2O (10 mbar, 1.0 kPa, 10 hPa, 8 mmHg)
Rate	10	15	25	12
I:E	1:2	1:2	1:2	1:2
Tinsp	1.70	1.0	0.4	
PEEP	Off	Off	Off	Off
Psupp	5 cmH2O (5 mbar, 0.5 kPa, 5 hPa, 4 mmHg)	3 cmH2O (3 mbar, 0.3 kPa, 3 hPa, 2 mmHg)	0	
Pmax	30 cmH2O (30 mbar, 3 kPa, 30 hPa, 23 mmHg)	30 cmH2O (30 mbar, 3 kPa, 30 hPa, 23 mmHg)	12 cmH2O (12 mbar, 1.2 kPa, 12 hPa, 50	40 cmH2O (40 mbar, 4 kPa, 40 hPa, 29 mmHg)
Plimit	100 cmH2O (20 mbar, 2 kPa, 20 hPa, 15 mmHg)	100 cmH2O (20 mbar, 2 kPa, 20 hPa, 15 mmHg)	100 cmH2O (20 mbar, 2 kPa, 20 hPa, 15 mmHg)	
Insp Pause	0	0	0	
Rise Time	100 ms	100 ms	100 ms	100 ms
Trig Window	25	25	25	
Trigger	2 l/min (0.03 l/s)	1 l/min (0.02 l/s)	0.5 l/min (0.008l/s)	2 l/min (0.03 l/s)
Bias Flow	3 l/min (0.05 l/s)	2 l/min (0.04 l/s)	2 l/min (o.04 l/s)	3 l/min (0.05 l/s)
End Flow	25	25	25	
Low FiO2	44	44	44	
High FiO2	56	56	56	
Low MVexp	2 l/min (0.03 l/s)	1 l/min (0.02 l/s)	0.2 l/min (0.003 l/s)	
High MVexp	10 l/min (0.16 l/s)	5 l/min (0.08 l/s)	0.4 l/min (0.007 l/s)	
Low TVexp	Off	Off	Off	
High TVexp	Off	Off	Off	
Low RR	Off	Off	Off	
High RR	Off	Off	Off	
Low EtO2	Off	Off	NA	
High EtO2	Off (8kPa, 60 mmHg)	Off (8 kPa, 60 mmHg)	NA	
Low EtCO2	3% (3 kPa, 23 mmHg)	3% (3 kPa, 23 mmHg)	NA	
High EtCO2	8% (8 kPa, 60 mmHg)	8% (8 kPa, 60 mmHg)	NA	
Wave Field 3	Vol (Volume)	Vol (Volume)	Vol (Volume)	
Digit Field	Compl (Pulmonary Mechanics)	Compl (Pulmonary Mechanics)	Compl (Pulmonary Mechanics)	
Split Screen	None	None	None	
Alarm Volume	3	3	3	

4.3 Calibration menu

Menu Item	Message text	Comments
O2 FCV	Start O2 Flow Control Valve calibration and leak test.	Select Start Calibration. Open inspiratory port to atmosphere. Start O2 Flow Control Valve calibration.
Air FCV	Start Air Flow Control Valve calibration and leak test.	Select Start Calibration. Open inspiratory port to atmosphere. Start Air Flow Control Valve.
Exhalation Valve	Patient must not be connected to circuit during calibration. Start Exhalation Valve calibration.	Connect to the patient circuit. Occlude the patient wye. Start Exhalation Valve calibration.
Backlight Test	Start display backlight test.	This test turns off one backlight to test the other light. Screen brightness may change during the test.
Gas Calibration	Start gas calibration. Calibrate CO2 and O2 measurements.	Gas Calibration is enabled whenever an MGAS module is installed. Gas Calibration is disabled if the MGAS module is warming up.
Cal. Flag	Turn the Calibration required message On/Off.	When Cal. Flag is set to On, the “Calibration required” message is displayed in the general message area.
Previous Menu	Return to previous menu.	

Note The ***Cal. Flag*** menu item is used by the factory to activate the “Calibration required” alarm. It is set as a reminder that calibrations must be performed when the machine is set up for operation at its permanent location.

After completing the ***O2 FCV***, ***Air FCV***, and the ***Exhalation Valve*** calibrations, set the ***Cal. Flag*** to Off.

If EC Service Application is connected, ensure DAC is set to 0 and the checkbox is marked.

Refer to Section 5.1.1 for further information.

4.4 Service menu

Use the service-level password to access the Service menu:
"34-22-14."

Whenever service menu is entered, "Enter Service dd-mmm-yyyy hh:mm:ss" is recorded in the Event log.

Menu Item	Message text
Configuration	Set language, altitude and units.
Options Key	Enable software options.
Options List	Display software options.
Options Card	Install card to enable software options.
Copy Config	Save or install configuration and default settings using memory card.
Service Log	Show error, event, and alarm histories and system information.
Exit	Turn power off to exit menu.

4.4.1 Configuration

Menu Item	Message text	Values	Comments
Decimal Marker	Select decimal delineator.	0.01, 0 01 or 0,01	Default: 0.01
Language	Select language for screen.	Chinese (simplified) Czech Danish Dutch English Finnish French German Greek Hungarian Italian Japanese Norwegian Polish Portuguese Russian Spanish Swedish Turkish	Default: English
Paw	Change Paw units: kPa, cmH2O, mbar.	kPa, cmH2O, or mbar	Default: cmH2O
Flow	Change flow units: l/min or l/s.	l/min or l/s	Default: l/min
CO2	Change CO2 units: %, kPa, or mmHg.	%, kPa, or mmHg	Default: %
Height	Change height units: cm or in.	cm or in	Default: cm
Weight	Change weight units: kg or lb.	kg or lb	Default: kg
Energy Expenditure	Change energy expenditure	kcal/d or kJ/d	kcal/d
Altitude	Change altitude used for gas calculations.	–400 to 3000 m in 100-m increments	Default: 300 m

4.4.2 Options Key

Menu Item	Message text
Current Key	Enter key code to enable options.
Entry 1	Enter first value of key-code.
Entry 2	Enter second value of key-code.
Entry 3	Enter third value of key-code.
Entry 4	Enter fourth value of key-code.
Entry 5	Enter fifth value of key-code.
Entry 6	Enter sixth value of key-code.
Entry 7	Enter seventh value of key-code.
Save New Key	Confirm values for key-code
Control Board ID	Control number used by key-code.

4.4.3 Options List

Menu Item	Message text
Available Options	FRC, SpiroDynamics, Neonatal, SIMV-PCVG, BiLevel-VG

4.4.4 Options Card

Menu Item	Message text
Upgrade	Yes, No
Options Available on Card	Install card to enable software options.

4.4.5 Copy Configuration

Menu Item	Message text	Values	Comments
Save to Card	Save Configuration and defaults to card.	<blank>, Fail, or OK. The field is blank until the data has either been written to the card (OK) or the system determines it cannot write to the card (Fail).	Saves all settings that are not hardware dependent, including facility defaults, screen configuration, trend settings, colors, units, decimal marker, altitude, patient type, backup settings, and the Show Alarm Limits selection.
Copy from Card	Copy Configuration and defaults from card. When completed: Copy from card complete. Please reboot system.	<blank>, Fail, or OK. The field is blank until the data has either been read from the card (OK) or the system determines it cannot read the card or the card does not have the required data (Fail).	

Systems cannot accept configuration files from a different product model.

The software version is stored with the saved configuration. A system will reject any configurations from other than the current version of software.

Selecting Save to Card overwrites any configuration on the card.

4.4.6 Service Log menu

The Service log menu is a organized listing of stored events.

Menu Item	Message text
Scroll Recent	Scroll through newest entries.
Error Log	Show error history.
Event Log	Show event history.
Alarm Log	Show alarm history.
SW HW versions	Show system information.
Copy Logs	Save HW/SW info, all logs and trend information to memory card.
Reset Logs	Erase Error and Alarm log entries
Previous Menu	Return to previous menu.

Each history log shows at the top of the screen total Running Hours, the date when the logs were last reset, and the Ventilator Serial Number.

Whenever logs are reset, “Reset Logs dd-MMM-yyy hh:mm:ss” is recorded in the Event log.

If the logs are saved to a memory card, the ventilator’s serial number, date, and time are saved along with the current contents of the logs.

Error Log ◂ The Error Log lists the last 200 errors logged since the last log reset, starting with the most recent. The system stores the last 1,000 errors logged since the last log reset.

Event Log ◂ The Event Log records the service history of the device. This includes: service calibrations, entry into the service mode, options enabled, and software installation. In the event of a board replacement, it is understood that this log like all others could be lost.

The Event History menu lists the last 200 events logged starting with the most recent. The Event History log stores the last 1000 events.

The Event History log cannot be reset.

Alarm Log ◂ The Alarm Log lists the last 200 alarms since the last log reset starting with the most recent. The Alarm History log store the last 1000 entries.

Copy Logs The Copy Logs function copies Error, Event, and Alarm logs along with the software/ hardware configuration to a text file on a PCMCIA card.

4.4.7 Software/ Hardware version menu

Turn the ComWheel to scroll through the list box.

Push the ComWheel to return to the Service menu.

System Information menu

X=Number, A, B, C = letter

SW HW version
System Information:
Running Hours: XXXXX
Software Release: XX.XX
Model Code: XXX
Serial Number: ABCDXXXXX
Option Package: XXX
Options Code: XXXXXXXXXXXXXXX
VCB Software Version: XX.XX
VCB Hardware Version: XXXX-XXXX-XXX REV A
VCB Hardware Serial Number: ABCXXXXX
DU Software Version: XX.XX
DU Hardware Version: XXXX-XXXX-XXX REV A
DU Hardware Serial Number: ABCXXXXX
VMB Software Version: XX.XX
VMB Hardware Version: XXXX-XXXX-XXX REV A
VMB Hardware Serial Number: ABCXXXXX
PMB Software Version: XX.XX
PMB Hardware Version: XXXX-XXXX-XXX REV A
PMB Hardware Serial Number: ABCXXXXX
BIOS Software Version
MGAS Software Version: X.X
MGAS Hardware Version: GAS SW Pr. XXXXXXX-X
MGAS Hardware Serial Number: ABCXXXXX

The MGAS information is only displayed when an Airway module is present.

4.4.8 Resetting feature option key codes

1. Power up the Engström Carestation and select ***Service Menu*** -***Options List***.
2. Record the available options that are "On".
3. Power down the ventilator.
4. Perform the software download per TRM Section 8.4, *"Download New"*.
5. After software download is complete, power up the ventilator and select ***Service Menu-Options List***.
6. Verify the options "On" match the options recorded in step 2. (IMPORTANT)
   - If the "On" options match the options recorded in step 2, proceed to step 11.
   - If the options "On" do not match the options recorded in step 2, go to the Datex Ohmeda "Key Code Generator" Web site: www.docodes.com, and follow the instructions to request a new "Key Code".
   - After you receive the new Key Code, select ***Service Menu***-***Options Key***. Enter the new key code, select ***Save New Key*** and proceed to step 7.
7. Select ***Service Menu- Options key***. Record the new three digit Control Board ID and new seven digit Key Code on the new Key/BID label. (1504-3521-000)
8. Remove the existing Key/BID label from the back of the machine.
9. Clean the area with Isopropyl alcohol.
10. Affix the new Key/BID label to the machine. (1504-3521-000)
11. Perform ***Super User Calibrations*** per TRM Section 5.1.1.
12. Perform Checkout procedure (*Section 3)*.

5 Service Tests and Calibration

⚠ WARNING After adjustments and calibration are completed, always perform the checkout procedure. Refer to Section 3 of this manual.

In this section

5.1 Calibration (super-user)

The EC ventilator includes integrated software that allows a qualified user to periodically calibrate the O_2 flow valve, the Air flow valves, and the Exhalation valve.

At a minimum, these calibrations should be completed every 6 months, whenever performance is questioned, or when associated components are serviced or replaced. These calibrations can be performed more frequently, as needed, for optimal performance.

The menu structure for accessing the calibration software is described in Section 4, "*Installation and Service Menus*" .

Note The Valve calibrations (Section 5.1.1) can be performed without performing the Service level test and calibrations (Section 5.2). However, if the Service level test and calibrations are performed, the Valve calibrations should be performed again after the Service level test are completed (passed).

Note To file a quality report or request technical assistance regarding a calibration failure, create and include a Calibration log while using the EC Service application .

Run the Calibration while the EC Service Application is running and select ***Log Calibration Results .***

5.1.1 Calibration procedure

1. If present, disconnect the patient circuit from the inspiratory port (open to atmosphere).
2. Access the Calibration menu.
   - In the standby mode, push the **System Setup** key.
   - On the System Setup menu, select ***Install/Service*** (23-17-21).
   - On the Install/Service menu, select ***Calibration***.
3. On the Calibration menu, select ***O2 FCV***.
   - On the O2 FCV menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When O2 FCV calibration is complete (passed), select ***Previous Menu***.
4. On the Calibration menu, select ***Air FCV***.
   - On the Air FCV menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When Air FCV calibration is complete (passed), select ***Previous Menu***.
5. On the Calibration menu, select ***Exhalation Valve***.
   - Connect a patient circuit and block the patient port.
   - On the Exhalation Valve menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When Exhalation Valve calibration is complete (passed), select ***Previous Menu***.

Backlight Test

6. On the Calibration menu, select ***Backlight Test***.
7. Select ***Start Test***.
8. The display will show the test running on light 1 and then on light 2. If the display goes completely blank or flickers during the test, one of the lights has failed.
   Note: Screen brightness may change during test.
9. Turn power off to exit the Install/Service menu.

5.2 Service level tests and calibration

The service level tests require the Windows based service application as described in Section 8.5, "*EC Service Application (PC based)*" .

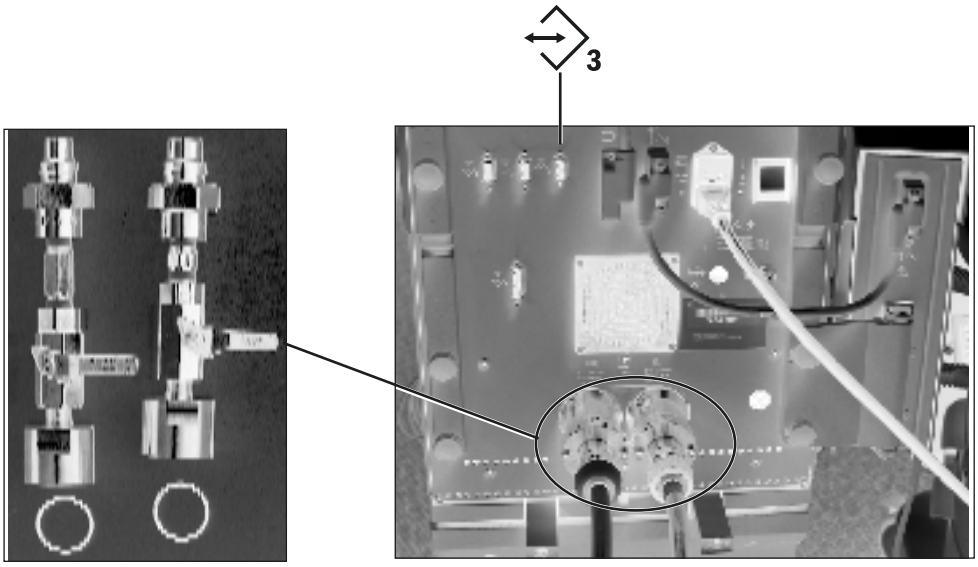
Note After completing the Service level test and calibrations, perform the Valve calibrations in Section 5.1.1.

5.2.1 Service application setup

1. Connect a Windows based PC to the serial port (Port 3) of the EC using a USB to RS-422 converter (Refer to section 10.1.1).
2. Start the Service Application on the PC.
   - Open the ***VCB*** and ***VMB*** windows.
3. To establish communication between the PC Service Application and the EC, the EC must be powered On.
   a. Read only access is available in normal operation mode.
   b. Controlled access is available in Super User or Service modes.

5.2.2 Test setup

1. Connect a manual shut-off valve to each gas supply inlet.
   - Remove the inlet fittings from the EC and ensure o-ring remains on the adapter).
   - Connect the shut-off valve to the respective EC pipeline adapter.
   - Connect the removed inlet fitting to the respective shut-off valve.
2. Close both shut-off valves.
3. Connect pipeline supplies to each shut-off valve.



5.2.3 Vent engine debris clean-out

This procedure is needed only if:

- The pneumatic system within the vent engine was serviced; that is, components were replaced or removed for evaluation.
- A gas inlet filter was replaced.

Clean-out procedure

1. Open both shut-off valves.
2. Verify that the inspiratory outlet is open to atmosphere (not plugged).
3. On the VCB screen:
   - Verify that the ***Air*** and ***O2 Flow Valve***s are energized (☑).
   - Set the ***Air DAC*** counts to 60,000 (fully open).
   - Set the ***O2 DAC*** counts to 60,000 (fully open).
4. After 20 seconds:
   - Close both shut-off valves. Pulse the Air and O2 flow valves 5 times for 5 seconds.
   - Set the ***Air DAC*** counts to zero (closed).
   - Set the ***O2 DAC*** counts to zero (closed).

Note Closing the shut-off valves before setting the flow DAC counts to zero, bleeds pressure from the system.

5.2.4 Regulator output pressure test

Important The regulator output pressure should be checked during battery replacement intervals or whenever the unit is already opened for other reasons.

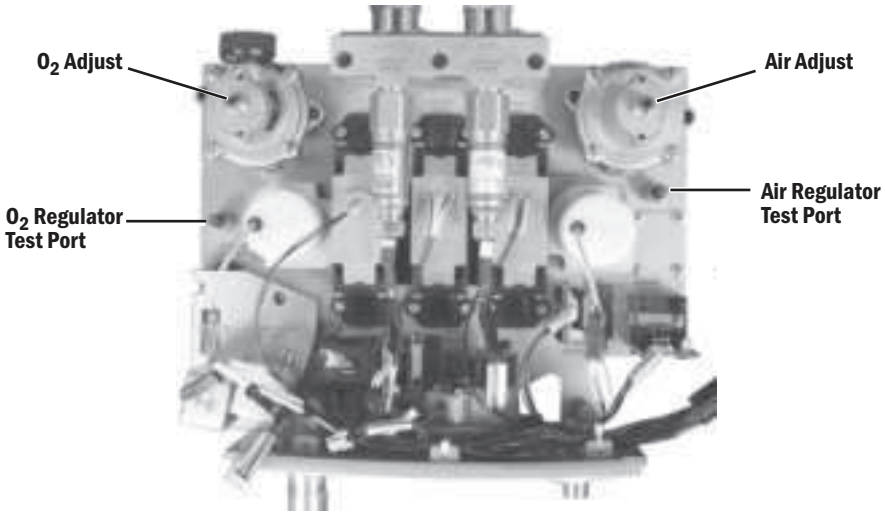
Air regulator

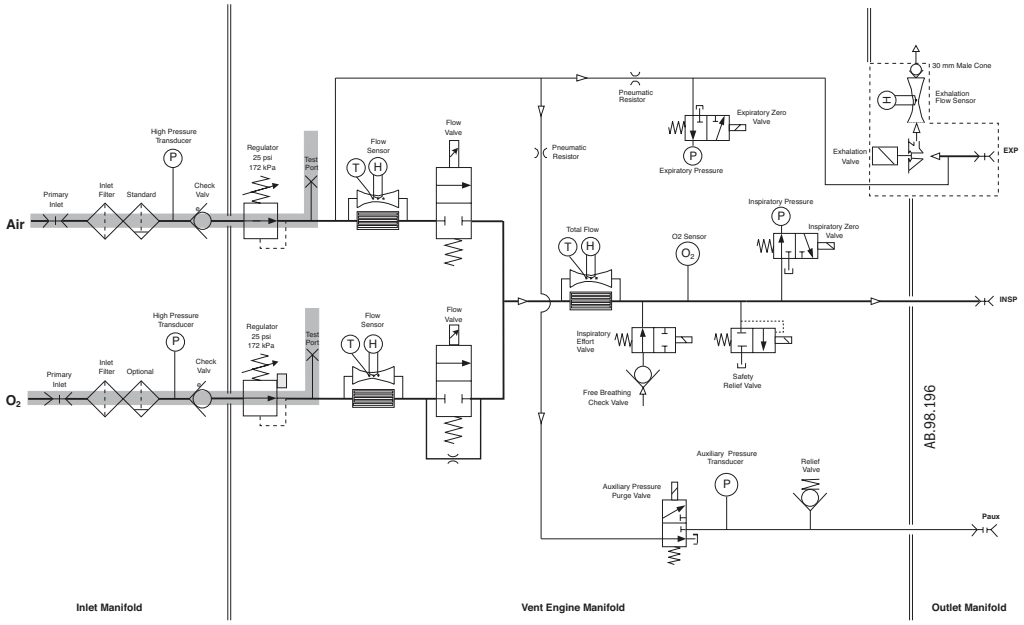
1. Remove the plug from the Air regulator outlet test port.
2. Connect a test pressure gauge to the Air regulator outlet test port.
3. Open the manual Air shut-off valve.
4. On the VCB screen:
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Adjust the ***Air DAC*** reading (start at approximately 9,500) until the Air flow reading is 15 l/min.
5. Verify that the test gauge indicates 172 ± 0.69 kPa (25 ± 0.10 psi).
6. If required, adjust the regulator.
   - Be sure to tighten the locking nut after adjustment.
7. Close the manual Air shut-off valve.
8. Remove the test gauge and plug the test port.

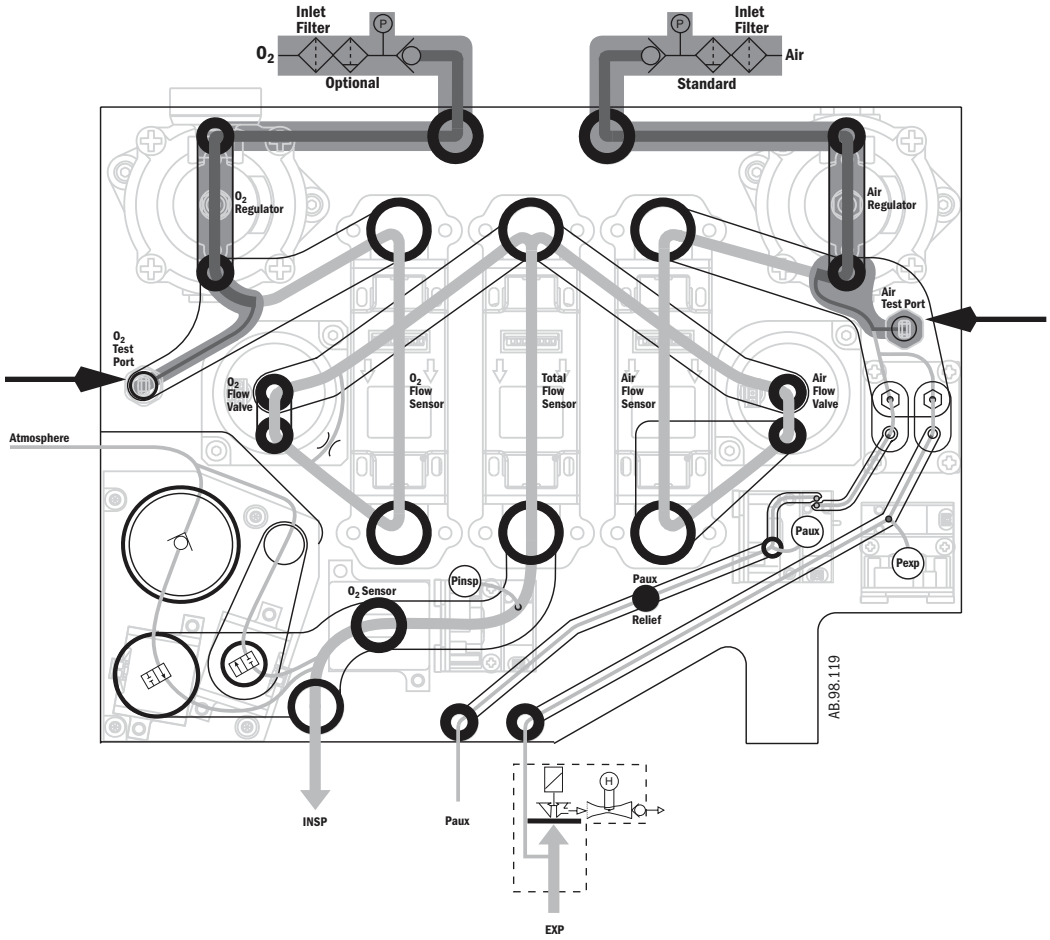
O_2 regulator

1. Remove the plug from the O_2 regulator outlet test port.
2. Connect a test pressure gauge to the O_2 regulator outlet test port.
3. Open the manual O_2 shut-off valve.
4. On the VCB screen:
   - Verify that the ***O_2 Flow Valve*** is energized (☑).
   - Adjust the ***O_2 DAC*** reading (start at approximately 9,500) until the O_2 flow reading is 15 l/min.
5. Verify that the test gauge indicates 172 ± 0.69 kPa (25 ± 0.10 psi).
6. If required, adjust the regulator.
   - Be sure to tighten the locking nut after adjustment.
7. Close the manual O_2 shut-off valve.

Remove the test gauge and plug the test port.




Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
AB.98.196
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.119
INSP
Paux
EXP

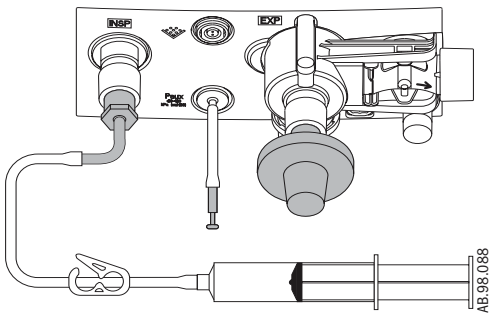
5.2.5 Vent engine leak test (low pressure)

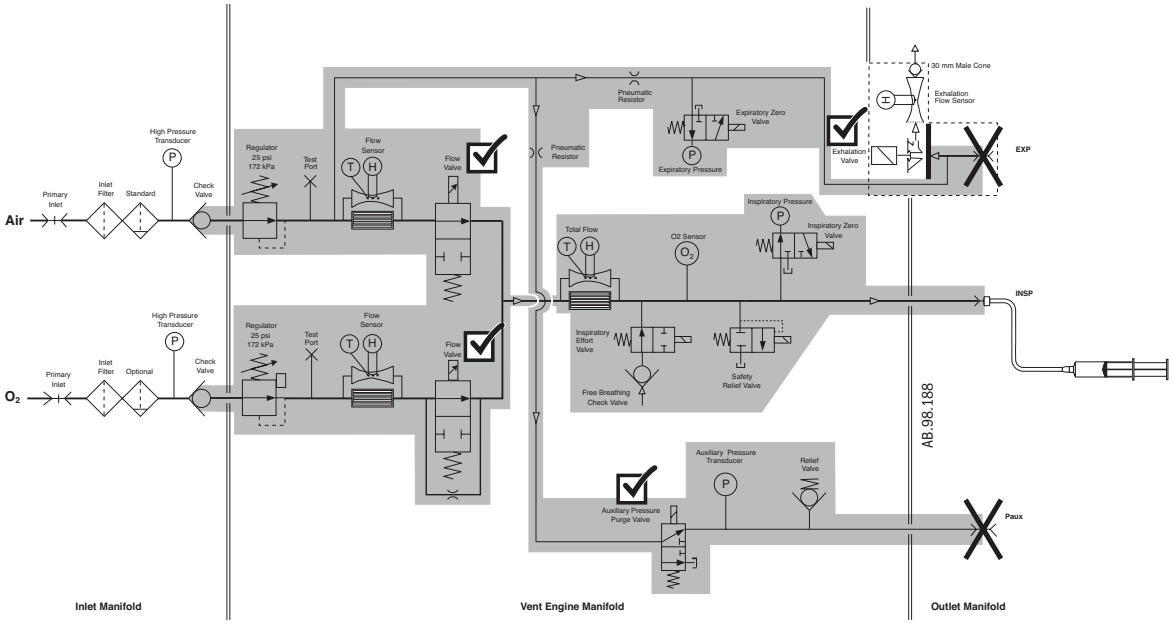
There are two low pressure leak tests to perform: P1 and P2.

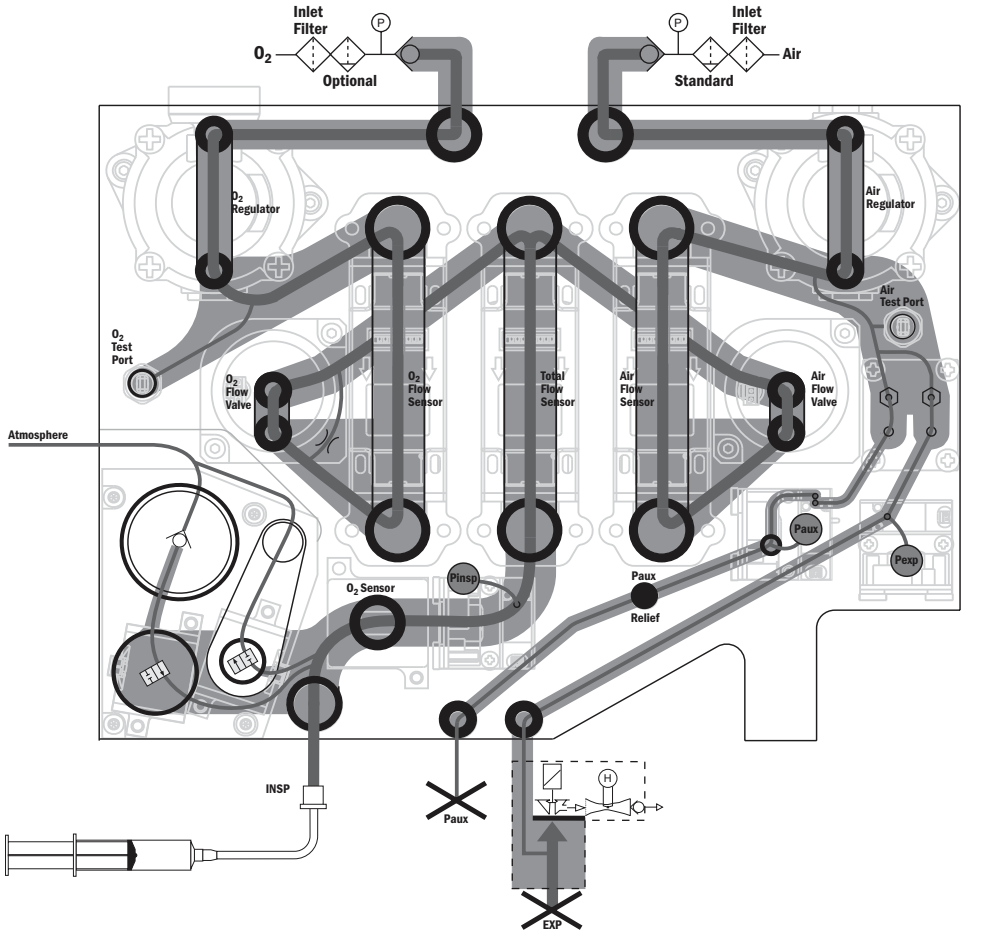
Low P1 Test

1. Verify that both shut-off valves are closed.
2. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Verify that the ***Air Flow Valve***, ***O2 Flow Valve*** and the ***Exhal***ation ***Flow Valve*** are energized (☑).
   - Set the ***Air DAC***, ***O2 DAC***, and the ***Exh***alation ***DAC*** counts to 60,000 (this will release all pressurized gas from the system).
3. Attach the “low-pressure test tool” to the ***INSP***iratory outlet.
4. Plug the following ports:
   - Expiratory inlet (***EXP***).
   - Auxiliary pressure port (***Paux***).
5. Using the low pressure test tool, increase the pressure in the low pressure side of the system until the measured ***Expiratory Press***ure (VMB), ***Auxiliary Press***ure (VCB), and ***Inspiratory Press***ure (VCB) readings indicate 70 cmH2O.

   Note: Ensure that the three pressures are stable and approximately equal (within 5 cmH2O). If not, refer to Section 7.2.2.
6. Once 70 cmH2O is reached, clamp the tube on the low pressure test tool to prevent gas flow from the ***INSP***iratory outlet.
7. On the VCB screen, select ***Low P Leak 1*** to start the low pressure P1leak test.
8. After the test is complete (15 seconds):
   - If the leak result does not exceed 10 ml/min, proceed to to step 9. (Note: The Low P2 test is not required if Leak result ≤ 10 ml/min.)
   - If Leak result is >10 ml/min and ≤ 35 ml/min, perform the Low P2 test.
   - If the Leak rate exceeds 35 ml/min, refer to Section 7.2 to help identify the cause of the leak.
9. Remove the plugs from the ***EXP***iratory inlet and the ***Paux*** port.
10. De-energize (☐) the ***Aux***iliary ***Press***ure ***Purge*** valve.



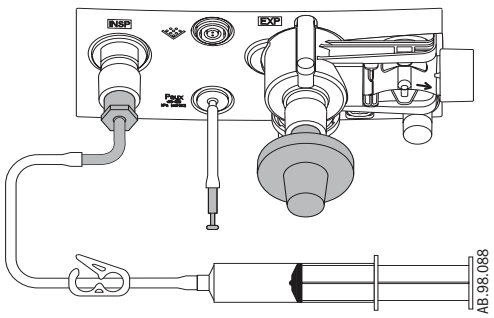

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valve
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
INSP
AB.98.188
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

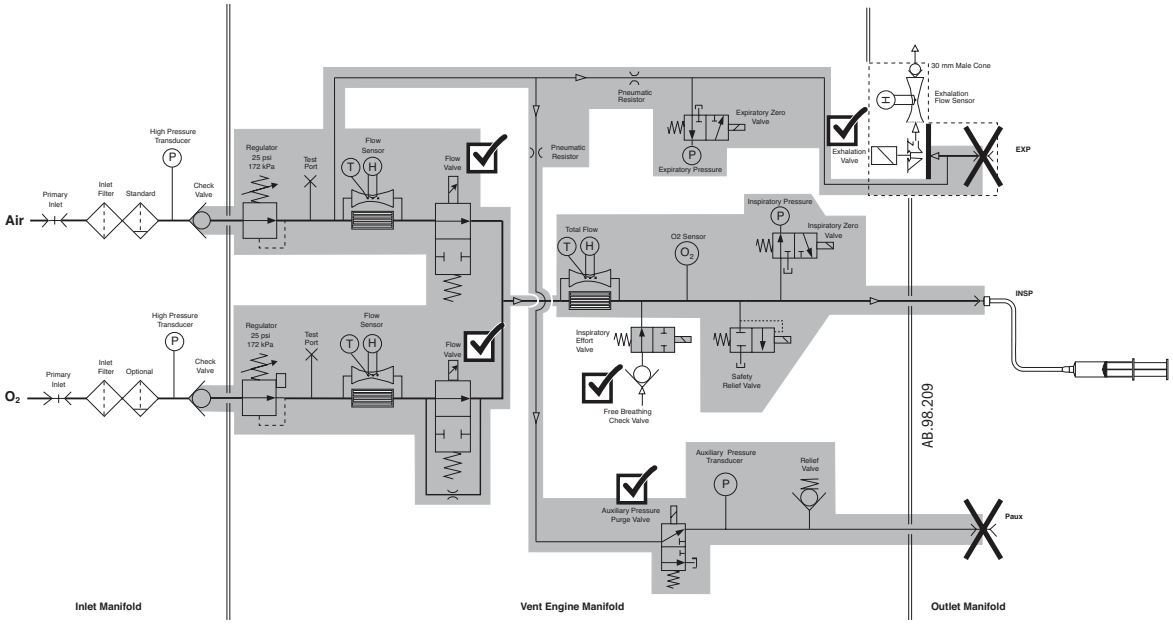

Inlet Filter
O2
Optional
Standard
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Relief
INSP
EXP

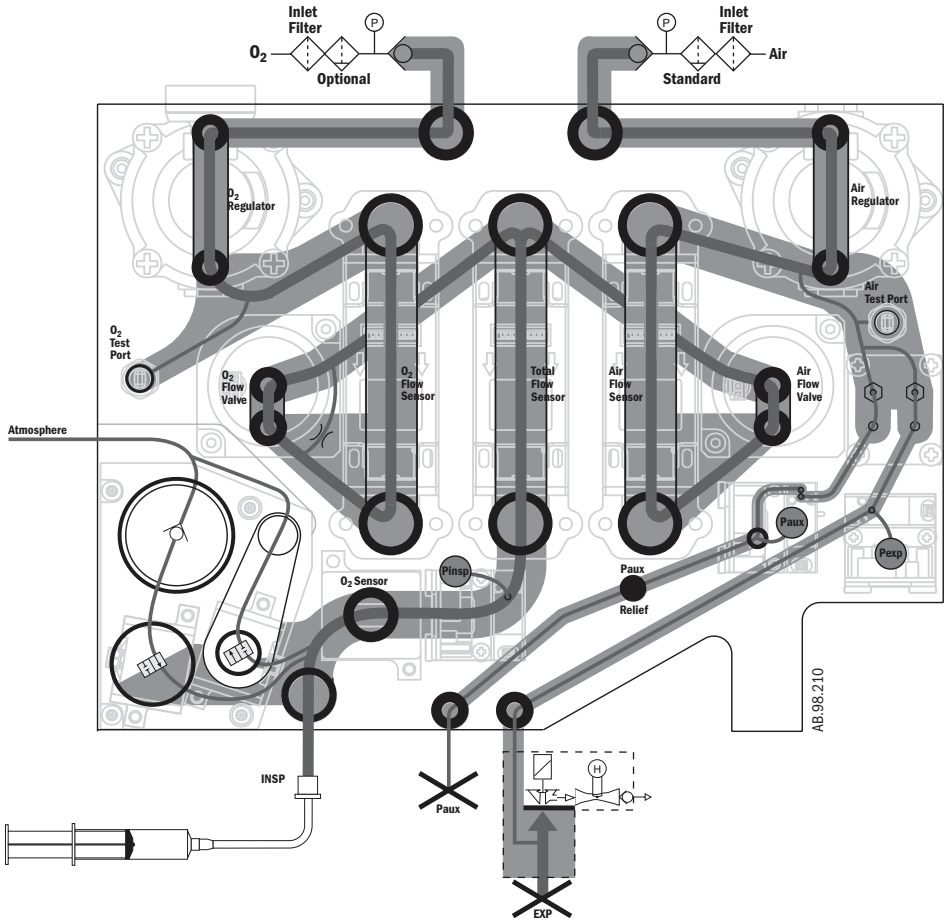
Low P2 Test

1. Verify that both shut-off valves are closed.
2. On the VCB screen:
   - Energize (☑) the ***Effort Valve Energized*** valve.
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Verify that the ***Air Flow Valve***, ***O2 Flow Valve*** and the ***Exhal***ation ***Flow Valve*** are energized (☑).
   - Set the ***Air DAC***, ***O2 DAC***, and the ***Exh***alation ***DAC*** counts to 60,000 (this will release all pressurized gas from the system).
3. Attach the "low-pressure test tool" to the ***INSP***iratory outlet.
4. Plug the following ports:
   - Expiratory inlet (***EXP***).
   - Auxiliary pressure port (***Paux***).
5. Using the low pressure test tool, increase the pressure in the low pressure side of the system until the measured ***Expiratory Press***ure (VMB), ***Auxiliary Press***ure (VCB), and ***Inspiratory Press***ure (VCB) readings indicate 70 cmH2O.

   Note: Ensure that the three pressures are stable and approximately equal (within 5 cmH2O). If not, refer to Section 7.2.2.
6. Once 70 cmH2O is reached, clamp the tube on the low pressure test tool to prevent gas flow from the ***INSP***iratory outlet.
7. On the VCB screen, select ***Low P Leak 2*** to start the low pressure P2 leak test.
8. After the test is complete (15 seconds):
   - IVerify that the displayed Leak result does not exceed 10 ml/min.
   - If the Leak rate exceeds 10 ml/min, refer to Section 7.2 to help identify the cause of the leak.
9. Remove the plugs from the ***EXP***iratory inlet and the ***Paux*** port.
10. De-energize (☐) the ***Aux***iliary ***Press***ure ***Purge*** valve.



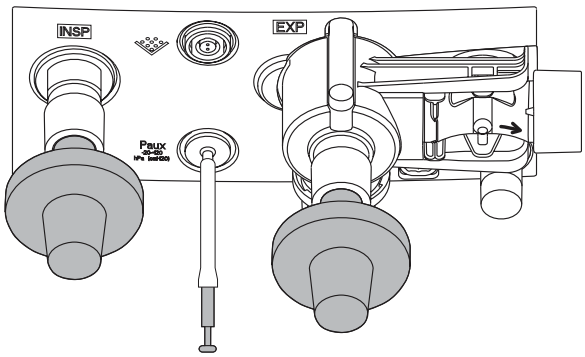

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valve
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
AB.98.209
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

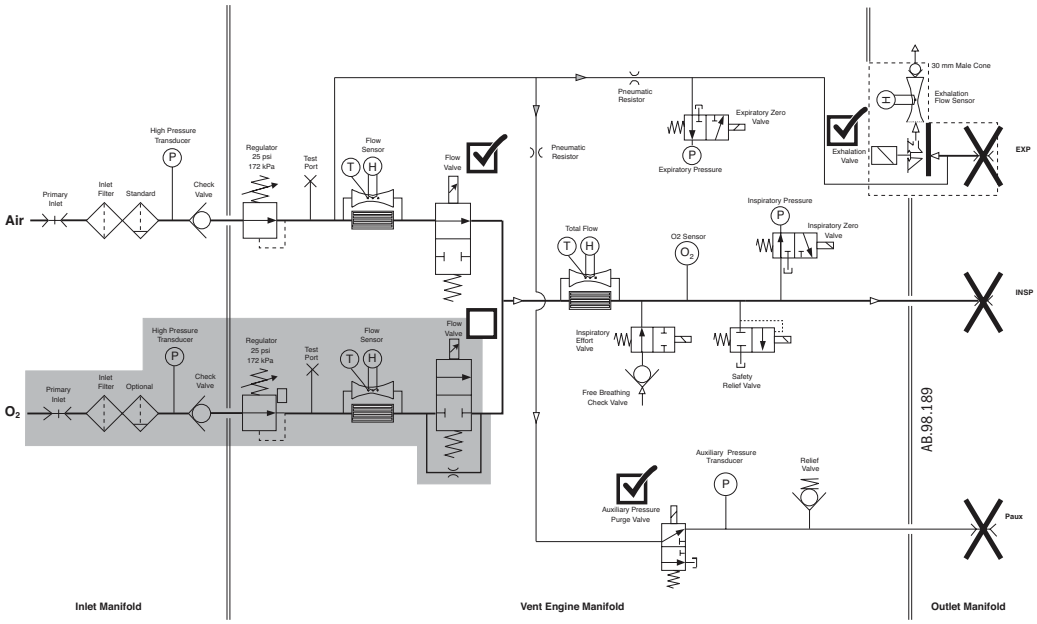

Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux
Relief
AB.98.210
INSP
Paux
EXP

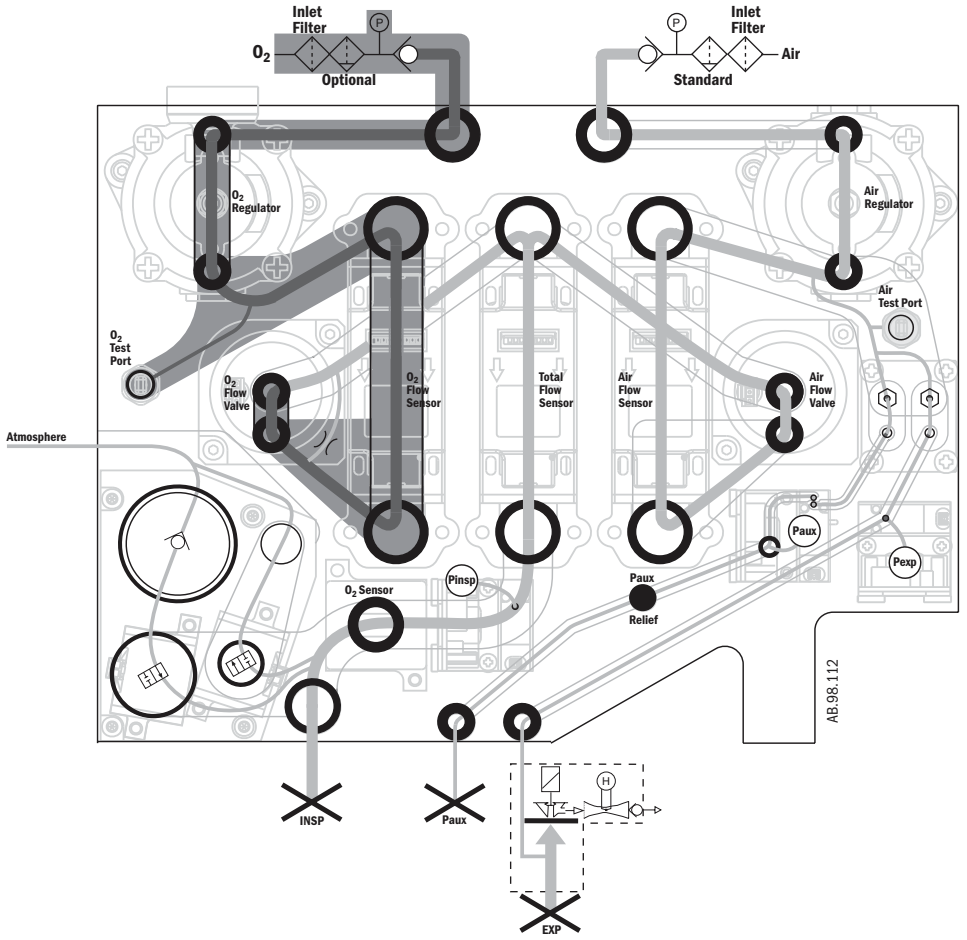
5.2.6 Vent engine leak test (high O_2 pressure)

Note: The high O2 pressure leak test will not start if the O2 supply pressure is 35 psig or below.

1. Verify that the inspiratory outlet is open to atmosphere (not plugged).
2. Open the manual O_2 shut-off valve.
3. On the VMB screen:
   - Verify that the measured ***O2 Supp***ly ***Press***ure = pipeline pressure.
   - Verify that the measured ***Air Supp***ly ***Press***ure = 0.0 psig.
4. On the VCB screen:
   - Energize (☑) the ***Effort Valve Energized*** valve.
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Verify that the ***Exhal***ation ***Flow Valve*** is energized (☑).
   - Set the ***Exh***alation ***DAC*** counts to 60,000.
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Set the ***Air DAC*** counts to 60,000 (this will release any air pressure in the system).
   - De-energize (☐) the ***O2 Flow Valve***.
5. Plug the following ports:
   - ***INSP***iratory outlet.
   - ***EXP***iratory inlet.
   - Auxiliary pressure port (***Paux***).
6. Close the manual O_2 shut-off valve.
7. On the VCB screen, select ***High O2 Leak*** to start the test.
8. After the test is complete (Max 15 seconds):
   - Verify that the displayed ***Leak*** rate does not exceed 26 ml/min.
   - if not, troubleshoot for leaks in the shaded area.
9. Remove the plugs from the ***INSP***iratory, ***EXP***iratory, and ***Paux*** ports.
10. On the VCB screen:
    - De-energize (☐) the *Effort Valve Energized* valve.
    - De-energize (☐) the ***Aux***iliary ***Press***ure ***Purge*** valve.



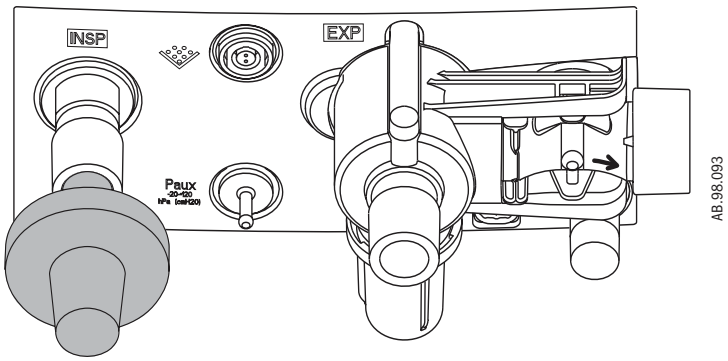

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valve
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.189
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

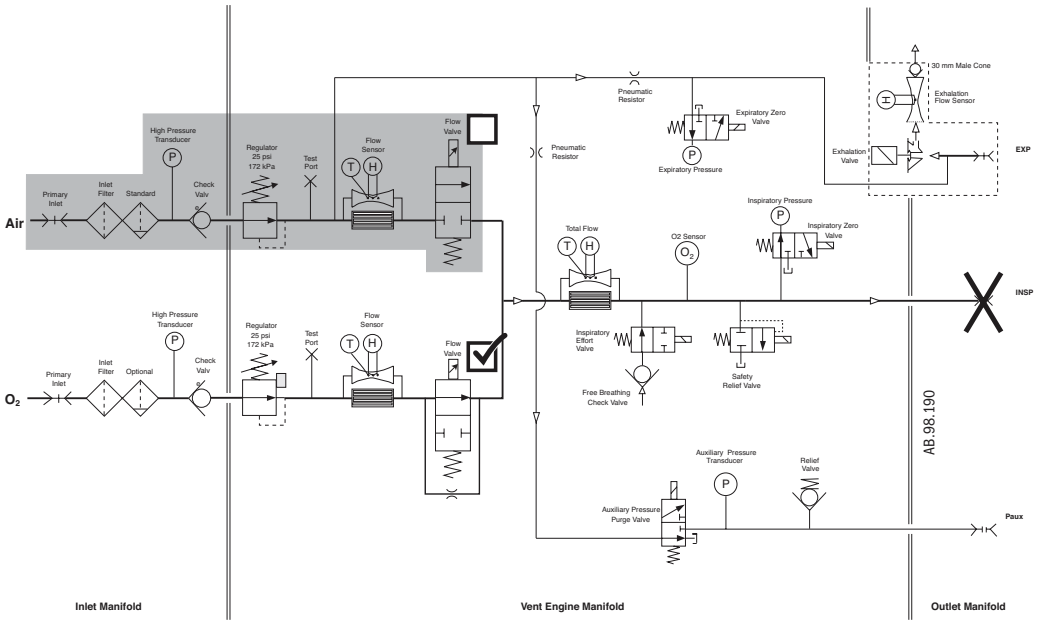

Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.112
INSP
Paux
EXP

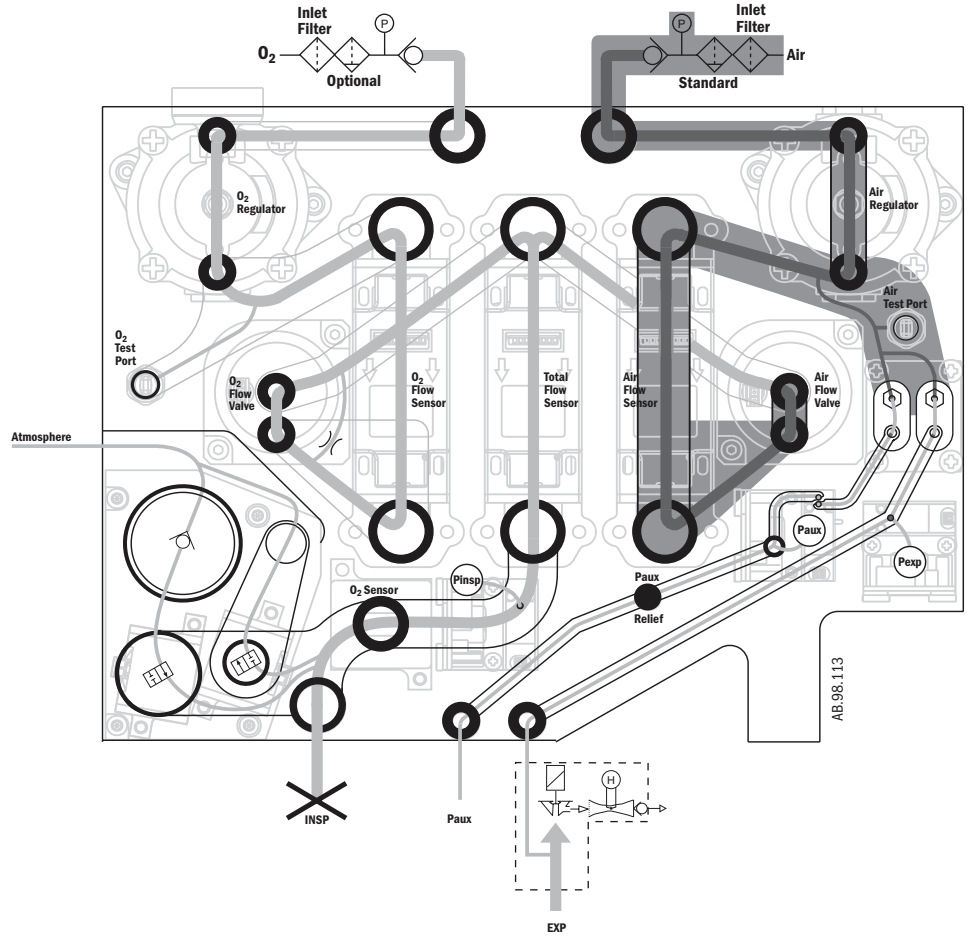
5.2.7 Vent engine leak test (high Air pressure)

Note: The high Air pressure leak test will not start if the Air supply pressure is 35 psig or below.

1. Verify that the INSPiratory outlet is open to atmosphere (not plugged).
2. Open the manual Air shut-off valve.
3. On the VMB screen:
   - Verify that the measured Air Supply Pressure = pipeline pressure.
   - Verify that the measured O2 Supply Pressure = 0.0 psig.
4. On the VCB screen:
   - Energize (☑) the ***Effort Valve Energized Valve***.
   - Energize (☑) the ***O2 Flow Valve***.
   - Set the ***O2 DAC*** counts to 60,000 (this will release any O2 pressure in the system).
   - De-energize (☐) the ***Air Flow Valve***.
5. Plug the ***INSP***iratory outlet.
6. Close the manual Air shut-off valve.
7. On the VCB screen, select ***High Air Leak*** to start the test.
8. After the test is complete (Max 6 seconds):
   - Verify that the displayed ***Leak*** rate does not exceed 50 ml/min.
   - if not, troubleshoot for leaks in the shaded area.
9. Remove the plug from the ***INSP***iratory outlet.
10. On the VCB screen:
    - De-energize (☐) the ***Effort Valve Energized Valve***.




Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
AB.98.190
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.113
INSP
Paux
EXP

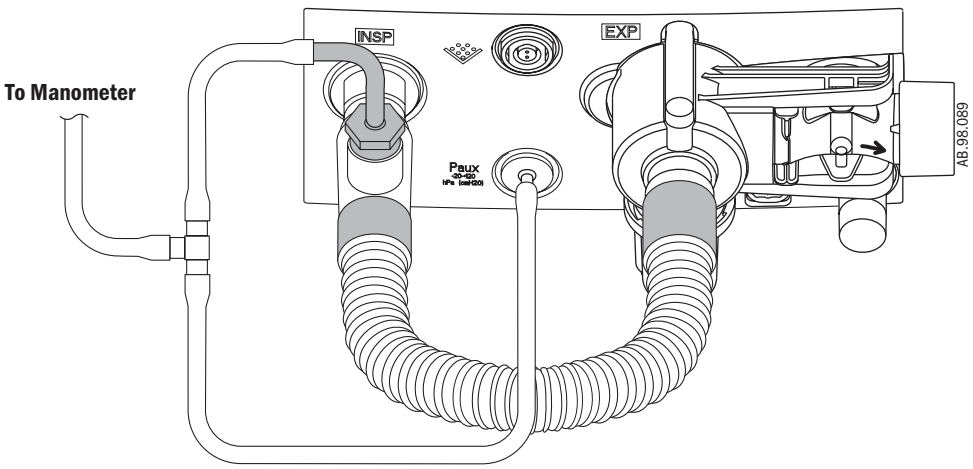
5.2.8 Calibrate airway pressure transducer Zero and Span

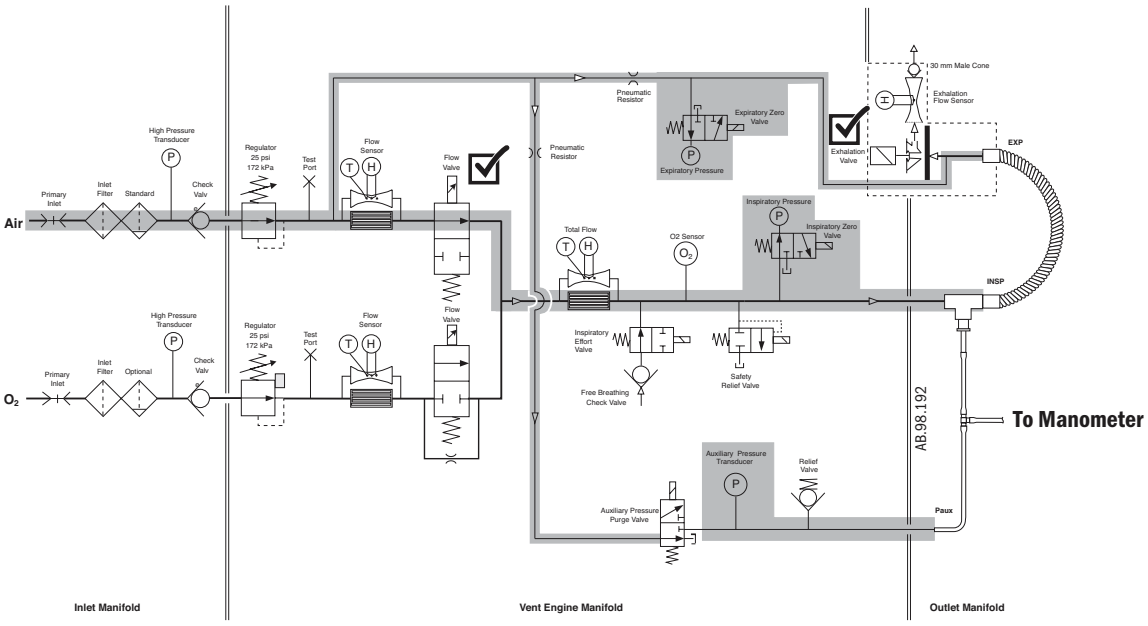
This procedure calibrates the Inspiratory, Expiratory, and Auxiliary pressure transducers.

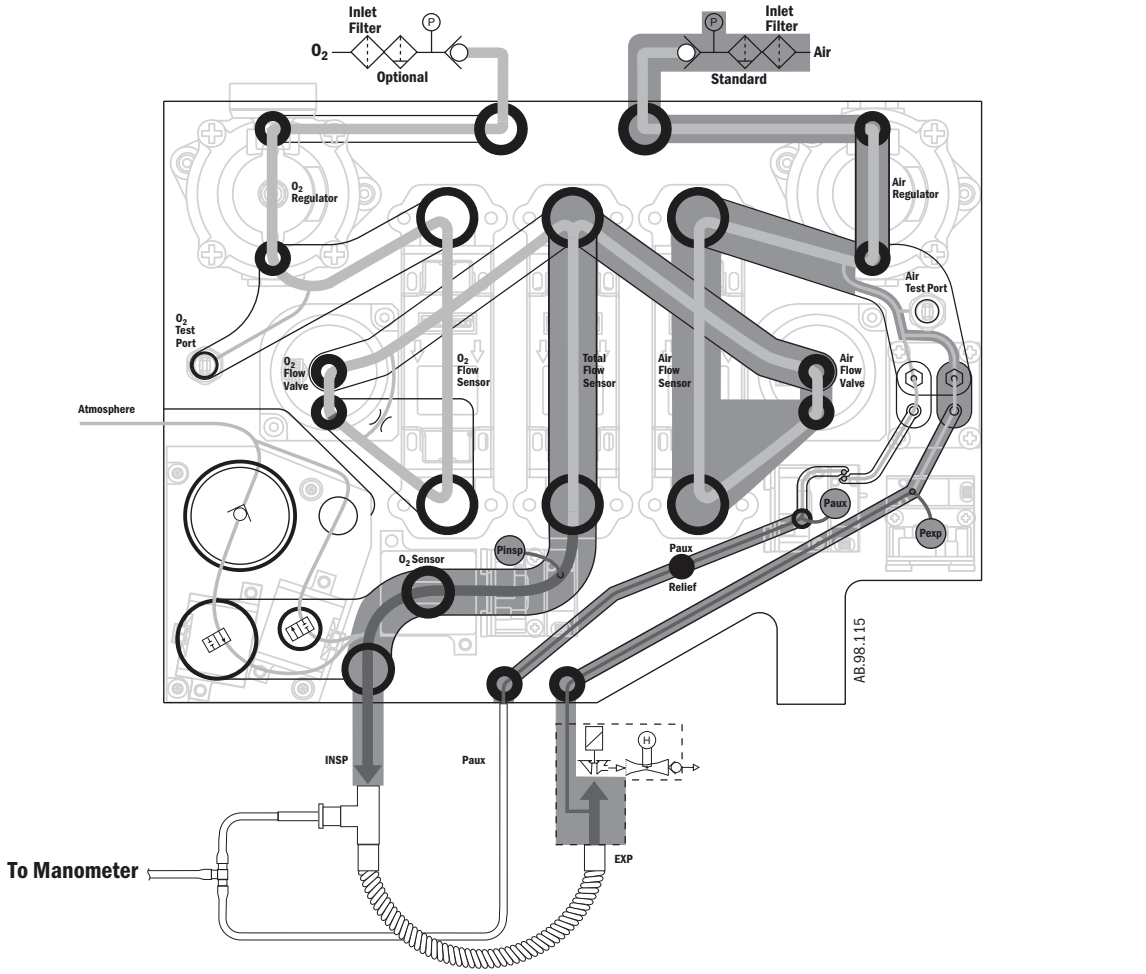
Note: If Air is not available, the O_2 supply can be used to calibrate the pressure transducers. The Service Application senses which supply is available and, in step 5, activates the corresponding flow valve.

1. Start up the system and enter the Install/Service mode.
2. Verify that the ventilator passes the low pressure leak test (Section 5.2.5).
3. Attach the test setup to the EC as shown in the illustration below.
   - Connect a tee adapter to the ***INSP***iratory outlet.
   - Connect a short patient circuit tube from the tee adapter to the ***EXP***iratory inlet.
   - Connect a pressure sensing tube from the Inspiratory tee to a manometer and to the Auxiliary pressure port (***Paux***).
4. Open the manual Air (O_2) shut-off valve.
5. On the VCB screen:
   - Verify that the ***Exhal***ation ***Flow Valve*** is energized (☑).
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Select ***Start Paw Span*** (~2 L/min established through Air (O_2) flow valve).
   - Adjust the ***Span DAC Value*** (Exhalation valve) reading (start at approximately 40,000) until the manometer reading equals 100 ±0.2 cmH_2O.
6. At 100 cmH_2O, select ***End Paw Span***.
7. Close the manual Air (O_2) shut-off valve.
8. Remove the test setup.

Note If the span calibration is aborted or failed, the last known good calibration will be used.

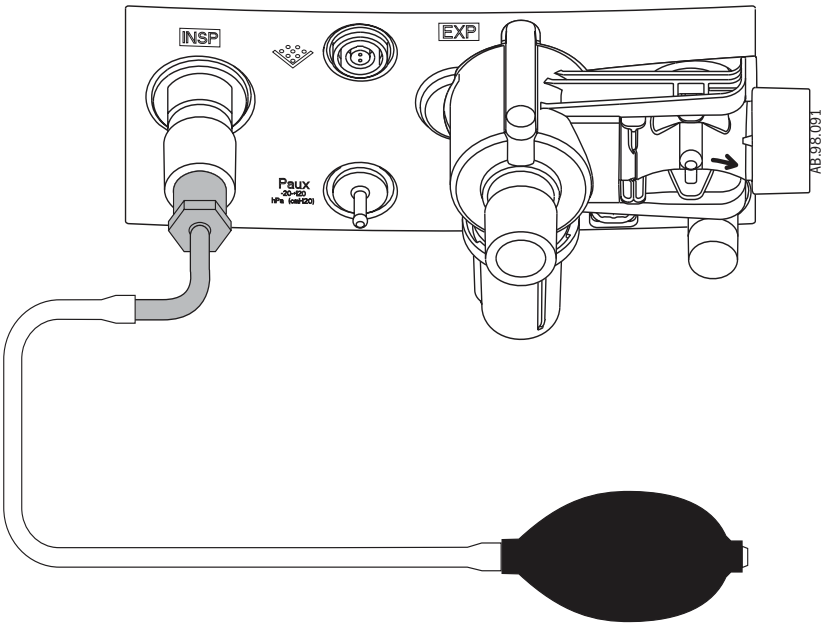


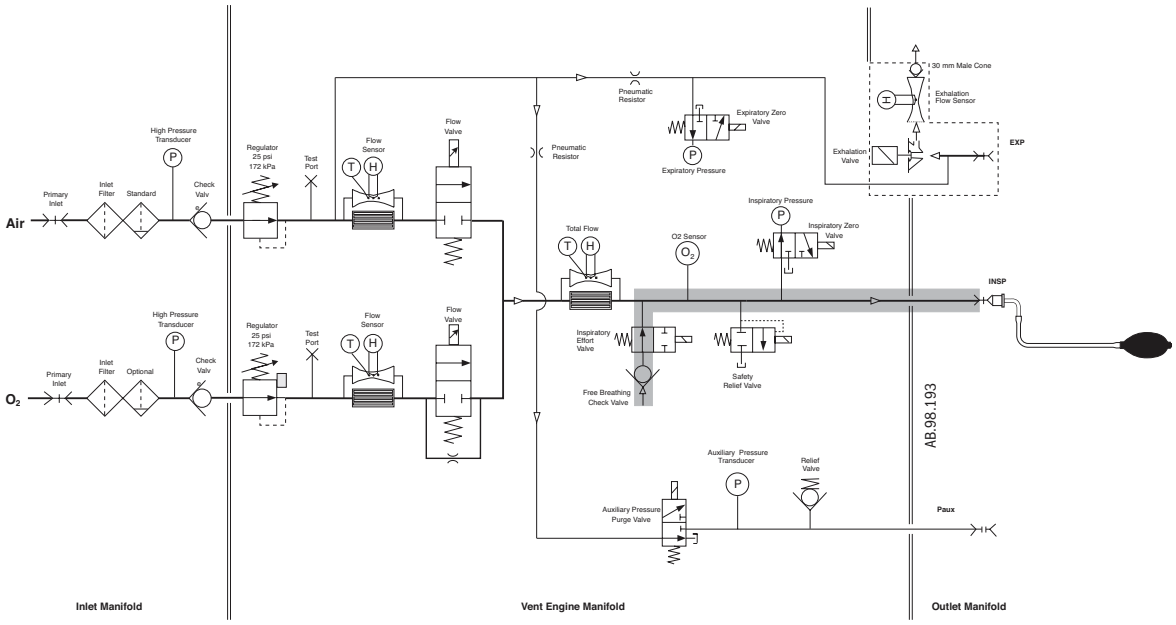

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
To Manometer
AB.98.192
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

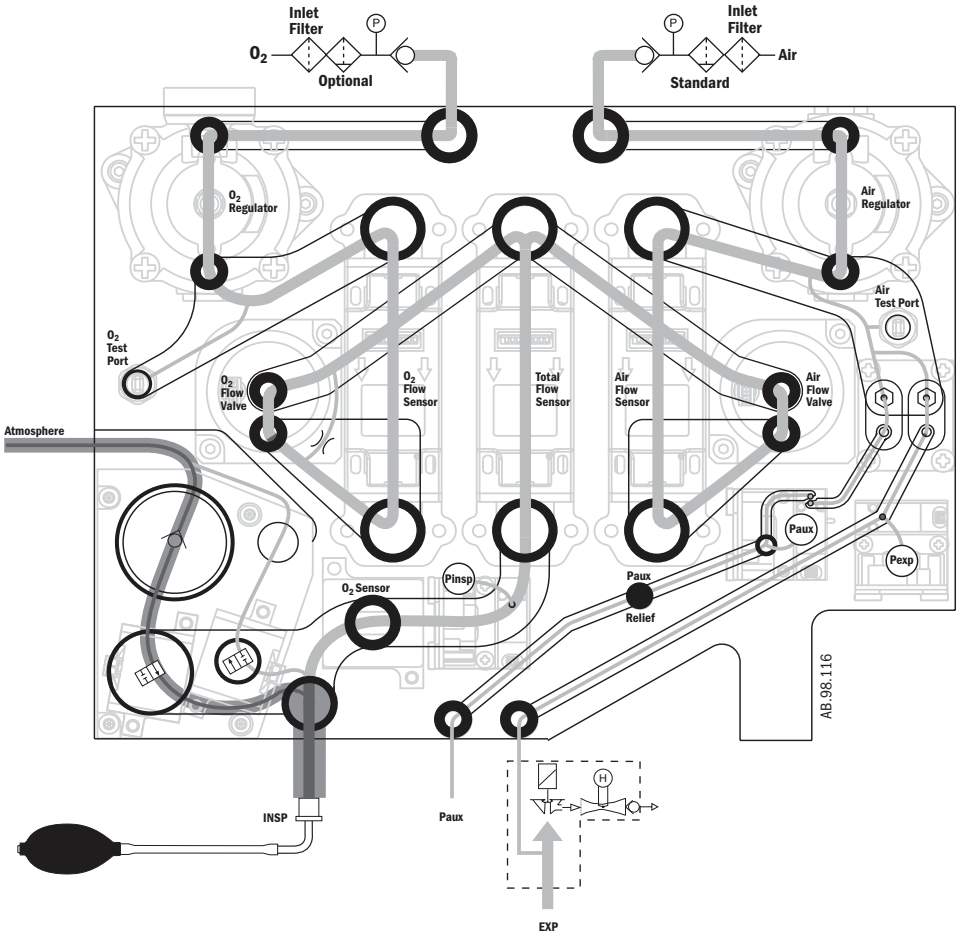

Inlet Filter
O2
Optional
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Relief
AB.98.115
INSP
Paux
EXP
To Manometer

5.2.9 Verify operation of free-breathing valve

1. Ensure both manual shut-off valves are closed.
2. Connect a negative pressure squeeze bulb to the ***INSP***iratory outlet.
3. Fully depress the bulb a minimum of 10 times.
4. On the VCB screen:
   - Verify that the measured ***Inspiratory Press***ure is more positive than - 3 cmH_2O at all times.
   - if not, troubleshoot the free-breathing check valve and the inspiratory effort valve.
5. Disconnect the squeeze bulb from the ***INSP***iratory outlet.

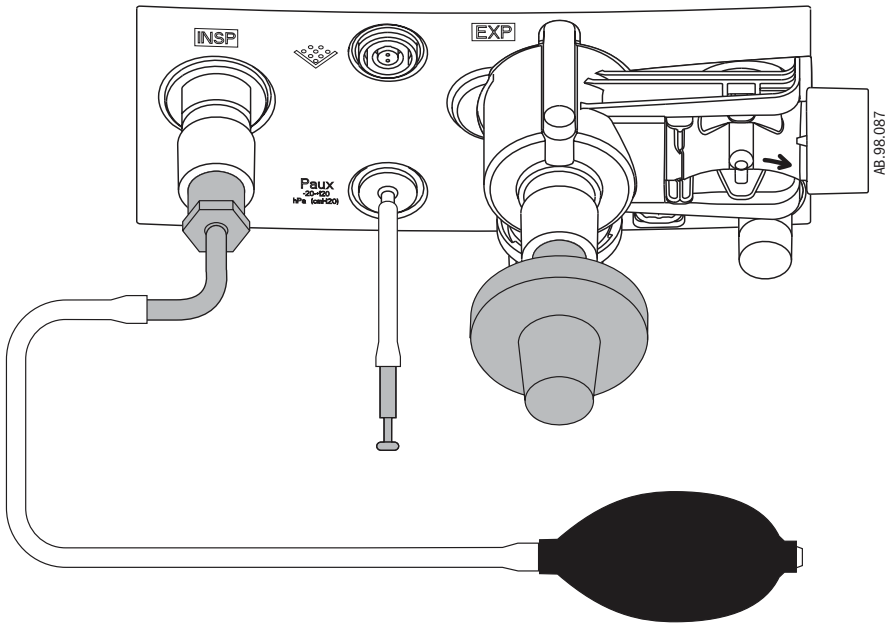


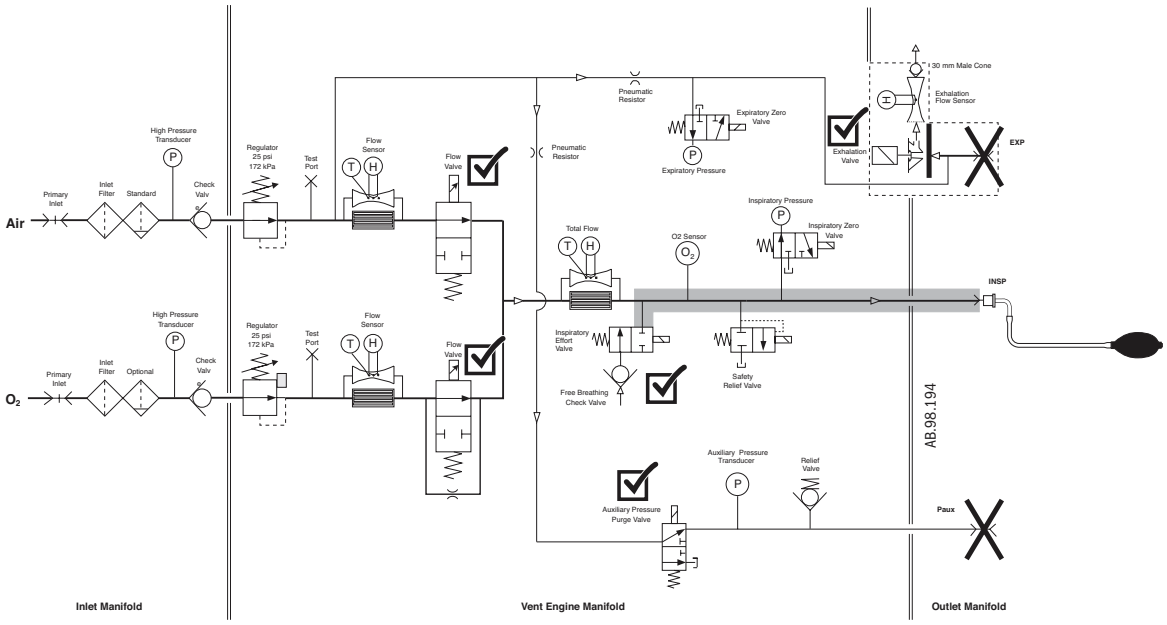

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
AB.98.193
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

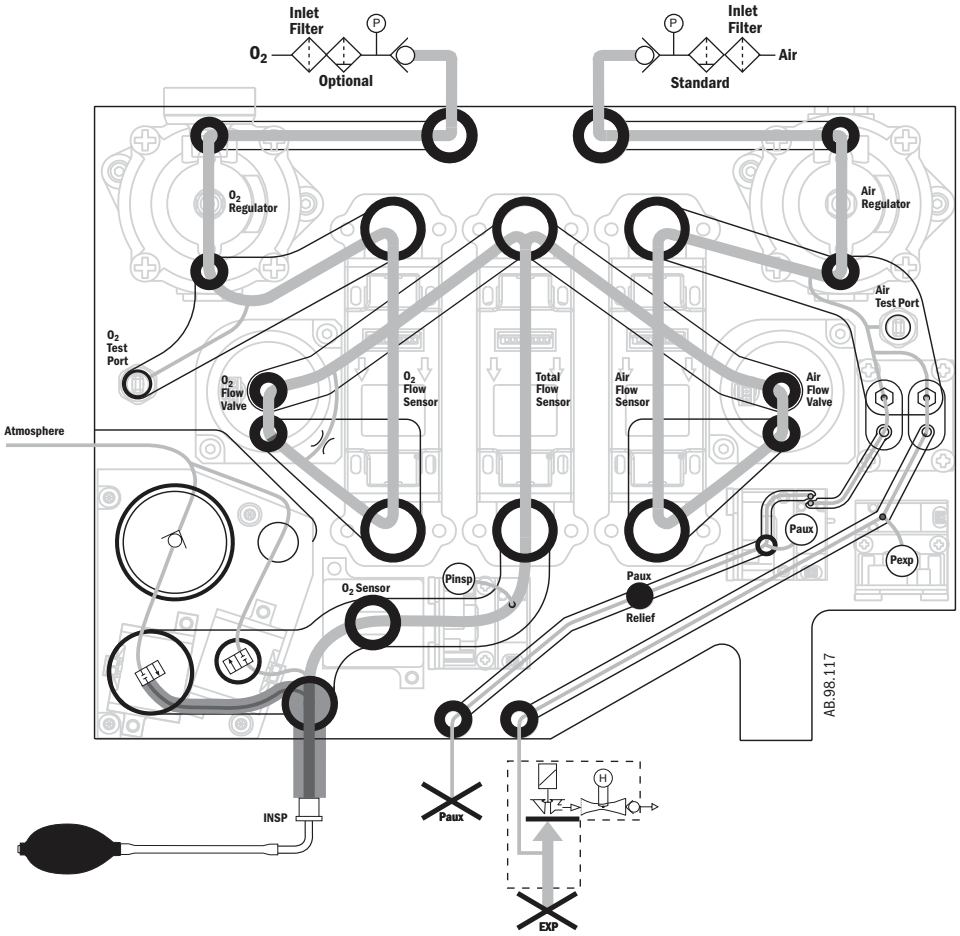

Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.116
INSP
Paux
EXP

5.2.10 Verify operation of inspiratory effort valve

1. Ensure both manual shut-off valves are closed.
2. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Energize (close) the inspiratory effort valve (☑ ***Effort Valve Energized***).
   - Verify that the ***Air Flow Valve***, ***O2 Flow Valve*** and the ***Exhal***ation ***Flow Valve*** are energized (☑).
   - Set the ***Air DAC***, ***O2 DAC***, and the ***Exh***alation ***DAC*** counts to 60,000.
3. Connect a negative pressure squeeze bulb to the ***INSP***iratory outlet.
4. Plug the ***EXP***iratory inlet and the Auxiliary pressure port (***Paux***).
5. Fully depress the squeeze bulb.
   - The bulb should not fully inflate in less than 5 seconds.
   - if not, troubleshoot the inspiratory effort valve.
6. Disconnect the squeeze bulb from the ***INSP***iratory outlet.
7. De-energize (open) the inspiratory effort valve (☐ ***Effort Valve Energized***).
8. Set the ***Air DAC***, ***O2 DAC***, and ***Exh***alation ***DAC*** counts to zero.



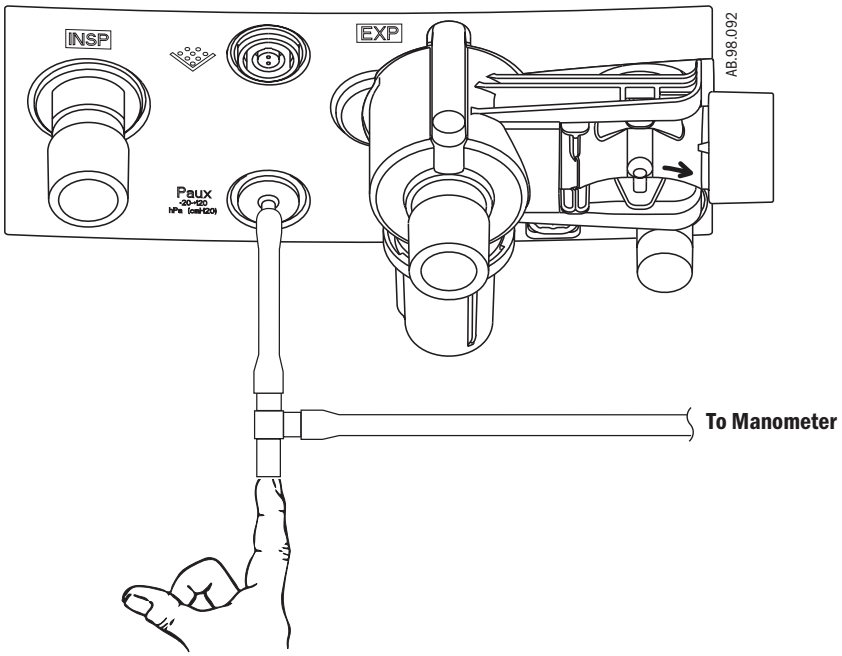

Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.194
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

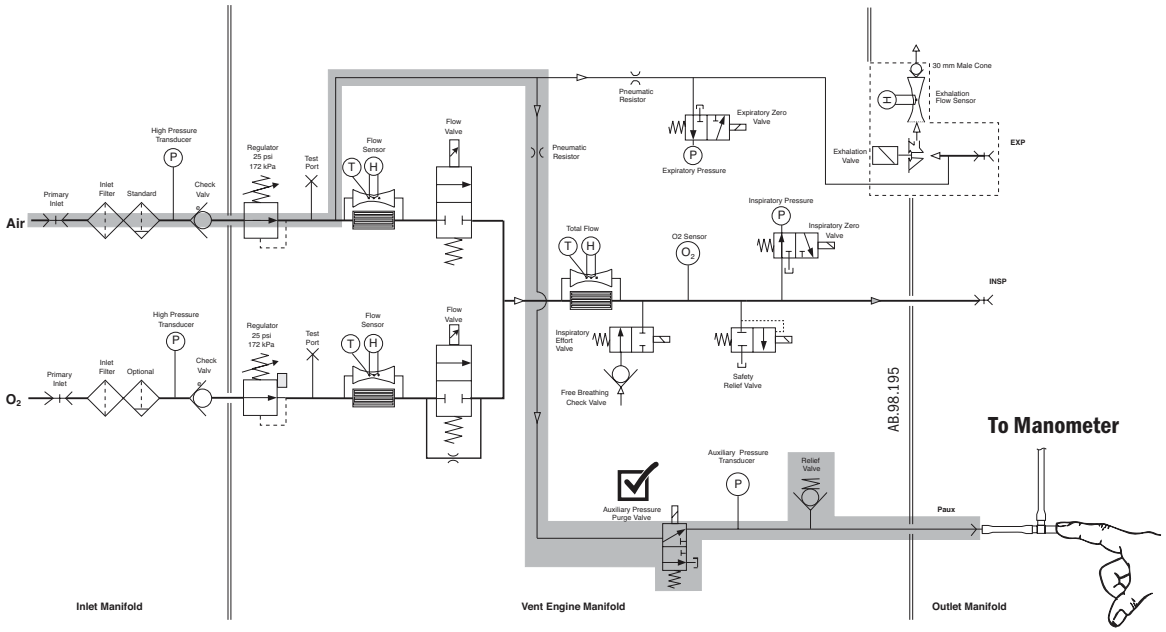

Inlet Filter
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.117
INSP
Paux
EXP

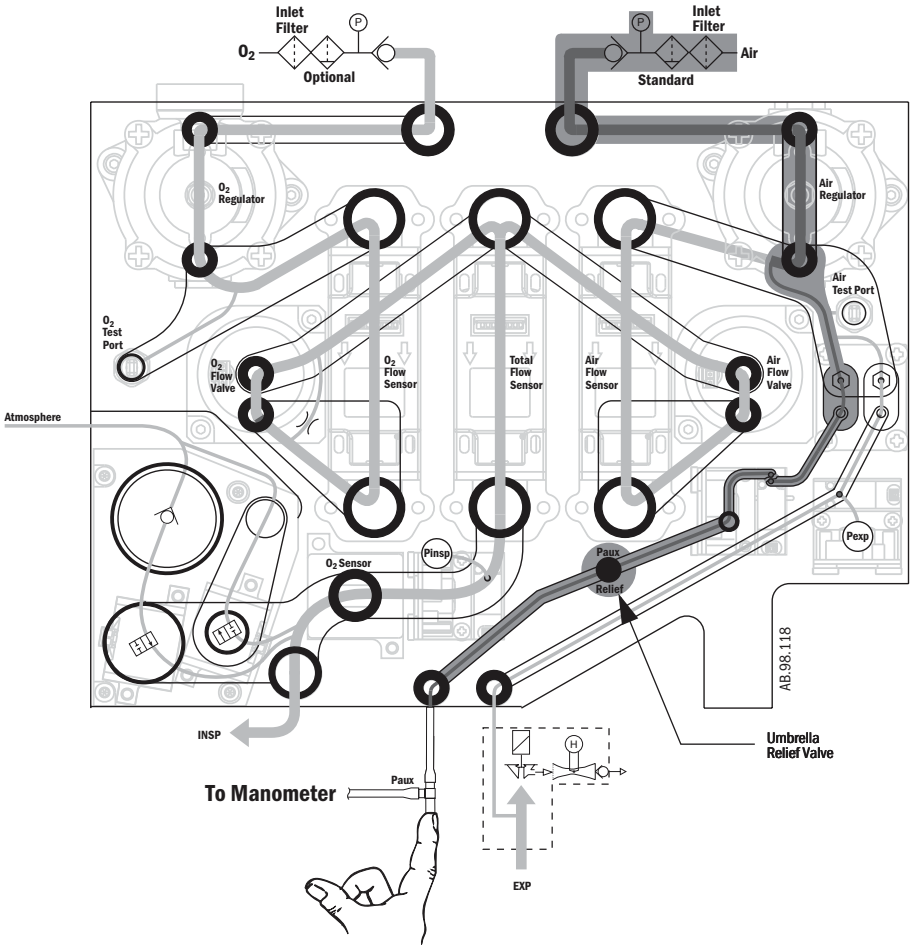
5.2.11 Verify operation of auxiliary pressure relief valve

1. Connect a manometer to the auxiliary pressure port (***Paux***) using a tee fitting and a short piece of 3-mm (1/8 inch) tubing.
2. Open the manual Air shut-off valve.
3. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
4. Block the outlet of the tee.
5. Verify that the pressure indicated by the manometer (not the PC based application) is greater than 90 cmH_2O but less than 230 cmH_2O.

   Caution: Do not allow the pressure to build up over 250 cmH_2O.
   - if not, troubleshoot the umbrella relief valve (1505-3267-000).
6. Close the manual Air shut-off valve.
7. Remove the test setup.




Air
O2
Primary Inlet
Inlet Filter
Standard
Optional
Check Valv
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.195
To Manometer
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold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Air Test Port
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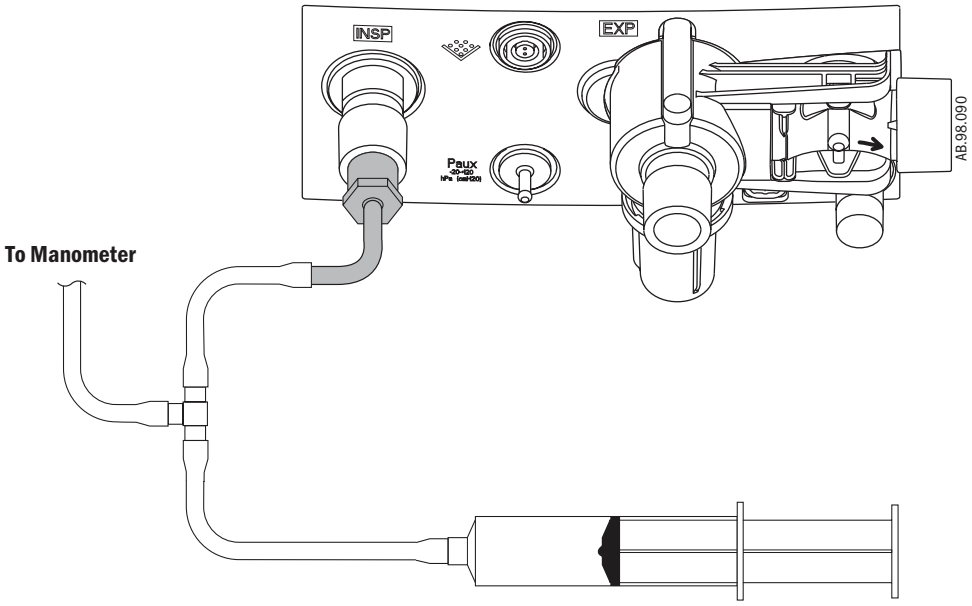
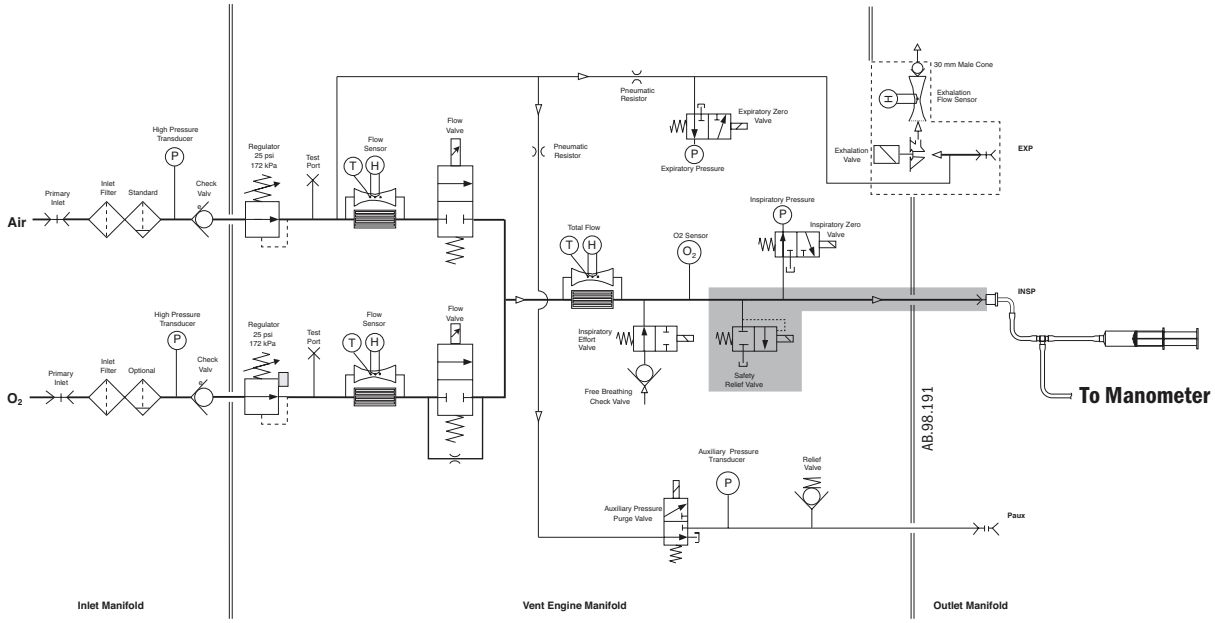
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Pexp
Pinsp
O2 Sensor
Paux
Relief
AB.98.118
INSP
Umbrella Relief Valve
To Manometer
Paux
EXP

5.2.12 Mechanical over-pressure valve test

1. Verify that the ventilator passes the low pressure leak test (Section 5.2.5).
2. Turn the ventilator off.
3. Using a syringe, inject 60 ml of air into the ventilator through the ***INSP***iratory port.
4. After the entire volume is delivered, verify that the pressure reading on the manometer is greater than 100 and less than 130 cmH2O.
   - if not, troubleshoot the safety relief valve.

Note: Pressure may spike higher than 130 cmH2O during 60 ml volume delivery if delivered at a rate greater than 4 l/min.

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Standard
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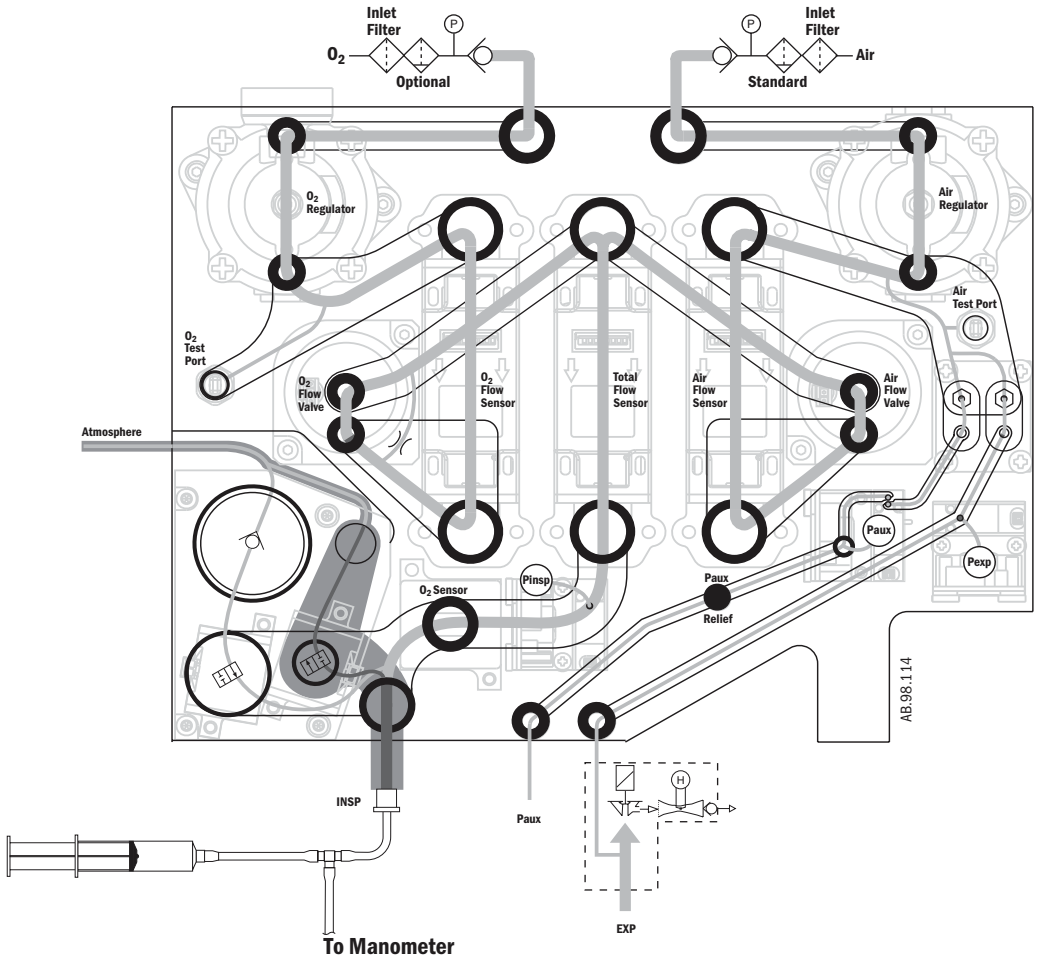
High Pressure Transducer
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
INSP
To Manometer
AB.98.191
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold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O2
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Inlet Filter
Air
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O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux
Relief
AB.98.114
INSP
Paux
EXP
To Manometer

6 Installation and Maintenance

In this section

This section covers the regular maintenance procedures (minimum requirements) needed to make sure that the Engström Carestation operates to specifications.

⚠ WARNINGS

Do not perform testing or maintenance on the Engström Ventilator while it is being used on a patient. Possible injury can result.

Items can be contaminated due to infectious patients. Wear sterile rubber gloves. Contamination can spread to you and others.

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

6.1 Engström Carestation Installation Checklist

Serial Number:	Date: (YY/MM/DD) / /
Hospital:	Performed by:

Note: Check for shipping damage, if any is noted, take photos and notify the shipping carrer.

☐ 1. Unpack and assemble the Engström Carestation. Refer to Section 3.

☐ 2. Remove protective tape from casters if applicable (Cart only).
Make sure the power cord is fully seated in the power inlet connector(s) and the power cord clamp(s) is secure.

☐ 3. Power system On and access the Install/Service menu *(TRM - Section 4.2).*
Change the following as required:

☐ a. Trends Setup *(TRM - Section 4.2.1)*

- Default Trend
- Graphical Trends

☐ b. Display Settings *(TRM - Section 4.2.2)*

- Color
- Units
- Show Alarm Limits
- Time and Date

☐ c. Ventilator Settings *(TRM - Section 4.2.3)*

- Timing and Flow
- Modes with Backup

☐ d. Parameter Settings *(TRM - Section 4.2.4)*

- TV Based on
- CO2 Numbers

☐ 4. Access the ***Service Menu*** and change the following as required *(TRM Section 4.4)*:

☐ a. Configuration *(TRM - Section 4.4.1)*

- Decimal marker
- Language
- Paw
- Flow
- CO_2
- Height
- Weight
- Altitude

☐ b. Options List *(TRM - Section 4.4.3)*

- Verify that the factory installed ventilation options match the configuration purchased with the machine.

☐ c. Copy Configuration menu *(TRM - Section 4.4.5)*

- Can be used to copy a configuration to a Compact Flash card and then copy the configuration to additional machines.

☐ d. From the Service menu select the Service Log menu *(TRM - Section 4.4.6)*

- Review and reset the error and alarm log entries.

☐ 5. Access the Install/Service menus and perform the following as required *(TRM Section 5.1.1)*:

☐ a. Calibration *(TRM - Section 4.3)*

- O_2 FCV
- Air FCV
- Exhalation Valve
- Backlight test

☐ b. Cal Flag

- Set to Off

☐ c. Power system Off.

☐ 6. System Checkout *(TRM - Section 3):*

☐ a. Power system On and verify the *"Calibration Required"* message is not displayed (upper right portion of the display).

☐ b. Perform Checkout Procedure *(TRM - Section 3)*

- Inspect system *(TRM Section 3.1)*
- Automated Checkout (*TRM Section 3.2)*
- Power Failure test *(TRM Section 3.4)*
- Electrical Safety tests *(TRM Section 3.5)*

6.2 Engström Carestation Planned Maintenance

Serial Number:	Date: (YY/MM/DD) / /
Hospital:	Performed by:
☐ 12 months ☐ 24 month ☐ 48 month	☐ _____

6.2.1 Every twelve (12) months

Perform the following steps every 12 months.
For details, refer to the sections listed.

- ☐ 1. If required, adjust the Display Unit arm joints (*Section 9.6*).
- ☐ 2. If required, adjust patient monitoring module rack arm.
- ☐ 3. Visually inspect Vent Engine fan filter. Clean or replace as needed.
- ☐ 4. Visually inspect Display Unit fan filter. Clean or replace as needed.
- ☐ 5. Visually inspect exhalation valve assembly. Clean or replace as needed.
- ☐ 6. Visually inspect gas inlet filters (O_2 and Air). Replace as needed.

CAUTION Any visual signs of moisture or particulate matter indicates that the facility may have a problem with their Medical gas delivery system. Return the replaced filter to the appropriate authority in the facility so that they are aware of the problem and can correct as needed. If there is any indication of moisture in the filter, the main manifold must be inspected to ensure there are no visual signs of moisture entering into the ventilator engine.

- ☐ 7. Complete the battery capacity test (*Section 6.5*).
- ☐ 8. Electrical safety tests (*Section 3.5*).
- ☐ 9. Complete all Service level tests and calibrations (*Section 5.2*).
- ☐ 10. Complete all Super-User calibrations (*Section 5.1*).
- ☐ 11. Complete the Checkout procedure (*Section 3.2*).

6.2.2 Every forty-eight (48) months

In addition to the 12-month requirements, replace the following parts every 48 months (4 years).

- ☐ 1. Replace the system batteries* (Stock Number 1009-5682-000).

  Note: Refer to the "*Battery capacity test*" in *Section 6.5*.

- ☐ 2. Check regulator output (*Section 5.2.4*).

6.2.3 Every sixty (60) months

In addition to the 12-month requirements, replace the following parts every 60 months (5 years).

- ☐ 1. Replace Lithium battery (1009-5800-000) on display CPU board. Refer to *Section 9.5.2*, item 5.

6.3 JunAir EVair03 Compressor Maintenance (Model OF302-1.5DSA)

Serial Number:			Date: (YY/MM/DD) / /
Hospital:			Performed by:
☐ 12 months	☐ 24 month	☐ 48 month	☐ _____

6.3.1 Every twelve (12) months

Perform the following steps every 12 months.

Refer to the JunAir EVair03 Compressor Technical Reference manual (TRM) - 6189655 for additional information.

☐ 1. Disconnect the air pipeline supply if present.

☐ 2. Unplug mains AC power from compressor.

☐ 3. Remove the protective cover from compressor (four screws on front panel).

☐ 4. Open the drain valve on the receiver, if water is present in the receiver; refer to "Fault finding and repair" section of the JunAirEvair03 TRM, Step 7, Figure 3.

☐ 5. Check the o-rings' in the non-return valve and replace if necessary. Part numbers 6243000 and 6242500 - refer to JunAir EVair03 TRM Figures 4 and 7.

☐ 6. Install filter kit f/OF302-1.5SDA, 5471001.
Filter kit includes the following components:

- Intake filters - 2 each, 5412400
  Refer to JunAir EVair03 TRM - Figure 5.
- F/5 um filter - 2 each, 4071230
  Refer to JunAir EVair03 TRM - Figures 6b and 6c.
- F/0.01 um Filter -1 each, 4071240
  Refer to JunAir EVair 03 TRM - Figure 6d.
- F/air intake - 1 each, 6985795
  Refer to JunAir EVair03 TRM - Page 10.

☐ 7. Check the condition of internal hoses and connectors.

☐ 8. Use a soft, damp cloth to clean unit by wiping the exterior and interior of the compressor.

☐ 9. Connect the air pipeline supply (if present) and mains AC power.

☐ 10. Power the unit On and check for leaks and proper operation.

6.3.2 Every 10, 000 hours

In addition to the 12-month requirements, replace the following parts every 10,000 hours. All parts should be replaced before performing the checks, tests, and calibrations.

☐ 1. Install 10,000 Hour Kit after 10,000 hours of operation (Check hour meter).

- P/N 5471002 - 10,000 Hour Kit -230V/50 Hz
- P/N 5471003 - 10,000 Hour Kit - 120 V/60 Hz

10,000 Hour Kit includes:

- Motor OF302
  Refer to JunAir Evair 03 TRM - Page 10.
- Non-return valve - 2 each, P/N 5414500
  Refer to the JunAir EVair 03 TRM - Figures 4 and 7.
- Solenoid valve
  Refer to JunAir EVair03 TRM - Figures 8 and 9.
- Auto drain
  Refer to JunAir Evair03 TRM - Page 9.

6.4 Cleaning and sterilizing agents

WARNING The following cleaning/disinfection agents have been validated for material compatibility only. The effectiveness of sterilization with these agents has not been validated.

	Ethyl Alcohol	Sporox II	Cidex	NU-CIDEX	CIDEX OPA	Autoclave at 134° C	Mild detergent and warm water
Expiratory flow sensor	yes	yes	no	no	no	yes	yes
Exhalation valve housing and parts	yes	yes	no	no	no	yes	yes
Fan filters	no	no	no	no	no	no	yes
Aeroneb Pro Nebulizer	no	no	yes	yes	yes	yes	yes
Water trap (cart mounted)	yes	yes	no	no	no	yes	yes
Cables	yes	no	no	no	no	no	yes
External surfaces	no	no	no	no	no	no	yes
Neo Flow Sensor	yes	yes	no	no	no	yes	yes

6.5 Battery capacity test

Although replacement of the backup batteries is recommended at the end of 4 years, batteries that pass the capacity test can be considered viable for battery backup of the system for up to 6 years at the discretion of the hospital.

Before testing the batteries, ensure that the PMB Diagnostics screen shows that the battery is fully charged. Battery status will show "Float Charge" which indicates that the battery is fully charged. Refer to section 8.1.3 .

Test procedure

1. Turn the system on and start a case (simulated).
2. Disconnect the power cord from the mains outlet.
3. Allow the system to run on battery until it does an orderly shutdown.
4. Reconnect the power cord to a mains outlet.
5. Boot the system with the PCMCIA Service Application for the DU and Compact Flash for HPDU, then access the Power Diagnostics function as detailed in Section 8.
   - On the Main Menu of the Service Application, select ***Power Diagnostics***.
   - On the Power Diagnostic menu, select ***Power Control***.
6. Page 1 of the Power Controller Power Diagnostics screen shows the 'Date battery Tested' (the last full battery discharge until shutdown) and the 'Discharge Time'.
   - If Discharge Time information is not displayed on the screen, the test has not been run. Repeat the test procedure.
   - If the 'Discharge Time' is greater than 60 minutes, the batteries can be left in service for one more year.
   - If the 'Discharge Time' is less than 60 minutes, both batteries should be replaced.

Note: Charge battery for at least 8 hours before next use.

7 Troubleshooting

In this section

7.1 Troubleshooting Checkout Failures

Note: If the Automated Checkout (Section 3.2) results in failures, refer to the following sections to troubleshoot a specific failure. Use EC Service Application PC based (Section 8.5) while running all tests .

To file a quality report or request technical assistance regarding a checkout failure, create and include a Checkout log using the EC Service Application.

7.1.1 Paw transducer check

The Paw Transducer Check can indicate a failure from four conditions:

1. Inspiratory Pressure Sensor Zero Failure:

   With the Inspiratory Pressure Zero Valve actuated, raw counts from the Inspiratory Pressure Sensor must be between 631 and 968; if not, test results indicate **Fail** and the ***Pinsp sensor out of range*** message is displayed.

   - Use EC Service Application PC based (Section 8.5) to facilitate problem isolation.
   - Ensure proper connections.
   - Remove the Inspiratory Pressure Zero valve. If the Inspiratory Pressure Sensor values are between 631 and 968 counts, replace the Zero Valve.
   - Replace the Inspiratory Pressure Sensor Board.
   - Replace the Vent Control board (VCB).

2. Expiratory Pressure Sensor Zero Failure:

   With the Expiratory Pressure Zero Valve actuated, raw counts from the Expiratory Pressure Sensor must be between 631 and 968; if not, test results indicate **Fail** and ***Pexp sensor out of range*** message is displayed.

   - Use EC Service Application PC based (Section 8.5) to facilitate problem isolation.
   - Ensure proper connections.
   - Remove the Expiratory Pressure Zero valve. If the Inspiratory Pressure Sensor values are between 631 and 968 counts, replace the Zero Valve.
   - Replace the Expiratory Pressure Sensor board.
   - Replace the Vent Monitor board (VMB).

3. Cannot achieve 34 cmH_2O pressure:

   The Air (O_2) flow valve is set to approximately 10 lpm and the test is initiated if 34 cmH2O pressure is not achieved; test results indicate **Fail** but no alarm message is displayed.

   - Use EC Service Application PC based (Section 8.5) to facilitate problem isolation.
   - Ensure supply gas is connected.
   - Continue with other tests. If a significant leak is indicated during the Low Pressure Leak test, repair the leak then repeat this check.
   - Check respective Flow Control Valve for proper operation.

4. **Paw insp** and **Paw exp** are not within 4 cmH_2O when pressurized to 34 cm H_2O.

   Test results indicate **Fail** but no alarm message is displayed.

   - Use EC Service Application PC based (Section 8.5) to facilitate problem isolation.
   - Use the Service Application to calibrate sensors (Section 5.2.8).
   - Replace the affected Sensor board(s) or Zero valves, if calibration fails.

If this check fails, all ventilation modes will still be available.

7.1.2 Barometric pressure test

A failure indicates that the difference between calculated barometric pressure based on the input altitude, and the measured barometric pressure is greater than 20%.

- Verify correct altitude setting.
- If setting is correct, calibrate the barometric sensor (Section 8.7.4).
- Replace the Vent Monitor board (VMB) - recalibrate barometric sensor.

If this check fails, all ventilator modes will still be available and the calculations will use the input altitude as basis for absolute pressure.

7.1.3 Low pressure leak and compliance check

If there are errors in the calculation (negative values, divide by zero) the results will be dashed. The results of this calculation will be displayed after the Safety Relief Valve test is completed.

1. The first calculation is compliance and is based on the amount of time it takes for a 3 lpm flow to create 34 cmH_2O of pressure at the Pexp sensor. If this pressure cannot be achieved, a "Failed" message will appear and no compliance information will be available.
2. The second calculation is the low pressure leak rate. It is based on the amount of pressure decay from 25 cmH_2O pressure in approximately 3 seconds.
   - If the leak rate is greater than 1 lpm (@ 25 cmH_2O), the compliance value will be dashed and the leak value will show "> 1000 ml/min." This value can be useful in diagnosing other failures during checkout.
   - If the Leak is greater than or equal to 500 ml/min or Compliance cannot be measured or Resistance cannot be measured, the "Failed" message will apear across from Circuit Check.
   - If the the Leak is less than 500 ml/min and Compliance and Resistance can be measured, a message will be displayed.
3. Finally, a correction based on the leak rate is applied to the compliance calculation and the information will be displayed.

7.1.4 Safety valve relief and back pressure

The Safety Valve Relief test checks the ability of the Safety Relief Valve to relieve all patient pressure on demand. Failures include:

1. Set the Air (O2) flow valve to 3 lpm. If at least 30 cmH2O cannot be achieved, the test will indicate **Fail** but no alarm message is displayed.
   - Ensure supply gas is connected.
   - A leak is indicated; use the EC Service Application PC based (Section 8.5) and the Low Pressure Leak test (Section 7.2) to isolate and repair the leak.
   - Repeat check.
2. Once pressure stabilizes, the Safety Relief Valve is opened. If Pexp does not go to less than 2 cmH_2O within 250 msec, the test will indicate **Fail** and ***Relief Valve Failure*** message will be displayed.

   Use the Service Application to simulate this test.

   a. If pressure remains significantly above 2 cmH_2O:
      - Listen for the valve actuator to "click" when actuating. Check the connections to the safety relief valve.
      - Ensure seat/seal interface is clean.
      - Replace the Manifold Assembly.

   b. If pressure is only slightly above 2 cmH_2O:
      - Re-zero pressure sensors.
      - Ensure seat/seal interface is clean.
      - If Exhalation Valve Calibration Check also fails, replace the Pexp sensor.
      - Repeat check.
3. If a flow of 75 l/min creates more than 15 cmH_2O pressure at Pexp sensor with the safety relief valve open, the test will indicate **Fail** and ***Relief Valve Failure*** message will be displayed. If 75 l/min cannot be achieved, the test will indicate **Fail** but no message will be displayed.

   Use the Service Application to simulate this test.

   - Check the connections to the safety relief valve.
   - Replace the Manifold, Insp Valve Assembly.

If this test fails, no mechanical ventilation is allowed.

7.1.5 Exhalation valve calibration check

The Exhalation Valve Calibration check sets flow at 4 l/min as measured by the total flow sensor and the expiratory valve to 34 cmH2O. Once stable, it opens the Expiratory Valve and verifies that the exp Paw is less than 2 cmH2O within 250 ms.

1. Cannot achieve 34 cmH_2O (+/- 10 cmH2O pressure.

   The test will indicate **Fail** but no alarm message is displayed.

   - Ensure supply gas is connected and device can achieve at least 4 lpm at the 10 lpm calibration point (see step 3a).
   - Calibrate the Exhlation Valve.
   - A leak is indicated; use the EC Service Application PC based (Section 8.5) and the Low Pressure Leak test (Section 5.2.4) to isolate and repair the leak.
   - Repeat check.

2. If both the Relief Valve and Exhalation Valve tests fail and the leak rate is less than 2000 counts, the most likely problem is with the Pexp Sensor not returning to zero:

   - Use the Service Application to apply 34 cmH_2O of pressure until stable, then release the pressure using either the Exhalation Valve or the Safety Relief Valve. The Pexp value must return to less than 2 within 250 msec. If not, re-zero and repeat or replace the Pexp sensor.

3. If only this check is failing:

   a. Use the Service Application to verify at least 4 l/min is generated by the FCV. If not:
      - Recalibrate the FCV.
      - Replace the FCV.
   b. Remove the Exhalation Valve Assembly and ensure the Voice coil shaft is clean and dry and moves freely without binding.
   c. Replace the Exhalation Valve Assembly.
   d. Replace the Voice coil assembly.

If this check fails, all ventilator modes will still be available.

7.1.6 Exhalation flow sensor calibration test

The Exhalation Flow Sensor Calibration test compares the Exhalation Flow Sensor output to the Total Flow Sensor output at 10 l/min. If the Expiratory Flow Sensor is within 20% of the Total Flow Sensor, the test passes and an Expiratory Flow normalization table is created to compensate for up to 10% of this discrepancy.

1. If only this test fails, replace the Exhalation Flow Sensor.
2. If the Air and/or O2 Inspiratory Flow Sensor calibration checks also fail, use the Service Application to determine the accuracy of the Total Flow Sensor.

If this test fails, all ventilator functions will still be available. The message ***Flow Sensor Error*** will be displayed.

7.1.7 Measure breathing circuit resistance

The breathing circuit resistance is calculated from the amount of resistance created when 60 l/min is flowing through the circuit. It is calculated and displayed on the bottom of the screen. It represents the resistance of 1/2 of the breathing circuit.

7.1.8 Air inspiratory flow sensor calibration check

This check verifies that the Air Flow Sensor is functioning and compares the flow and temperature measurements with the total flow sensor at 30 l/min. Total flow and Air flow must be within 15% and temperature must be within 9° C.

Failure can be due to lack of flow as well as flow or temperature differences. Use the EC Service Application (Section 8.5) to simulate the test and isolate the problem.

If this check fails, all ventilator functions will still be available. The message ***FlAir Control Error*** will be displayed.

7.1.9 O_2 inspiratory flow sensor calibration check

This check verifies that the O_2 Flow Sensor is functioning and compares the flow and temperature measurements with the total flow sensor at 30 l/min. Total flow and O2 flow must be within 15% and temperature must be within 9°C.

Failure can be due to lack of flow as well as flow or temperature differences. Use the EC Service Application (Section 8.5) to simulate the test and isolate the problem.

If this check fails, all ventilator functions will still be available. The message ***FIO2 Control Error*** will be displayed.

7.1.10 O_2 sensor test and calibration

This test/calibration will only be performed if both Air and O_2 are connected. The O_2 offset is calibrated while flowing 30 l/min of Air, and the O_2 gain is calibrated with 30 l/min of O_2. The test will **Fail** if either Air or O2 fail to achieve 30 l/min flow.

Calibration is verified by flowing 15 l/min Air and 15 l/min O_2 and comparing the sensor output to the calculated valve (approximately 60.5%). The test will **Fail** if O2 sensor is not within 5% of the calculated value.

If this check fails, all ventilator functions will still be available.

Note: This test is performed before the O_2 inspiratory flow sensor calibration check.

7.1.11 Neonatal flow sensor calibration check

This test verifies the accuracy of both the inspiratory and expiratory flow sensor circuits in the Neonatal Flow Sensor at 20 l/min.

1. During this stage the circuit is occluded. The flow is set to 4 l/min and the flow sensor should indicate 0 l/min. If not, the test will indicate **Fail** and the next step will be skipped (no message box will appear).
2. A message box is displayed requesting removal of the circuit occlusion. After detecting that Paw drops below 3 cmH2O, flow will be set at 20 l/min. The exhalation valve is closed.
   a. The Total Flow Sensor must be within 25% of the expiratory neonatal flow (absolute value) +4.59 l/min.
   b. The Total Flow Sensor must be within 15% of the inspiratory neonatal flow (absolute value).

Use the EC Service Application to simulate the test and isolate the problem.

If this check fails, all ventilator functions will still be available.

Important

Volume control and monitoring will be more accurate if the neonatal flow sensor is calibrated in the following situations:

- Before use, during the Checkout procedure.
- After replacing the flow sensor.
- After a power cycle.

7.2 Troubleshooting Vent Engine Leaks

Note: Use the EC Service Application PC based (Section 8.5) while running all tests.

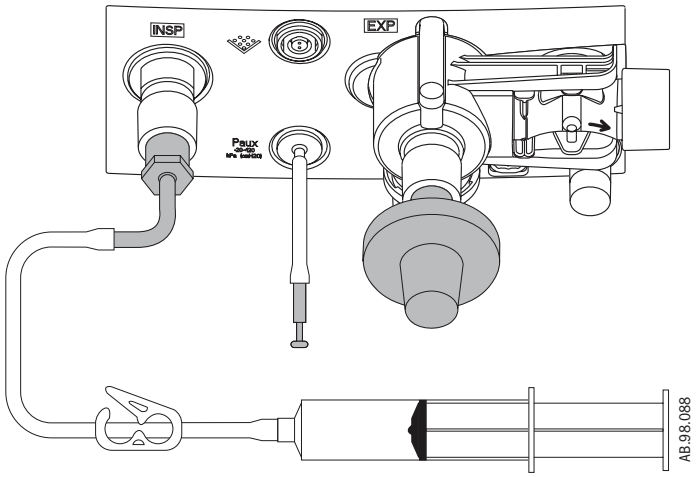
- Refer to Section 7.2.1 if the vent engine leak test fails (Section 5.2.5) by either being unable to build 70 cmH2O pressure or if the leak rate exceeds 10 ml/min.
- Refer to Section 7.2.2 if able to build inspiratory pressure to 70 cmH2O inspiratory pressure, but unable to build 70 cmH2O of either expiratory pressure or auxiliary pressure.

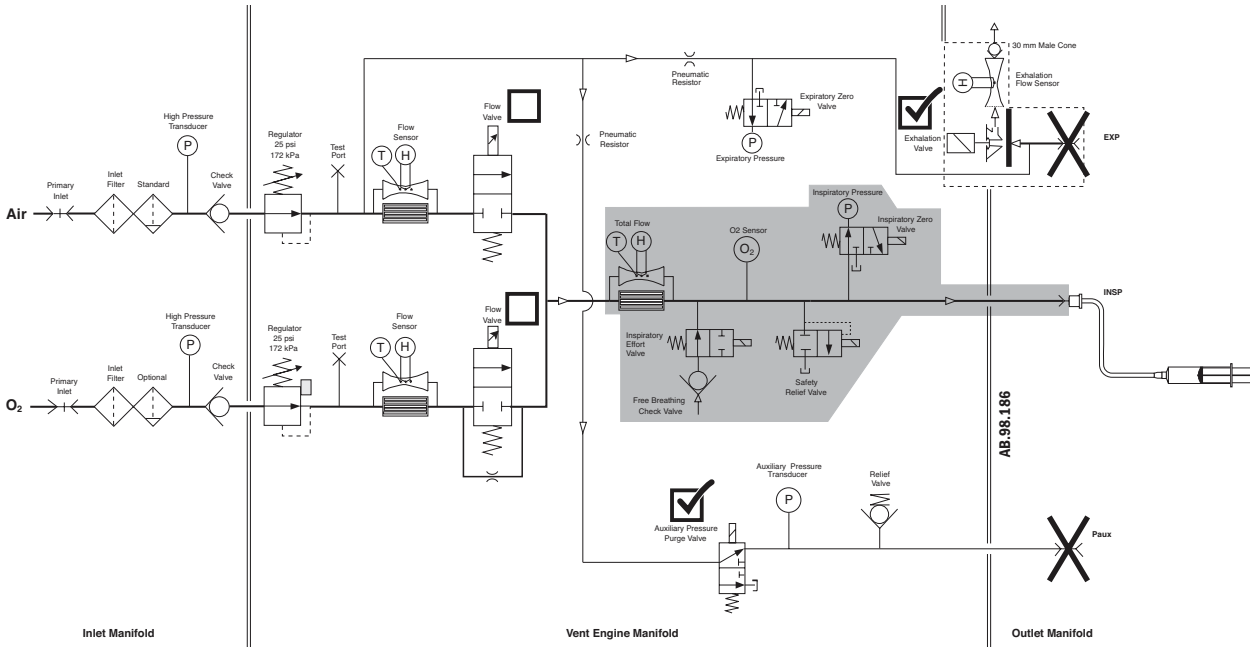
To file a quality report or request technical assistance regarding a checkout failure, create and include a Checkout log using the EC Service Application.

7.2.1 Vent engine leak test

While retaining the leak test setup:

1. Close the Air and O_2 flow valves to limit the components tested (remove the checkmarks from the boxes next to the DAC counts).
2. Repeat the Vent Engine Leak Test.
   - If the test passes, proceed to step 5.
   - If the leak remains, toggle the Effort Valve closed.
3. Repeat the Vent Engine Leak Test.
   - If the system passes, check the Free Breathing Valve diaphram and o-ring seal.
   - If the leak remains, toggle the safety valve open/closed.
4. Repeat the Vent Engine Leak Test.
   - If the system passes, check the safety valve seal.
   - If the leak remains, check the individual components in the Total Flow path.

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Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
INSP
AB.98.186
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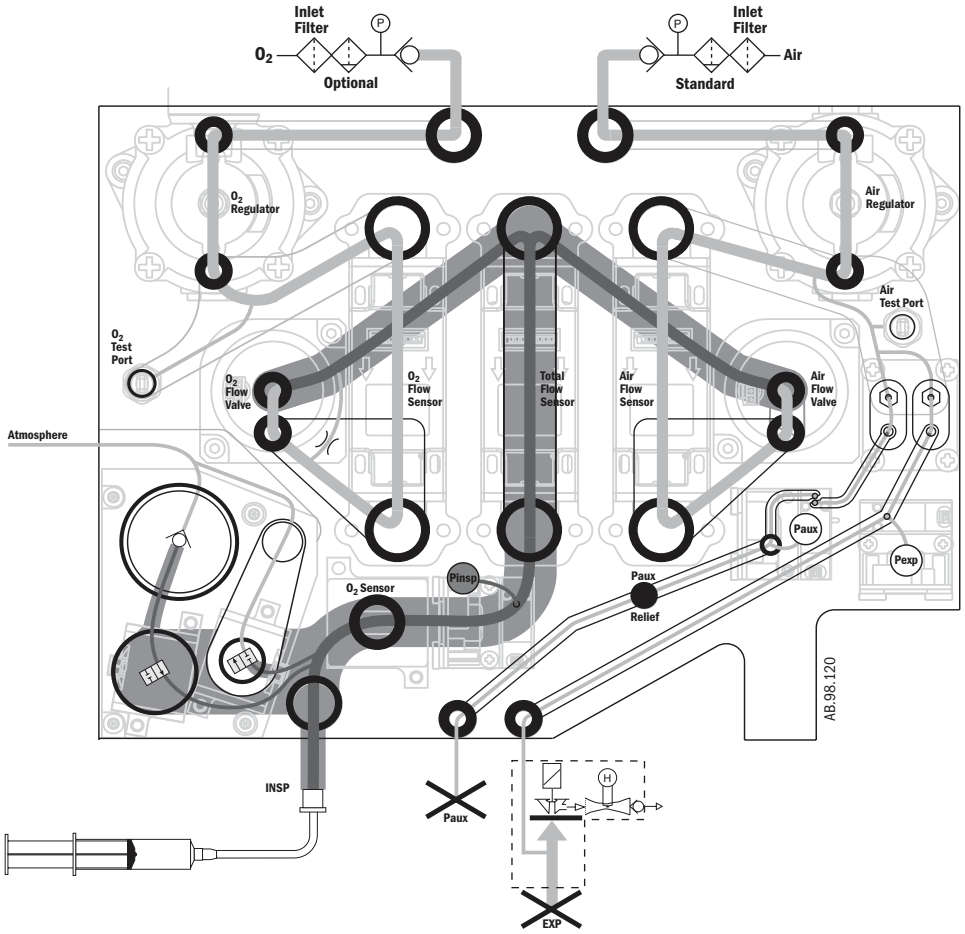
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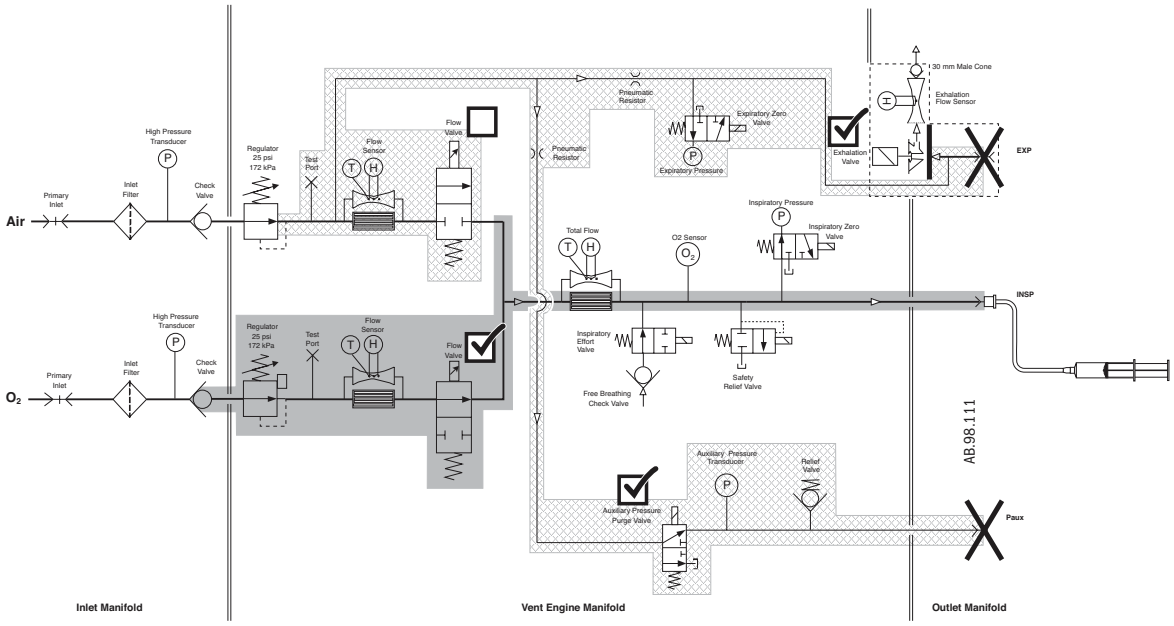
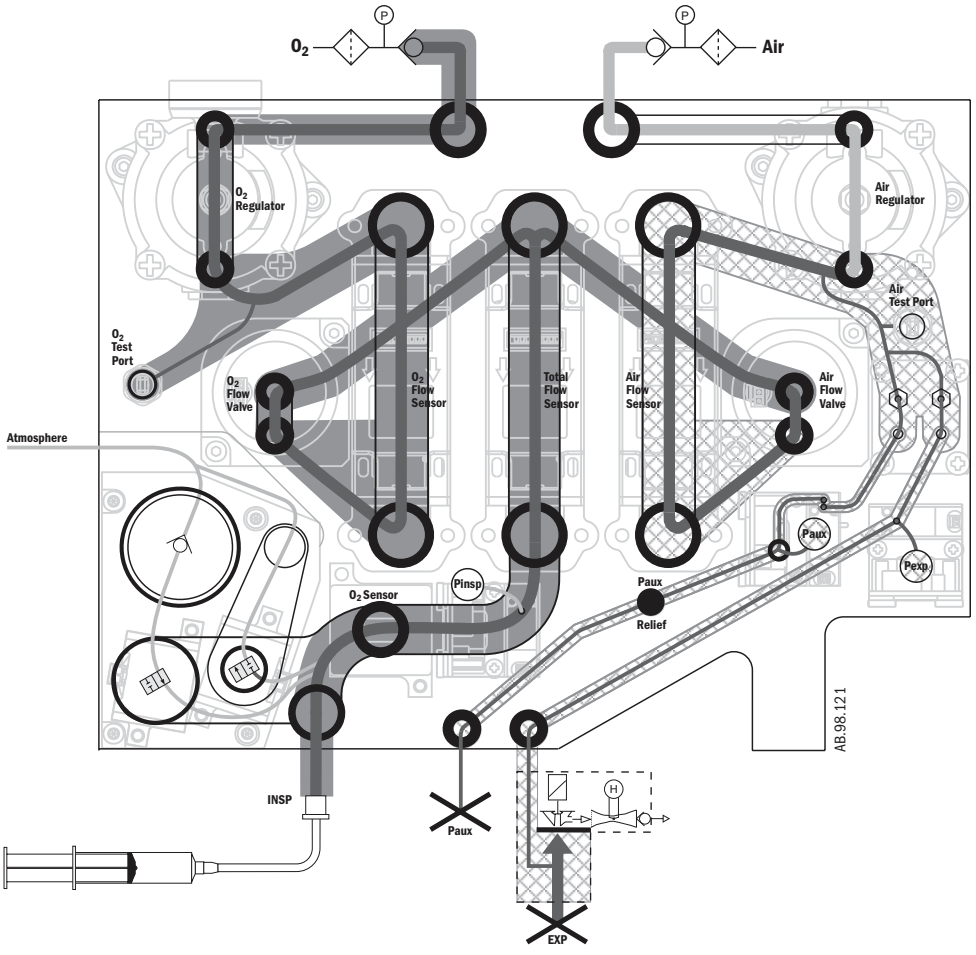
O2
Optional
Inlet Filter
Air
Standard
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.120
INSP
Paux
EXP

5. Open only the O_2 flow valve by checking the ***O2 Flow Valve*** box (verify that 60000 DAC counts are set).
6. Repeat the Vent Engine Leak Test.
   - If the test fails, check the individual components in the O_2 Flow path.
   - If the test passes, check the individual components in the Air Flow path.


Air
O2
Primary Inlet
Inlet Filter
High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
AB.98.111
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.121
INSP
Paux
EXP

7.2.2 Auxiliary and expiratory pressure circuit leaks

If the vent engine leak test (Section 5.2.5) fails at step 5, the following steps will help to locate the possible leak locations. Flow in the Auxiliary and Expiratory pressure circuits is restricted, therefore failure to build pressure may not cause the leak test to fail, and may not affect checkout, or system while in use.

Note: If both the Auxiliary and Expiratory pressure is low, it is possible that both restrictors are partially plugged, or both circuits have leaks. Therefore, it is best to troubleshoot each pressure circuit as an individual problem.

If the Expiratory pressure is lower than the Inspiratory pressure:

1. Remove the Exhalation valve and plug the Exhalation Pressure opening on the front panel. Repeat the test:
   a. If pressures equal, the problem is from the Exhalation valve housing, or the seal located between the Exhalation valve and the front panel.
   b. If not, continue.

Warning Before removing restrictors: shut off supply valves and open flow valves to bleed system pressure build-up.

1. Remove the restrictor and reinstall the restrictor access cover. Repeat the test.
   a. If pressures equal, install a new restrictor and repeat the test.
   b. If not, or if the test fails with the new restrictor, continue.
2. Check the following seals on the individual components in the order listed, replace components as needed, and repeat the test.
   a. Restrictor cover gasket
   b. Expiratory pressure zero valve gasket.
   c. Expiratory pressure sensor o-ring.
   d. Outlet manifold o-ring.
3. If the test fails, replace the following components in the order listed.
   a. Expiratory pressure sensor assembly.
   b. Outlet panel assembly.
   c. Main manifold assembly.

If the Auxiliary pressure is lower than the Inspiratory pressure:

1. Remove the restrictor and re-install the restrictor access cover. Repeat the test.
   a. If pressures equal, install a new restrictor and repeat the test.
   b. If not, or if failure occurs with new restrictor, continue.
2. Check seals on the following individual components in the order listed, replace components as needed, and repeat the test:
   a. Restrictor cover gasket.
   b. Auxiliary pressure relief valve.
   c. Auxiliary pressure zero valve gasket.
   d. Auxiliary pressure sensor o-ring.
   e. Outlet manifold o-ring.
3. If failure occurs, replace the following components in the order listed:
   a. Auxiliary pressure sensor assembly.
   b. Auxiliary zero valve.
   c. Outlet panel assembly.
   d. Main manifold assembly.

7.3 Troubleshooting Startup Screen (POST) messages

If the EC system encounters a problem at startup to where it cannot initiate system software, a BIOS error message indicating the failure will be displayed.

Message	What it indicates	Troubleshooting Action Required
***NOTE: RTC failed. xx	This indicates an illegal value in the CPU's Real Time Clock date or time registers.	Set the system date and time manually to the correct values.
***NOTE: CMOS defaults reloaded.	This is an informational message.	No action needed.
***NOTE: CMOS battery failed. Replace soon.	Service is required to replace the CPU battery.	Replace the battery on the DU CPU board. Reload software and check out the system.
***NOTE: Alarm tone detection failed.	Service is required to correct a faulty connection to the speaker.	Reconnect the speaker if possible. Replace DU CPU board if speaker connection can not be corrected.
***NOTE: ECC failed. xx	The RAM memory ECC circuitry is faulty.	Replace the DU CPU board.
***NOTE: System reset. EC xx	This usually indicates a software (BIOS) failure.	Report this error, along with the machine logs, to Technical Support. Reload software. If problem persists, replace the DU CPU board.
***NOTE: Critical hardware failure. xx	Some of the DU hardware could not be initialized.	Replace the DU CPU board.
***NOTE: OS/App ROM CRC failed.	The software must be reloaded.	Reload software and check out the system.
***NOTE: System reset.	The software must be reloaded.	Reload Software and check out the system.

Some system failures can result in a High Priority alarm displayed.

Message	What it indicates	Troubleshooting Action Required
VCB/VMB Fail	This usually indicates a software failure.	Report this error, along with the machine logs, to Technical Support. Reload software. If problem persists, replace the DU CPU board.

7.4 Troubleshooting Startup Screen (POST) messages - for HPDU

If the EC system encounters a problem at startup to where it cannot initiate system software, a BIOS error message indicating the failure will be displayed.

Message	What it indicates	Troubleshooting Action Required
***ERROR: CPU data cache fault.	This indicates a hardware failure.	Replace the HPDU CPU board.
***ERROR: No bootable device available.	This indicates a problem with the internal CF card.	Check or replace the internal compact flash card.
***ERROR: Program load failed - CRC.	This usually indicates a software file corruption.	Reload the software and check out the system.
***ERROR: RAM memory error.	This indicates a hardware failure.	Replace the HPDU CPU board.
***ERROR: System reset: ECxx xx xx . . .	This usually indicates a software failure.	Report this error, along with the machine logs, to Technical Support. Reload software. If problem persists, replace the internal flash card and reload software. If problem persists, replace the HPDU CPU board.
***ERROR: System reset: FFFF FF FF	Indicates the HPDU lithium battery has lost contact with the holder or the battery is below voltage.	Replace the lithium battery if below rated voltage. Install the software downloader card to restore system setups.
***ERROR: watchdog circuit failed.	This indicates a hardware failure.	Replace the HPDU CPU board.
***NOTE: Alarm speaker not detected. Check connection.	Service is required to correct a faulty connection to the speaker.	Reconnect the speaker if possible. Replace the HPDU CPU board if speaker connection can not be corrected.
***NOTE: CMOS battery is weak. Please replace.	Service is required to replace the CPU battery.	Replace the battery on the HPDU CPU board. Reload software and check out the system.
***NOTE: RTC date/time error. Battery may be weak.	Service is required to replace the CPU battery.	Replace the battery on the HPDU CPU board. Reload software and check out the system.

Some system failures can result in a High Priority alarm displayed.

Message	What it indicates	Troubleshooting Action Required
VCB/VMB Fail	This usually indicates a software failure.	Report this error, along with the machine logs, to Technical Support. Reload software. If problem persists, replace the HPDU CPU board.

7.5 Troubleshooting the Display - HPDU

Symptom	Resolution
System will not boot from external Compact Flash card during software installation process	1. Verify that the Compact Flash card is properly inserted. 2. Insert a backup Compact Flash card. 3. Open the HPDU and verify that the external Compact Flash card carrier socket (1009-5961-000) is properly seated. 4. Replace external Compact Flash card carrier socket (1009-5961-000). 5. Replace HPDU main PCB.
Display appears mostly white and the green LED is on	1. Verify that the cable connecting the HPDU to the system's rear panel is properly seated. 2. Open the HPDU and verify that the cable connecting the main PCB to the display at J28 is properly seated within the mating housing and check for damage and/or wear. 3. Replace the HPDU.
Rotary encoder fails to work	1. Open the HPDU and verify that the cable connecting the main PCB to the rotary encoder at J38 is properly seated within the mating connector. 2. Verify that the revision of the flex cables connecting the main PCB to the keypads at J23 and J26 are at revision 101 or greater by inspecting the labels directly adhered to the flex cables. 3. Replace the rotary encoder, 4. Replace the HPDU main PCB.
Unit fails to boot and the green LED is on	1. Open the HPDU and ensure that the lithium coin cell at J17 on the main PCB is properly installed. 2. Replace the lithium coin cell at J17 on the main PCB. 3. Verify that the internal Flash card at J10 on the main PCB is properly seated. 4. Attempt to boot the system using a spare compact flash card and replace the card if necessary. 5. Attempt to boot the system from the external Compact Flash card. 6. Replace the HPDU main PCB.
Excessive fan noise	1. Clean the HPDU fan inlet filter. 2. Check for obstructions within the external fan and verify source of fan noise. 3. Open the HPDU and verify internal CPU fan noise. 4. Replace internal or external fan assembly if causing excessive noise.

7.6 Alarm message troubleshooting chart

Note: Whenever “Check/replace harness” is indicated, ensure that all terminals are fully inserted into the connector body window and that all wires are properly crimped.

Troubleshooting guidelines are listed in order of probability. The entire list does not need to be carried out if the problem is resolved. The list may not include all possible solutions.

- Alarm message = display message
- Alarm ID = message in Error log or Event log

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
-none-	DU RAM Error	Failed	Self test failure or multi bit error detected.	Run Backup Ventilation if in Therapy.
• Cycle power. • Replace display unit CPU board.				
-none-	Neo Flow Sensor Comparison	High	(Neo TVexp - Neo TVinsp)>(0.3* Neo TVinsp) or 5 mL whichever is greater for 6 consecutive breaths.	Freeze vent engine volume compensation on first breath detection.
• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB				
-none-	Neo Total Flow Sensor Comparison	High	(Neo TVexp - Neo TVinsp)>(0.3* Neo TVinsp) or 30 mL whichever is greater for 6 consecutive breaths.	Freeze vent engine volume compensation on first breath detection.
• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Calibrate expiratory flow sensor. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace expiratory flow sensor. • Replace total flow sensor. • Replace VMB. • Repace motherboard. • Replace VCB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
-none-	Neo Exh Flow Sensor Comparison	High	(Exh TVexp - Neo TVexp) > (0.3* Neo TVexp) or 30 mL whichever is greater for 6 consecutive breaths.	
• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Calibrate expiratory flow sensor. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace expiratory flow sensor. • Replace VMB. • Repace motherboard. • Replace VCB.				
-none-	Therapy Power Off	High	Power switch is set to Off.	Non-silenceable.
• Normal operation if On/Standby switch is moved to standby while in therapy. • Verify vent is in standby state prior to turning power On/Standby switch to standby. • Verify display unit encoder accepts other inputs reliably. If not, replace encoder. • Check/replace harness to On/Standby switch. • Check/replace On/Standby switch. • Check/replace PMB.				
Air supply pressure high	Air Supply Pres High	Low	Air supply pressure > 95 psig for more than 0.5 seconds	May result in FiO2 low alarm.
• Check air supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, replace supply pressure sensor. • If not, check/replace VMB.				
Air supply pressure low Flow Wave: O2 only	Air Supply Pres Low	Medium	Air supply pressure < 24.3 psig for more than 0.5 seconds	Unit shuts down Air supply and delivers 100% Oxygen
• Check air supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If not harness, check/replace VMB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Air temp high Flow Wave: O2 only	Temp High	High	Total flow sensor temperature ≥ 48°C	Switch to 100% O2. Air is turned off regardless of other alarm conditions (for example, O2 Supply Low). When the condition clears, the vent changes back to previous known good set O2 mixture.
	• Check inlet air temperature. • Use Service App to check temperatures of air and total flow sensors. • If inlet air temp is NOT high, and if temp from total flow sensor reports more than 9°C higher than the air sensor, replace Total Flow Sensor. • With a air flow of approximately 10 l/min, verify air and total flows are within 10% of each other.			
Air temp sensor error	Air Temperature Sensor Failure	Low	Out of range air temperature sensor data (range is 0-60 degrees C).	Use total flow temperature for all air flow sensor calculations, including alarms. If total flow sensor temperature not available, use 50°C.
	• Check inlet air temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of air and total flow sensors. Air flow sensor and total flow sensor shall not differ by more than 9°C. • Replace sensors.			
Backup audio failure	Backup Buzzer POST	Medium	Current to buzzer indicates audio is not sounding.	This alarm is logged at start-up and can be de-escalated but cannot be cleared from the screen. The primary and backup alarm audio sounds upon every power-up of the EC system.
	• Check harness connection between PMB/On-Standby switch. • Verify buzzer current with voltage measurement at TP15 on VCB. If voltage IS NOT present, replace PMB. If voltage IS present, replace VCB.			
Backup mode active	Backup Mode Active	Medium	Spontaneous breathing is insufficient or Display Unit failure. System goes into Backup Ventilation mode.	Uses PCV mode and preset settings (customer configurable).
	• Ensure the patient's spontaneous breathing and ventilatory support is adequate. This alarm could be triggered by user errors regarding patient ventilation requirements. See URM for details. • Check error log for communication errors or DU errors.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Cannot calculate FRC	FRC invalid	Low	An FRC measurement was started for FRC or PEEP Inview, but unable to be completed within the last 5 seconds.	
	• Check end tital CO2 reading. • Ensure airway module is available and active. • Stop any active procedures. • Start a new FRC measurement. • Ventilation changes will stop an FRC measurement. • With gas module plugged in, check power supply status LEDs on MIB from bottom of sheetmetal enclosure. If any LEDs are lit, then unplug module. If LEDs remain lit, replace MIB. • Replace gas module.			
Check D-fend CO2 or O2 wave instruction: Check D-fend. Wait 30 sec and press **Normal Screen** to continue.	MGAS D-fend Not Connected >40 Sec MGAS D-fend Not Connected >60 Sec	Low Medium	MGAS communicates that the D-fend module is not installed.	The pump turns Off. If **Normal Screen** is selected the DU commands the MGAS to start sampling again.
	• Check that the sample tube is connected. • Check that the water trap is connected. • Check that the gas outlet is not blocked. • Replace Module.			
Check sample gas out CO2 or O2 waveform instruction: Check sample gas out. Wait 30 sec and press **Normal Screen** to continue.	MGAS Check Sample Gas Out > 40 Sec MGAS Check Sample Gas Out > 60 Sec	Low Medium	MGAS communicates continuous occlusion for 40 seconds. MGAS communicates continuous occlusion for 60 seconds.	The pump turns Off. If **Normal Screen** is selected, the DU commands the MGAS to start sampling again.
	• Check the gas outlet. • Replace module.			
Clean neo flow sensor	Neo Flow Sensor Contaminated	Medium	Neo flow sensor reporting flow > 32 l/min for 4 continuous seconds as measured by the VCB or VMB.	
	• Calibrate neo flow sensor. • Clean neonatal flow sensor • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Connect nebulizer	Nebulizer not Connected	Low	Nebulizer disconnected while nebulization procedure is running.	
	• Re-connect Nebulizer. • Replace Nebulizer cable. • Replace Nebulizer head. • Replace Nebulizer board.			
Controls frozen. Need service	Front Panel Com Fail	High	Display CPU board fails to send life tick for greater than 10 seconds	DU to allow power off confirmation, even in Therapy. *(The Power lock popup will not appear.)*
	• Look for physical damage to the keypad. If damaged, disconnect the internal keypad cable. • If the unit powers up with no failures indicated, replace the membrane switch assembly. • If failure still exists, disconnect each of the the remaining keypad connections (one-by-one) until the failed component is located. Replace the failed component. • If failure still exists with all keypads disconnected, replace the CPU board.			
Display fans failed	CPU Fan Speed Fail CPU Overheat	Medium Medium	CPU fan speed less than 2500 RPM (50% of nominal speed). Temperature reading of either DU thermistor >60°C.	
	• Verify fan connection. • Verify fan is not spinning while powered. If not, then replace fan. • Replace DU CPU board.			
Exp flow sensor failure	Exhalation Flow Sensor Communications Failure	High	Failed communications with exhalation flow sensor.	Use open loop pressure control.
	• Check harness connection between VMB and exhalation flow sensor PCB. • Replace exhalation flow sensor PCB. • Replace VMB.			
Exp Flow sensor error	Exhalation Flow Sensor Comparison	Medium	(TVexp – TVinsp) > (0.3* TVinsp) or 100 mL whichever is greater for 6 consecutive breaths.	Freeze vent engine volume compensation on first breath detected.
	• Using Service App, verify Inspiratory flows match Expiratory flow within tolerance stated above. • Replace expiratory sensor as necessary. • Replace exhalation flow sensor board (EFSB).			
Fans require service	Fan Fail	Medium	Fan Power Status Bits for main fan or vicor fan is low.	
	• Check connections to fans. • Replace broken fan(s).			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
FiO2 control error	Air Flow Sensor Communications Failure	Medium	Loss of communication with Air Flow Sensor.	Use Open Loop valve mixture control. Return to closed loop volume delivery control when cleared.
	• Check Error Log for Air/O2 Insp Flow Sensor Supply Voltage. • If yes: -Disconnect vent engine harness at air flow sensor. If voltage error stops, replace air flow sensor. -Disconnect vent engine harness at O2 flow sensor. If voltage error stops, replace O2 flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to Air Flow Sensor. -Interchange harness connection between air and total flow sensor. -If problem stays with sensor, replace sensor. If alarm follows harness, check/replace harness. If harness is OK, replace VCB.			
FiO2 control error	O2 Flow Sensor Communications Failure	Medium	Loss of communication with O2 Flow Sensor.	Use Open Loop valve mixture control. Return to closed loop volume delivery control when cleared.
	• Check Error Log for Air/O2 Insp Flow Sensor Supply Voltage. • If yes: -Disconnect vent engine harness at air flow sensor. If voltage error stops, replace air flow sensor. -Disconnect vent engine harness at O2 flow sensor. If voltage error stops, replace O2 flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to O2 Flow Sensor. -Interchange harness connection between O2 and total flow sensor. -If problem stays with sensor, replace sensor. If alarm follows harness, check/replace harness. If harness is OK, replace VCB.			
FRC series stopped	FRC series terminated	Low	Set O2 is >set FRC O2 and user decreases the set O2 during a series interval with the last 5 seconds Or Set O2 is <set FRC and user increases the set O2 so that FRC O2 would be > 100% within the last 5 seconds.	Alarm is removed upon state change or when new series is initiated.
	• Verify correct settings. • Restart series.			
Internal power failure **On battery**	PMB DC-DC Fail	Medium	AC supply is OK but batteries are being discharged.	
	• Check screw terminal connections and harness between AC-DC power supply and PMB • Check fuse F1. If not OK, replace PMB. • Replace AC-DC power supply.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Mixed gas temp sensor error	Total Flow Temperature Sensor Failure	Low	Out of range total temperature sensor data or loss of communication.	Use air flow temperature for total flow sensor calculations, including alarms. If air flow sensor temperature not available use 50°C.
	• Check inlet air temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of air and total flow sensors. If either reports temperature out of range (0 to 60°C), replace that sensor.			
Missed scheduled FRC	FRC missed	Low	Another procedure or condition prevented the FRC series measurement from starting within the last 5 seconds.	Series continues (only one measurement was missed).
	• Ensure airway module is available and active. • Stop any active procedures. • Start a new FRC measurement. • Ventilation setting changes will stop an FRC measurement.			
Module fail. No CO2, O2 data	MGAS Sensor Inop > XX	Medium	MGAS communicates hardware failure (RAM failure, ROM checksum error, Error in CPU EEPROM, Error O2 preamp EEPROM, Error in SSSboard EEPROM, Voltage error, or Lamp control failure.)	
	• Replace Module			
Module not compatible	Module Not Compatible	Low	The monitoring module detected is not compatible with system software. Refer to *Airway Modules - Section 5* in the User's Reference manual.	
	• Remove and reseat Module. • Check software revision in the Service Log. • Replace Module.			
Negative airway pressure	Negative Pressure	High	Paw insp < -10 cmH20 for greater than 50 continuous ms.	Latched alarm. PEEP numeric changes to flashing red background.
	• Compare Insp and Exp sensor values using the Service App at zero and 100 cm/H2O. The Insp and Exp pressure sensors should match within ±5 cmH20 (while at 0 cmH2O true pressure) and ±10 cmH2O (while at 100 cmH20 true pressure) • Calibrate pressure sensors. • Refer to pneumatic troubleshooting section for testing zeroing valve. • Check harness connection on VCB and VMB. • Replace sensor as needed.			
Neo flow sensor error	Neonatal Flow Comparison - System	High	Neo flow sensor comparison alarm active or neo-total flow sensor comparison alarm active or neo-exh flow sensor comparison alarm active.	
	• See Neo flow sensor comparison alarm, neo-flow sensor comparison alarm, or neo-exh flow sensor comparison alarm troubleshooting			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Neo flow sensor off	Neo Flow Sensor Off	Medium	Neo flow sensor turned off in neo flow sensor setup menu.	
	• Turn on neo flow sensor.			
Remove airway module	Neo module not compatible	Low	Any MGAS module is installed in the module bay during neo patient type.	
	• Remove module or change patient type to adult or pediatric.			
No neo flow sensor	No Neonatal Flow Sensor - Standby	Low	Both neonatal flow sensor hot wires reporting less than 20 ADC as measured by the VCB or VMB.	
	• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB.			
Neo flow sensor reversed	Neo Flow Sensor Reversed	High	Neo TVinsp more negative than -3 mL for 6 consecutive mechanical breaths.	• Verify FMI 34014 has been completed on unit.
	• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB.			
No neo flow sensor	No Neonatal Flow Sensor - Therapy	High	Both neonatal flow sensor hot wires reporting less than 20 ADC as measured by the VCB or VMB.	
	• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Replace neo flow sensor. Neonatal flow sensor is warranteed for 90 days. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB.			
No battery backup	Degraded Battery	Medium	The total battery voltage is <20VDC -or- Each battery voltage is <10VDC	
	• Verify unit has been connected to mains for more than 24 hours. • Check error log for related messages. • Use Service App to determine charge state. If in trickle charge, replace batteries. • Check/replace harness. • Check/replace PMB.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
No battery backup? (Note "?" in alarm message)	DU to PMB Com Error -or- PMB to DU Com Error	Medium	Communications from the DU to the power controller cannot be established for 10 seconds. -or- Communications from the power controller to the DC cannot be established for 10 seconds.	PMB assumes failed state and allows system to shutdown without confirmation from DU. (This alarm allows vent to be shut down if DU communications is lost.) Note question mark at end of message and no battery status indicator on display.
	• Check error logs for related messages. • Check communication (no software information indicates no communication). • If multiple failures, replace DU CPU board. • Check / replace display cable. • Check (reseat) all connections on all PC boards. • Check/replace DU interface board. • Replace motherboard. • Replace PMB.			
No battery backup? (Note "?"in alarm message)	PMB POST Failure	Medium	Power controller failed CPU self tests	Note question mark at end of message and no battery status indicator on display
	• Cycle power. • Replace PMB.			
No battery backup	Battery Charge Fail -or- Standby Current High	Medium	The system is powered on with a battery current >1.3 amps. -or- System is in Standby and the charge current is >1.7 Amps.	Refer to Section 8.1.3 for more information.
	• Cycle power. • Check/replace harness. • Replace Power Supply. • Replace PMB.			
No battery backup	Battery Fail	Medium	While bulk, over, or float charging any battery is <10.5VDC (short) -or- Battery has been charging for >24h while powered on (sulfated) -or- Voltage >16.5V during bulk or over charging and normal current >0.25 amps (sulfated).	Battery status indicator appears under clock. Refer to Section 8.1.3 for more information.
	• Cycle power. • Check/replace harness. • Replace batteries.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
No battery backup	Battery Missing	Medium	Any battery voltage is between -1.0 and +1.0VDC.	Battery status indicator appears under clock. Refer to Section 8.1.3 for more information.
	• Cycle power. • Check connections/replace harness. • Check/replace fuse. • Replace batteries.			
No battery backup	Battery Reversed Connection	Medium	Any battery voltage is less than -1.0VDC	Battery status indicator appears under clock. Refer to Section 8.1.3 for more information.
	• Cycle power. • Check connections to battery. • Replace batteries. • Replace PMB.			
No battery backup	PMB Self Test Fail	Medium	Power controller failed self tests (memory, voltages, or CPU).	Battery status indicator appears under clock. Refer to Section 8.1.3 for more information.
	• Cycle power. • Replace PMB			
No battery backup	Standby Bulk Charge > 12Hrs	Medium	System is in Standby and the charge mode is bulk charging and the duration has exceeded 12 hours.	Refer to Section 8.1.3 for more information.
	• Check connections • Replace batteries. • Replace PMB.			
No D-lite sensor?	MGAS source D-lite off	High	MGAS Ppeak< 3 cmH2O and (MGAS Ppeak +5 cmH2O < Vent Ppeak) for 3 consecutive breaths.	
	• Verify tube connections at D-lite sensor. • Replace D-lite sensor and tubing. • See Module TRM for additional troubleshooting information.			
No exp flow sensor	No Exhal Flow Sensor	High	No Exhalation Flow Sensor connected	Use Open Loop pressure control. This alarm can be suspended.
	• Check Exhalation flow sensor connection. • Replace Exhalation Flow Sensor. Waranteed for 90 days. • Verify low pressure leak test passes. • Check/replace interface PCB and flex circuit. • Check/replace exhalation flow sensor PCB.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
No gas supply pressure	No Supply Pressure	High	O2 supply pressure and air supply pressure < 24.3 psi for more than 0.5 seconds	Continue 100% gas flow of whichever gas has the higher pressure value at the onset of the alarm; if both are equal, use 100% O2.
• Check O2 and Air supply pressures. • Check/replace harness between sensor and VMB. • Check error log for reference voltage errors. • Check/replace VMB.				
O2 sensor failure	O2 Sensor Fail	Medium	Out of range O2 sensor (Paracube) data greater than 103% or communication error	
• Calibrate O2 sensor with Checkout (ensure both Air and O2 gas supply are connected). • Calibrate O2 sensor with Service App (ensure both Air and O2 gas supply are connected). • Verify O2 Concentration sensor voltage error is not present in error log. • Check/replace harness. • Check/replace O2 sensor. • Check/replace VMB.				
O2 supply pressure high	O2 Supply Pres High	Low	O2 supply pressure > 95 psi for more than 0.5 seconds	
• Check O2 supply. • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, replace supply pressure sensor. • If not, check/replace harness. • If not harness, check/replace VMB.				
O2 supply pressure low Flow Wave: Air only	O2 Supply Pres Low	Medium	O2 supply pressure < 24.3 psi for more than 0.5 seconds	Latched De-escalatable Go to 100% Air.
• Check O2 supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If not harness, replace VMB.				
O2 temp sensor error	O2 Temperature Sensor Failure	Low	Out of range O2 temperature sensor data. (range is 0-60 degrees C)	
• Check inlet O2 temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of O2 and total flow sensors. O2 flow sensor and total flow sensor shall not differ by more than 9°C. • Replace sensors.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
On battery	Low Internal Battery – 30 Min	Medium	Mains power not available. Internal battery supply < 30 minutes calculated via battery discharge algorithm.	
On battery	On Battery	Medium	Mains power not available. System powered by internal battery for more than 300 ms.	
• Normal alarm if system is operating on battery. • Check connection to AC supply (verify green LED on DU is lit). • If LED is not lit, check AC mains source, check rear power cord clamp, check fuses. • If LED is lit, check output of DC power supply at screw terminals. Range is 20-32 V. If out of range, disconnect DC power supply input harness and verify output is still out of range. Check/replace DC power supply input harness. If out of range and harness is OK, replace DC power supply. • Measure voltage at F1 (both sides) on PMB. Range is 20-32V. • Check/replace fuse F1 on PMB. • Replace PMB.				
Pair sensor out of range	Air Supply Pressure Sensor Out of Range	Low	Out of range Air supply pressure sensor data. Range is 195 to 4760 mV	
• Check Air supply • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If harness OK, replace VMB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Patient connected?	Standby Patient Detection	High	Paw insp or Paw exp > 3 cmH2O when bias flow set to 3 l/min air or O2 (if Air not available) and exhalation valve set to 6 cmH2O for 3 seconds.	Non-silencable Audible in Standby and Monitoring states. When placed in Standby state either by the user or after power up, the ventilator will maintain a bias flow so as to detect if a patient has been attached to the circuit. This functionality alerts for an inadvertent attachment of the patient without the user actuating ventilation. The Standby menu shall be displayed with the highlight on Start Ventilation when alarm is initially activated.
	Suction patient detection		Paw exp> 3 cmH2O for approx. 1 second Or Paw exp< -0.5 cm H2O for approx. 1 second Or Or Exp Flow< -1 l/min for 1 second	
• Was patient connected during standby state? If yes, this is a user error. If no: • Remove all tube connections from vent. If alarm persists, check exhalation pressure port and exhalation valve housing. • Calibrate Flow control valves. • Calibrate airway pressure transducers. • Using the Service App and occluded circuit, set 3 l/min flow, and set 6 cmH2O on exh. Valve. Ensure both Insp and Exp pressure sensors read 6 ±3 cmH2O. Open circuit and verify pressure is < 2 cmH2O. • Check/replace zero valves. • Replace appropriate pressure sensor board. • Replace appropriate flow control valve.				
Paux high	Paux High	Low	Paux > 100 cmH2O	De-energize Paux purge valve (if purge valve is energized) until alarm condition clears.
• Verify Paux port (and any tubing that is connected to Paux port) is not occluded when purge valve is energized (purge is turned ON). • Zero Paux pressure sensor. • Use the Service App to calibrate the Paux pressure sensor (Section 5.2.8). • Interchange Paux and Pexp connections. If Paux high alarm stops, replace Paux sensor. • If Paux High alarm continues, replace VCB.				
Paux sensor out of range	Paux Sensor out of range	Low	Paux sensor data out of range. Range: 10-4095 mV	
• Check/replace harness. • Interchange Paux and Pexp connections. If Paux alarm stops, replace Paux sensor. • If Paux alarm continues, replace VCB				
Paux sensor out of range	Paux Zeroing Error	Low	Range for zero pressure: 631-968 mV (counts)	If failed, use previous known good offset value for Paux.
• Verify Paux port (and any tubing that is connected to Paux port) is not occluded when purge valve is energized (Purge is turned ON). • Zero Paux pressure sensor. • Check/replace harness. • Interchange Paux and Pexp connections. If Paux alarm stops, replace Paux sensor. • If Paux alarm continues, replace VCB				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Pbaro sensor out of range	Barometric Pressure Sensor Out of Range	Low	Out of range barometric pressure data. Range: 2163-4340 mV or 732-1196 cmH2O	The EC will use the entered altitude setting to determine the calculated barometric pressure value.
	• Calibrate the barometric sensor (refer to Section 8.7.4). • Replace VMB (recalibrate barometric sensor).			
Pexp sensor out of range	Paw exp Sensor Out of Range	High	Out of range Paw exp sensor data. Range: 10-4095 mV	
	• Check/replace harness. • Interchange Paux and Pexp connections. If Pexp alarm stops, replace Pexp sensor. • If Pexp alarm continues, replace VMB.			
Pexp sensor out of range	Paw exp Zeroing Error	Low	Range for zero pressure: 631-968 mV (counts)	If failed, vent uses previous known good offset value for Paw exp
	• Verify Pexp port is not occluded. • Zero Pexp pressure sensor. • Check/replace zeroing valve. • Check/replace harness. • Interchange Paux and Pexp connections. If Pexp alarm stops, replace Pexp sensor. • If Pexp alarm continues, replace VMB.			
Pinsp sensor out of range	Paw insp Sensor Out of Range	High	Out of range Paw insp sensor data >= 50 ms or Inspiratory Pressure Zero Valve energized for >=1 second. Range: 10-4095 mV	
	• Check/replace harness. • Interchange Paux and Pinsp connections. If Pinsp alarm stops, replace Pinsp sensor. • If Pinsp alarm continues, replace VCB			
Pinsp sensor out of range	Paw insp Zeroing Error	Low	Range for zero pressure: 631-968 mV (counts)	If failed, vent uses previous known good offset value for Paw insp.
	• Zero Pinsp pressure sensor. • Check/replace zeroing valve. • Check/replace harness. • Interchange Paux and Pinsp connections. If Pinsp alarm stops, replace Pinsp sensor. • If Pinsp alarm continues, replace VCB.			
PO2 sensor out of range	O2 Supply Pressure Sensor Out of Range	Low	Out of range O2 supply pressure sensor data. Range is 195 to 4760 mV	
	• Check O2 supply. • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, then check/replace harness. • If not harness, then replace VMB			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Pressure sensor failure	Paw Cross- Check	High	Paw exp – Paw insp > 10 cmH2O for more than 100 ms	
	• Verify Pexp port is not occluded. • Check airway pressure transducer calibration(s) at 0, 50, and 100cmH2O. Calibrate if necessary. • Check/replace zeroing valve(s). • Check/replace harness. • Check/replace pressure transducer(s). • Check/replace VCB or VMB.			
Primary audio failure	Alarm Confirm Error	High	If the DU detects a speaker current sense bit false when attempting to sound the speaker.	Audible in Standby and Monitoring. De-escalates to Low priority. VCB/VMB will receive data from DU indicating: 1) High priority alarm successfully sounded. 2) High priority alarm not successfully sounded. 3) No High priority alarm currently active. The VMB or VCB will activate the backup buzzer when condition 2 in the special behavior column is active or if condition 1 in the special behavior column is not detected within 15 seconds of the VCB or VMB issuing A high priority alarm. (All high priority alarms that have the VCB or VMB as the source will activate this alarm.)
	• Adjust speaker volume to its highest volume. If alarm stops, replace DU speaker. • Check DU speaker connection. • Replace speaker. • Replace DU CPU board.			
Relief valve failure Paw and Flow Wave: Ventilation not available	Safety Valve Checkout Failure	High	Failed Safety Relief Valve Checkout. Paw reaches 30 cmH2O within 4 seconds of the start of the check.	User cannot enter Therapy state after a powerup until removal criteria is met.
	• Check for pneumatic leaks. • Verify seat/seal interface is clean. • Verify safety valve relief port (bottom of ventilator) is not blocked. • Perform the *Mechanical over-pressure valve test* (Section 5.2.12). Removal requires successful checkout.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Replace D-fend CO2 or O2 wave: Replace D-fend	MGAS Inlet Filter Residue >40 Sec	Low	MGAS communicates: Residue buildup on the water trap membrane. This decreases airflow.	De-escalatable. The pump turns Off. If a **Normal Screen** push is detected, the DU commands the MGAS to start sampling again.
• Replace D-fend.				
Replace neo flow sensor	Neo Flow Sensor Failure	High	Neo flow sensor with 1 hot wire reporting less than 20 ADC and other hot wire reporting normal as measured by VCB or VMB.	
• Calibrate neo flow sensor. • Check neo flow sensor and cable connections. • Replace neo flow sensor. • Replace neo flow sensor cable. • Replace VMB. • Repace motherboard. • Replace VCB				
Sample line blocked CO2 or O2 waveform instruction: Continuous blockage. Check sample line and D–fend. Wait 30 seconds and press Normal Screen to continue.	MGAS Line Blocked >40 Sec MGAS Line Blocked >60 Sec	Low Medium	MGAS communicates: The sample tubing inside or outside the monitor blocked, or the water trap is occluded.	De-escalatable. The pump turns Off. If a **Normal Screen** push is detected, the DU commands the MGAS to start sampling again.
• Replace the sample line. • Replace D-fend.				
SBT ends < 2 minutes	SBT<2 minutes	Low	SBT countdown time reaches 2 minutes	
•				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure. Service required**	DU to VCB Com Error	Failed	Proper communications from the DU to the VCB is not successfully completed within 90 seconds after startup or within a 10 second window after communications have been established with the DU.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VMB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VCB is fully inserted into mother board. -Verify yellow VCB communications activity indicator CR16 (RX DU) is lit and blinking. If not blinking: -Replace VCB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				
Failed State message: **System failure. Service required**	DU to VMB Com Error	Failed	Proper communications from the DU to the VMB is not successfully completed within 90 seconds after startup or within a 10 second window after communications have been established with the DU.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VMB is fully inserted into motherboard. -Replace VMB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure. Service required**	Processor Reset	Failed	Sequential watchdogs cause a processor reset on either VCB or VMB.	Vent Safe Operation. This requirement is intended to ensure that a SW or watchdog reset (indicating loss of processor control) of either the VCB or VMB will activate the backup audio alarm.
• Cycle power. • Using service card, check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB and VMB. • If no VCB comm., check VCB CR10 red reset indicators. If lit, replace VCB. • If no VMB comm., check VMB CR10 red reset indicators. If lit, replace VMB.				
Failed State message: **System failure. Service required**	VCB to DU Com Error	Failed	Proper communications from the VCB to the DU is not successfully completed within a 10 second window. **Note**: Timing does not start for 90 seconds after power up.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VMB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VCB is fully inserted into mother board. -Verify yellow VCB communications activity indicator CR15 (TX DU) is lit and blinking. If not blinking: -Replace VCB. -Check/replace motherboard. -Check/replace DU CPU board.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure. Service required**	VMB to DU Com Error	Failed	Proper communications from the VMB to the DU is not successfully completed within a 10 second window. **Note**: Timing does not start for 90 seconds after power up.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VMB is fully inserted into mother board. -Replace VMB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				
Failed State message: **System failure. Service required**	VMB to VCB Com Error	Failed	Proper communication of the high speed sensor data from the VMB to the VCB is not successfully completed within a 50 ms window.	
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Check DU/VMB and DU/VCB communication using Service Card. • Verify VMB and VCB are fully inserted into motherboard. • Check/replace VMB. • Check/replace VCB. • Check/replace motherboard.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
System shutdown in <20 min.	Low Internal Battery – 20 Min	High	Mains power not available. Internal battery supply < 20 minutes calculated via battery discharge algorithm.	
System shutdown in <10 min	Low Internal Battery – 10 Min	High	Mains power not available. Internal battery supply < 10 minutes calculated via battery discharge algorithm	
System shutdown in <5 min	Low Internal Battery – 5 Min	High	Mains power not available Internal battery supply < 5 minutes calculated via battery discharge algorithm	
System shutdown in <1 min	Low Internal Battery – 1 Min	High	Mains power not available. Internal battery supply < 1 minute calculated via battery discharge algorithm	
• Normal alarm if system is operating on battery. • Check connection to AC supply (verify green LED on DU is lit). • If LED is not lit, check AC mains source, check rear power cord clamp, check fuses. • If LED is lit, check output of DC power supply at screw terminals. Range is 20-32 V. If out of range, disconnect DC power supply input harness and verify output is still out of range. Check/replace DC power supply input harness. If out of range and harness is OK, replace DC power supply. • Measure voltage at F1 (both sides) on PMB. Range is 20-32V. • Check/replace fuse F1 on PMB. • Replace PMB • Use EC Service Application -PC based (Section 8.5) to verify charge discharge rate.				
Temp high. Shutdown possible Paw Wave Instruction: Check fan filter.	Power Supply Temp High	High	Vicor power supply temperature exceeds 75°C	
• Check main fan filter. • Check/replace fans. • Check error log/power diagnostics for underlying causes such as fan failure indicators or voltage range errors. • Verify ambient is < 40 degrees C. • Replace PMB				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Volume delivery error	Total Flow Sensor Communications Failure	High	Out of range total flow sensor data -or- Loss of communication.	Return to closed loop volume delivery control when cleared.
	• Check Error Log for Total Flow Sensor Supply Voltage. -If yes: - Disconnect harness at flow sensor. If voltage error stops, replace flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to Total Flow Sensor. -Interchange harness connection between air and total flow sensor. -If this alarm stops, replace total flow sensor. If this alarm persists, check/replace harness. If harness is OK, replace VCB.			

7.7 Troubleshooting Service App messages

The VCB Service App screen includes a ***Calibrations and Tests*** section (Section 8.6.5). This section includes a field "*Calibration Running*" that displays messages while a test is in progress. Some messages indicate that the test encountered a problem. Use the following table to help troubleshoot messages that result in a failed test or calibration.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
120 Lpm flow test	Prior to calibration flow valve, make sure system can flow 120 Lpm for at least 1 second.	None
125 Cal Point Too High: Value	Exhalation valve calibration point at 1.25 cmH2O was above 1.30 cmH2O. Value = pressure (cmH2O x 100) recorded at the 1.25 cm H2O cal point.	Verify exhalation housing and assembly are seated properly.
300 point too high	Flow valve calibration point targeting 300 mLpm was measured above 290 mLpm and could not be extrapolated down.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Aborted	Calibration or test in progress has been aborted.	None
Air Flow Sensor Chk	Air Flow Sensor Chk is in progress.	None
Air Flow Sensor Chk Complete	Air Flow Sensor Check passed.	None
Air Flow Sensor Chk Fail	Air Flow Sensor Check failed.	See previous message in status log for cause of failure.
Air Flow Sensor Fail: No Air	Air Flow Sensor step of Checkout has failed because no low/no air supply pressure was detected.	Verify proper supply pressure.
Air Flush Time: Value sec	Value = time (sec) needed to flush system with Air until stability of 0.1% O_2 is reached.	None
Air Valve Cal	Air Valve Cal in progress.	None
Air Valve Cal Complete	Air Valve Cal passed.	None
Air Valve Cal Fail	Air Valve Cal failed.	See previous message in status log for cause of failure.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Aux Span Counts: Value	Auxiliary pressure sensor DAC counts that correspond to 100 cmH_2O. (range: 3026 to 3589)	None
Aux Zero	Aux Zero Cal is in progress.	None
Aux Zero Complete	Auz Zero Cal passed.	None
Aux Zero Fail: *value*	Auxiliary pressure sensor zero DAC is out of range. *Value* = measured zero DAC (normal range = 631 to 968)	1. Verify ***Paux*** port is open to atmosphere (either directly or via open tube). 2. Replace zero valve. 3. Replace pressure transducer.
Bad Air Flow	Not able to achieve proper flow during exhalation valve calibration. Set at 4 L/min.	1. Verify FCV is opening to give flow. Should be at least 2 L/min. If no flow, replace FCV.
Bad Low Pressure: *value*	Lowest pressure achieved during exhalation valve cal > 2.5 cmH_2O. *Value* = lowest pressure achieved in cmH_2Ox100	1. Verify exhalation valve assembly is properly assembled and latched to outlet manifold. 2. Verify tube connecting Insp port to Exp port is not occluded/kinked.
Bad O2 Flow	Not able to achieve proper flow during exhalation valve calibration. Set at 4 L/min.	1. Verify FCV is opening to give flow. Should be at least 2 L/min. If no flow, replace FCV.
Barometric Chk	Barometric pressure sensor check in progress.	None
Barometric Chk Complete	Barometric Chk passed.	None
Barometric Chk Fail	During Barometric pressure check, barometric pressure sensor and calculated baro pressure from set altitude differ by more than 20% of calculated baro pressure.	Refer to Section 7.1.2.
Calibrating Flow Valve	Calibrating Flow Valve.	None
Can't Achieve 80cmH2O	Exhalation valve calibration can not generate 80 cmH_2O pressure in the breathing circuit.	1. Verify flow > 1 L/min from FCV. Recal if necessary. 2. Verify breathing circuit is connected and not leaking. 3. Verify low pressure vent engine system is not leaking. 4. Verify clean exhalation housing seat/seal. Replace parts as necessary. 5. Verify power to exhalation valve actuator. 6. Check/replace harness. 7. Replace VCB.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Can't Establish Pressure: Flow	During Checkout step, unable to achieve 8 Lpm with which to attempt to reach 34 cmH2O.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Can't Extrapolate Table	During flow valve calibration, if a weak or restricted gas supply pressure requires the 140 or 160 L/min points to be extrapolated and the calculated value is > 65,000 DAC counts, this message comes up. This results in maximum flow limited to whatever is the highest flow point in the calibration table.	Check for a weak or restricted gas supply pressure.
Can't Pressurize: Value	During Paw transducer check, the breathing circuit could not reach 33 cmH_2O. During Relief Valve check, the breathing circuit could not reach 30 cmH_2O. During Exh Valve Cal Check, the exp pressure does not stabilize within 0.1 cmH_2O within 12 seconds. Value = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Can't Pressurize1: Value	During 1st half of Low Pressure leak check, the breathing circuit could not reach 34 cmH_2O. Value = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Can't Pressurize2: Value	During 2nd half of Low Pressure leak check, the breathing circuit could not reach 25 cmH2O. Value = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Checking Supply Press1	During FCV calibration, the source and integrity of the gas supply (compressor or wall supply) is being tested.	None; normal operation.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Checking Supply Press2	During FCV calibration, the source and integrity of the gas supply (compressor or wall supply) is being tested.	None; normal operation.
Checking Supply Press3: Value	During FCV calibration, the source and integrity of the gas supply (compressor or wall supply) is being tested. *Value* = measured supply pressure (psi)	None; normal operation.
Checkout Aborted	Checkout Aborted	None
Checkout Done	Checkout Done	None
Ci=Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Disabling normalization - invalid leak	Leak value measured by checkout is greater than 0.5 Lpm; expiratory flow sensor normalization is being disabled.	1.Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Disagree Temp: Value	During Air (or O_2) flow sensor check, air flow sensor temp is more than 9 ˚C different than total flow sensor temp. Value = temperature difference (˚C)	1. If only one flow check fails, replace that flow sensor. 2. If both Air and O_2 flow check fails, replace total flow sensor.
Disagree Tot: Value1 Air: Value2	During air flow sensor check, air flow sensor is more than 15% different than total flow sensor at a nominal flow of 30 L/min. Value1 = measured total flow. Value2 = measured air flow.	Check regulator for oscillation. Replace if necessary.
Downstream Flow Diff: Value	Difference between flow measured by total flow sensor and expiratory wire of neonatal flow sensor during Checkout (mLpm).	None; for information only.
End Pressure: Value	Exhalation valve check: Value = time required to relieve pressure in system from 34 cmH_2O to less than 2 cmH2O. Must be less than 250 msec to pass.	Refer to Section 7.1.5.
Exh Flow Sensor Chk	Exhalation flow sensor check in progress.	None
Exh Flow Sensor Chk Complete	Exhalation flow sensor check passed.	None
Exh Flow Sensor Chk Fail	Exhalation flow sensor check failed.	See previous message in status log for cause of failure.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Exh Valve Cal	Exhalation valve calibration in progress.	None
Exh Valve Cal Chk	Exhalation valve check in progress.	None
Exh Valve Cal Chk Complete	Exhalation valve calibration passed.	None
Exh Valve Cal Chk Fail	Exhalation valve cal check failed.	See previous message in status log for cause of failure.
Exh Valve Cal Complete	Exhalation valve cal check passed.	None
Exh Valve Cal Fail	Exhalation valve calibration failed.	See previous message in status log for cause of failure.
Exp Flow Cal	Expiratory flow sensor calibration in progress.	None
Exp Valve Step Sweep Done	Exp valve sweep complete.	None
Exp Valve Sweep	Exp valve step sweep in progress.	None
FAIL No 120 Min: Value	Flow valve cal timeout: never made it to 1 20 L/min of flow during flow valve cal.	Check for weak or restricted gas pressure supply. If EC Service Application is connected, insure flow valves and exhalation valve DAC counts are set to "0" and checked "on".
Failed 120lpm flow: Value	During FCV calibration - could not hold 1 20 L/min flow for 1 second before supply pressure drops below 30 psi.	Check for weak or restricted gas pressure supply.
Failed Supply Press: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press2: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press3: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press4: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press5: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press6: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press7: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press8: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Failed Supply Press9: Value	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
fCompliance = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
fCorrectedLeak = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Final Flow Achieved: Value	Flow value (mLpm) achieved during current Checkout step.	None; for information only.
Final Rising Flow Achieved: Value	Flow value (mLpm) achieved during current Checkout step.	None; for information only.
fLeak = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Flow Cal - Waiting for Sensiron	Total flow sensor is being set up to read the proper gas for the current valve calibration.	None
Flow Diff: Value	Exhalation flow sensor check: *Value* = flow difference between insp (total) flow sensor and exh flow sensor (mL/min). Must be less than 20% difference. |Exp flow - tot flow| < 0.20 * tot flow.	Refer to Section 7.1.6.
Flow Too High: Value	During FCV calibration, the FCV is leaking more than 1150 mL/min. *Value* = leak in smL/min.	1. Run approximately 160 L/min flow through the FCV to dislodge any debris that might be present on the valve seat/seal. 2. Recal/Replace FCV.
Flow Valve Cal Complete	Flow valve cal passed.	None
Flow Valve Cal Fail	Flow valve cal failed.	See previous message in status log for cause of failure.
Flow Valve DAC Too Low	FCV- DAC counts went too low without a corresponding decrease in flow.	1. Check flow sensor. 2. Check for sticking valve.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Flow/O2 Disagree: Value1/Value2	During checkout, the O_2 sensor check failed. O_2 and Air flow set to 15 L/min. The O_2% is calculated from the O_2 and Air flow sensors and compared to the measured O_2% from the paracube O_2 sensor. If the absolute difference between the O_2 sensor and the calculated O_2% from flow measurement is > 5% O_2, then the check fails. Value1 = %O_2 measured from flow sensors Value2 = %O_2 measured from paracube	1. Using the Service App, create a flow of approximately 15 L/min on the air channel. 2. Verify (Tot Flow - Air Flow) < (0.15 * Air Flow). 3. If not, replace air pressure regulator. 4. Using the Service App, create a flow of approximately 15 L/min on the O_2 channel. 5. Verify (Tot Flow - O_2 Flow) < (0.15 * O_2 Flow). 6. If not, replace O_2 pressure regulator. 7. Recalibrate O_2 sensor. 8. Repeat tests 2 and 5. If only one fails, replace that channel's flow sensor. If both fail, replace total flow sensor. 9. Replace O_2 sensor.
fPressureDifference1 = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
fPressureDifference2 = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Guaranteed Flow Not Achieved: Value	Could not bring the flow down to the target flow with the minimum flow command. Value = minimum flow that was achieved (mLpm).	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
High Pres Air Leak Test Fail (Baro)	Vent engine high air pressure leak test failed because of invalid (low) barometric pressure reading.	1. Verify correct altitude setting. 2. If the seating is correct, calibrate the barometric sensor. 3. Replace Vent Monitor Board (VMB)
High Pres O2 Leak Test Fail (Baro)	Vent engine high O2 pressure leak test failed because of invalid (low) barometric pressure reading.	1. Verify correct altitude setting. 2. If the setting is correct, calibrate the barometric sensor. 3. Replace Vent Monitor Board (VMB).
High Pressure Air Leak Test	Vent engine high air pressure leak test in progress.	None
High Pressure Air Leak Test Complete	Vent engine high air pressure leak test passed.	None
High Pressure Air Leak Test Fail	Vent engine high air pressure leak test failed because measured leak was too high.	Refer to Section Section 5.2.7
High Pressure O2 Leak Test	Vent engine high O_2 pressure leak test in progress.	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
High Pressure O2 Leak Test Complete	Vent engine high O2 pressure leak test passed.	None
High Pressure O2 Leak Test Fail	Vent engine high O2 pressure leak test failed because measured leak was too high.	Refer to Section Section 5.2.6
High Pressure: Aborted	The Checkout step in progress was aborted due to high pressure.	1. Verify breathing circuit is properly connected for checkout. 2. Verify proper flow and exhalation valve calibration; recal if necessary.
Insp flow below target: >Target = Value1 >Insp = Value2	Flow cannot be controlled down to the target flow because the measured flow is already lower than the target flow.	1. Check for disconnected breathing circuit during Checkout. 2. Verify proper flow valve calibration; recal if necessary.
Insp Span Counts: Value	Inspiratory pressure sensor DAC counts that correspond to 100 cmH2O. (range: 3026 to 3589)	None
lInspFlowAccumulator= Value1, _jj=*Value2*	Intermediate values in low pressure leak check compliance calculation.	None; for information only.
Low Air Pressure: *value*	Air supply pressure < 30 psig	Verify proper gas supply.
Low Exp Pressure: Value1, Value *2*	During exh valve cal, the pressure dropped more than 1.25 cmH2O in 4 msec. *Value1* = Current measured pressure (cmH2Ox100). *Value2* = Current calibration point	Check for disconnected breathing circuit during calibration.
Low Max Flow: Value	FCV - Indicator that system will use the degraded wall supply routine for FCV calibration.	Check gas supply source to see if it is too weak or restricted if this causes problems.
Low O2 Pressure: Value	O2 supply pressure < 30 psig	Verify proper gas supply.
Low Pres Leak Test Fail (Baro)	Vent engine low pressure leak test failed because of invalid (low) barometric pressure reading.	1. Verify correct altitude setting. 2. If the setting is correct, calibrate the barometric sensor. 3. Replace Vent Monitor Board (VMB)
Low Pressure Leak Chk	Breathing circuit leak check in progress.	None
Low Pressure Leak Chk Complete	Breathing circuit leak check passed.	None
Low Pressure Leak Chk Fail	Breathing circuit leak check failed.	See previous message in status log cause of failure.
Low Pressure Leak Test	Vent engine low pressure leak test in progress.	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Low Pressure Leak Test Complete	Vent engine low pressure leak test in progress.	None
Low Pressure Leak Test Fail	Vent engine low pressure leak test failed because leak was too high.	Refer to Section Section 5.2.5
Measure Resis Chk	Breathing circuit resistance measurement in progress.	None
Measure Resis Chk Complete	Breathing circuit resistance measurement completed successfully.	None
Measure Resis Chk Fail	Breathing circuit resistance measurement failed.	See previous message in status log for cause of failure.
Measured Resistance: Value	Resistance measured during Checkout.	None; for information only.
Measuring P0.1	P0.1 procedure in progress	None
Minimum Flow not achieved: Value	Could not achieve minimum flow required for step in Checkout. Value = maximum flow that was achieved (mLpm)	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Neo Flow Sensor Cal	Neonatal flow sensor calibration in progress.	None
Neo Flow Sensor Cal Fail	Neonatal flow sensor calibration failed.	1. Verify neonatal flow sensor is properly connected and properly occluded. Recalibrate the sensor. 2. Clean or replace neonatal flow sensor.
Neo Flow Sensor Cal Pass	Neonatal flow sensor calibration passed.	None
Neonatal Check Failed (20 Lpm)	System was unable to achieve 20 Lpm of flow during the Neonatal checkout.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from control valves. Recal if necessary.
Neonatal Check Failed (Downstream)	The expiratory flow measured by the neonatal flow sensor is more than 25% different from the flow measured by the total flow sensor.	Refer to Section Section 7.1.11

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Neonatal Check Failed (Reaching 30)	System was unable to achieve 30 Lpm of flow during the Neonatal Checkout.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Neonatal Check Failed (Reversed @20)	The neonatal flow sensor indicated reversed flow during the 20 Lpm check during Checkout.	Clean or replace neonatal flow sensor.
Neonatal Check Failed (Reversed @ 30)	The neonatal flow sensor indicated reversed flow during the 30 Lpm check during Checkout.	Clean or replace the neonatal flow sensor.
Neonatal Failed	Neonatal flow sensor check failed because no gas supply was detected.	Verify proper gas supply.
Neonatal Flow Check	Neonatal flow sensor flow check is in progress.	None
Neonatal Zero	Neonatal flow sensor zero check is in progress.	None
Neonatal Zero Failed	Neonatal flow sensor zero check failed because no gas supply was detected.	Verify proper gas supply.
Neonatal Zero Failed (4 Lpm)	Neonatal flow sensor zero check failed because the system was unable to achieve 4 Lpm.	1, Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Neonatal Zero Failed (Expected 0 Flow)	Neonatal flow sensor zero check failed because the neonatal flow sensor measured non-zero flow while occluded.	1. Recalibrate neonatal flow sensor and rerun the Checkout. 2. Clean or replace the flow sensor.
NFS Check (10 Lpm)	Neonatal flow sensor zero check failed because system was unable to reach 10 Lpm prior to the zero.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
NFS Check (30 Lpm)	Neonatal flow sensor zero check failed because system was unable to reach 30 Lpm prior to the zero.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
NFS Checkout Complete	Neonatal flow sensor flow check completed,	None
No Air	Supply pressure for Air is below 30 psi.	Verify proper gas supply.
No Exp Flow Sensor	Expiratory flow sensor is not detected by system.	Verify proper installation of expiratory flow sensor and exhalation housing. Replace expiratory flow sensor if necessary.
No Gas Supply	Supply pressure for both Air and O2 is below 30 psi.	Verify proper gas supply.
No Oxygen	Supply pressure for O2 is below 30 psi.	Verify proper gas supply.
No Supply Pressure	Supply pressure for both Air and O_2 is below 30 psi.	Verify proper gas supply.
None	No calibrations, zero measurements, or checkout tests are running	None
Normalized Flow Comparison Failed: >Target = Value1 >I = Value2 >E = Value3	Normalized expiratory flow and total flow are more than 10% (or 200 mL, whichever is greater) apart. Value1 = Normalization Table flow point being tested (mLpm) Value2 = Inspiratory Flow measured by total flow sensor (mLpm) Value3 = Expiratory flow measured by expiratory flow sensor (mLpm)	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
O2 Flush Time: Value sec	*Value* = time (sec) needed to flush system with O_2 until stability of 0.1% O_2 is reached.	None
O2 Sensor Fail	Failed Paracube communications during O_2 sensor check	Replace Paracube.
O2 Sensor: Failed 100% Cal	Paracube Cal never competed, timed out during 100% O_2 cal	Check paracube sensor.
O2 Sensor: Failed 21% Cal	Paracube Cal never competed, timed out during 21% O_2 cal	Check paracube sensor.
O2 Too Low for 100% Cal	Measured O_2% < 41% during the 100% span calibration of the O2 sensor.	1. Verify proper connection of gases to ventilator. 2. Use the Service App's ***O2 Sensor*** cal to override limits on O_2 sensor calibration. 3. Replace Paracube.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
O2 Too Low for 21% Cal	Measured O_2% < 8% during 21% calibration of O2 sensor.	1. Verify proper connection of gases to ventilator. 2. Use the Service App's ***O2 Sensor*** cal to override limits on O_2 sensor calibration. 3. Replace Paracube.
O2 Valve Cal	O2 Valve Cal in progress	None
O2 Valve Cal Complete	O_2 Valve Cal Passed.	None
O2 Valve Cal Fail	O2 Valve Cal failed.	See previous message in status log for cause of failure.
Oxygen Flow Sensor Chk	Oxygen Flow Sensor Check.	None
Oxygen Sensor Chk Complete	O_2 flow sensor check passed.	None
Oxygen Flow Sensor Chk Fail	Oxygen Flow Sensor Check failed.	See previous message in status log for cause of failure.
Oxygen Flow Sensor Chk Fail: No O2	Oxygen Flow Sensor Check failed because oxygen supply not detected.	Verify proper gas supply.
Oxygen Flow Sensor Fail	Oxygen Flow Sensor Check failed because system was unable to achieve 30 Lpm during check.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Paracube Cal	O_2 Sensor calibration in progress.	None
Paracube Cal Complete	O_2 sensor check passed.	None
Paracube Cal Fail	O2 sensor check failed.	See previous message in status log for cause of failure.
Paracube Chk	Paracube (O_2 sensor) check in progress.	None
Paracube Chk Complete	Paracube (O2 sensor) check passed.	
Paracube Chk Fail	Paracube (O2 sensor) check failed.	See previous message in status log for cause of failure.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Paracube Chk Fail (50/50 Air)	Paracube (O2 sensor) check failed to reach 15 Lpm air flow for 50/50 cal.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Paracube Chk Fail (Air)	Paracube (O2 sensor) check failed 21% cal.	Paracube never completed 21% calibration. Check Paracube.
Paracube Chk Fail (O2)	Paracube (O2 sensor) check failed to reach 30 Lpm O2 flow for O2 cal.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Paracube Fail	Paracube (O2 sensor) check failed to reach 30 Lpm air flow.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Paracube Sensor Fail (50/50 O2)	Paracube (O2 sensor) check failed to reach 15 Lpm O2 flow for 50/50 cal.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Paux Zeroing...	Auxiliary pressure sensor is being zeroed at start of Span Cal.	None
Paw Xducer Check	Airway pressure sensor check in progress.	None
Paw Xducer Check Complete	Airway pressure sensor check passed.	None
Paw Xducer Check Fail	Airway pressure sensor check failed.	See previous message in status log for cause of failure.
Paw Xducer Check Fail (PressureZeroCal)	Pressure sensors were not successfully zeroed.	Refer to Section 7.1.1 and Section 5.2.8.
Paw Xducer OK	Airway pressure sensor check passed.	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Pressure not maintained: *value*	System was unable to maintain at least 25 cmH2O of pressure during relief valve check.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Q1 = Value	Intermediate value in low pressure leak check compliance calculation.	None, for information only.
Relief Pressure: Value	Safety Valve check: *Value* = back pressure generated from 75 L/min flow thru open relief valve. Must be less than 10 cmH_2O to pass.	Refer to Section 7.1.4.
Relief Time: Value	Safety Valve check: *Value* = time required to relieve pressure in system from 34 to less than 2 cmH_2O. Must be less than 250 msec to pass.	Refer to Section 7.1.4.
Relief Valve Chk	Relief valve check in progress.	None
Relief Valve Chk Complete	Relief valve check passed.	None
Relief Valve Chk Fail	Relief valve check failed.	See previous message in status log for cause of failure.
Rising Flow Not Achieved: Value	Could not achieve minimum flow required fro step in Checkout. *Value* = maximum flow that was achieved (mLpm)	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Sensor Disagree: Value	During FCV calibration, if the Air (or O_2) flow sensor disagree by more than: 20% of total flow or 1500 mL/min, whichever is greater, the calibration will fail. *Value* = flow difference between Air (or O_2) flow sensor and total flow sensor.	1. Check regulator for oscillation. 2. If only one FCV cal fails, replace that flow sensor. 3. If both FCV cal fail, replace total flow sensor.
Sensor Removed	Exhalation flow sensor removed prior or during checkout.	Install exh flow sensor and rerun checkout.
Skipping CHECKOUT - not in checkout state	A Checkout command was received by the Vent Control Board (VCB) while it was not in the Checkout sate. This is most often caused by a series of rapidly requested Checkout starts and aborts without allowing Checkout to run in between.	Restart Checkout and allow it to allow it to complete.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Span	Pressure transducer span calibration is in progress.	None
Start Normalization...	Expiratory flow sensor normalization is in progress.	None
T1 =	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
T2 =	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Target flow not reached @ 300	Flow remains greater than the target flow with the minimum flow command during Checkout.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Total: *Value1* 02: *Value2*	During O_2 flow sensor check, O_2 flow sensor is more than 15% different than total flow sensor at a nominal flow of 30 L/min. *Value1* = measured total flow. *Value2* = measured O_2 flow.	1. Check regulator for oscillation. Replace if necessary. 2. If only O_2 flow sensor check fails, replace O_2 flow sensor. If both Air and O_2 flow sensor checks fail, replace total flow sensor.
unbounded Qin = Value	Intermediate value in low pressure leak check compliance calculation.	None; for information only.
Upstream Flow Diff: Value	Difference between flow measured by total flow sensor and inspiratory wire of neonatal flow sensor during Checkout (mLpm).	None; for information only.
Upstream Flow Failed (Upstream)	The inspiratory flow measured by the neonatal flow sensor is more than 15% different from the flow measured by the total flow sensor.	Refer to Section 7.1.11
Valve Step Sweep	Valve step sweep in progress.	None
Valve Step Sweep Aborted	Valve step sweep aborted because maximum flow was reached.	None; normal operation.
Valve Step Sweep Done	Valve step sweep completed.	None
Valve Sweep	Valve sweep in progress.	None
Valve Sweep Done	Valve sweep completed.	None
VMB Exp Flow Sensor Cal Fail	Expiratory flow sensor calibration has failed.	Verify expiratory flow sensor and exhalation housing are properly installed.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
VMB Exp Flow Sensor Cal Pass	Expiratory flow sensor calibration has passed.	None
Waiting for supply pressure	FCV calibration - if a weak supply pressure is used, system will occasionally pause and wait for supply pressure to come back up before resuming FCV cal.	None; normal operation.
Weak Supply Detected1: Value	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply pressure was detected when trying to ramp the flow up to 165 L/min.
Weak Supply Detected2: Value	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply pressure was detected during the 120 L/min flow test.
Weak Supply Detected3: Value	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply was detected during final flow ramp-up before first cal points are taken.
Weak Supply Detected4: Value	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply was detected during final flow ramp-up before first cal points are taken if DAC output reached 65,000 counts before flow reached 170 L/min.
Xducer Error: Value	During Paw Xducer check, the insp and exp pressure difference > 4 cmH_2O. *Value* = pressure difference.	Refer to Section 5.2.8.
Zero flow samp	Error in FCV calibration cal point projection.	Check for weak or restricted gas pressure supply
Zero for flow sampl2	Error in FCV calibration cal point projection.	Check for weak or restricted gas pressure supply
Zero out of range	ADC counts are out of the acceptable zero pressure range for the inspiratory and/or expiratory pressure sensor. The acceptable range for each sensor is 631 to 968 ADC counts.	Refer to Section 5.2.8
Zero Pressure Sensors	Airway pressure sensors are currently being zeroed.	None
Zero Pressure Sensors Complete	Airway pressure sensor zeros are complete.	None

8 Service Diagnostics and Software Download

In this section

8.1 EC Service Application

This section documents the EC Service Application that loads from a PCMCIA card (DU) or Flash Card (HPDU) and is used to download software or to run various diagnostic functions.

To run the application, first set the system power switch to Off. Insert the card carrier (with card and slots facing to the rear) into the rear PCMCIA interface slot of the display unit (behind left side door), then set the system power switch On. The service application will load and display the Main Menu along with the System Information page.

8.1.1 Main menu and system information

The Main Menu appears on the left-hand side of the screen and includes the following selections:

Main Menu	Remarks
Power Diagnostics	Access to the Power Supply Diagnostics functions
Display Diagnostics	Access to the Front Panel Controls
Special Functions	Access to logs and compatibility tables

Software Download	Access to the Software Download function.

Note You can not return to the Diagnostic section of the service application after entering the software download section. You must reboot the system to exit Software Download.

The System Information page appears on the right-hand side of the screen and displays the following system information:

System Information

Subsystem	HW Rev	Serial #	SW Ver #	Boot
Front Panel Cntl	- - -	- - -	XX.XX	XX.XX
Power Monitor Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Vent Monitor Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Vent Control Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Dsply Unit BIOS	XXXX/A/XX	ABCXXXXX	XX.XX	
Dsply Unit App	XXX/A/XX	ABCXXXXX	XX.XX	

Machine Serial Number: ABCDXXXXX

PC Card ID: XXXXXX

8.1.2 Power diagnostics

The service application provides power supply diagnostics for the various circuit boards in the EC ventilator.

Selecting ***Power Diagnostics*** on the Main Menu brings up the following menu selections in the left-hand frame and the instructions in the right-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Power Diagnostics	**Power Diagnostics Instructions**
Power Control Display Unit -> Main Menu	Select a menu item to see the power status and measured voltages. To troubleshoot a power problem, start with the power controller and work forward. Problem voltages are in red.

8.1.3 Power controller power diagnostics

There are two pages of diagnostics for the Power Controller.

Selecting ***Power Control*** brings up the first page of the Power Controller Diagnostics.

Power Diagnostics
Power Control
Display Unit
->Main Menu

(Page 1 of 2)
Power Control Power Diagnostics

Label	Value Format	Units	Normal range
AC Status	OK, Fail		
12Vdc Supply	XX.XX	Vdc	11.70 to 12.30
3.3Vdc Supply	X.XXX	Vdc	3.201 to 3.399
1.5 Vdc Supply	X.XXX	Vdc	1.45 to 1.55
Battery Connected	Yes, No		
Battery Status	Fail, Bulk Chg, Over Chg, Float Chg, Trickle Chg, Discharge		
Battery Current	X.XXX	A	
Battery 1 Volts	XX.X < 6.0 FAIL (red) <10 T Chg (yellow) 10-15.5 (Green)	Vdc	10.0 to 15.5
Battery 2 Volts	XX.X < 6.0 FAIL (red) <10 T Chg (yellow) 10-15.5 (Green)	Vdc	10.0 to 15.5
Calc Battery Time	XX	Min	0 to 30
Date Battery Tested	XX-ABC-XXXX		
Last Full Discharge Time	XXX	Min	
Ext'l Battery Current	X.XX	A	

Turn the ComWheel to select the second page.

Push the ComWheel to return focus to the Power Diagnostics selection menu.

Power Diagnostics
Power Control
Display Unit
->Main Menu

(Page 2 of 2)
Power Control Power Diagnostics

Label	Value Format	Units	Normal range
Board Temperature	<65C OK (green) >65C <75C Warn (Yellow) >75C Fail (red)	Deg C	Upper Limit 64
Fan Speed	Slow, Fast		
Fan 1 Voltage	XX.XX (high fan speed = 23.7V typical) (low fan speed = 20.7V typical)	Vdc	17.5 to 25.0
Fan 1 Status	Fail, OK		
Fan 2 Status	Fail, OK		

Note: Fan 1 is located on the rear cage, Fan 2 is located on the PMB.

Turn the ComWheel to return to the first page.

Push the ComWheel to return focus to the Power Diagnostics selection menu.

Battery Status

Battery Status	Description
Fail	Battery is disconnected from Power Control Power Diagnostics and is in Trickle mode for > 12 hours.
Bulk Chg	Initial phase of battery charging. Battery is at 600 mA when system is running and 1.2 Amps when system is in standby.
Over Chg	Topping off remaining 5-10% of battery capacity and approaching full charge.
Float Chg	Battery is being maintained at full charge.
Trickle Chg	Independent of battery charger. Severely degraded batteries are charged at 25 mA constant current when either battery is 6-10 Vdc and batteries are not connected to Power Control Power Diagnostics.
Discharge	System is running on battery power.

8.1.4 Display Unit Power Diagnostics

Selecting ***Display Unit*** brings up the Display Unit Power Diagnostics page.

Power Diagnostics
Power Control
Display Unit
->Main Menu

Display Unit Power Diagnostics

Label	Value Format	Units	Normal range
5.0Vdc (PCMCIA)	X.XX	Vdc	4.50 to 5.50
3.3Vdc (PCMCIA)	X.XX	Vdc	2.97 to 3.63
5.0Vdc (Fan)	X.XX	Vdc	4.50 to 5.50
5.0Vdc (USB)	X.XX	Vdc	4.50 to 5.50
8.0Vdc (DIS)	X.XX	Vdc	7.20 to 8.80
11Vdc (LCD)	XX.XX	Vdc	10.35 to 13.62

8.2 Display Diagnostics

The service application provides several pages for display diagnostics.

Selecting ***Display Diagnostics*** on the Main Menu brings up the following menu selections in the left-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Display Diagnostics	**Display Diagnostics Instructions**
Test LEDs Test Speaker Test Backlight 1 Test Backlight 2 Test Keys -> Main Menu	Select a menu item To troubleshoot a display problem, start with Test LEDs and work forward

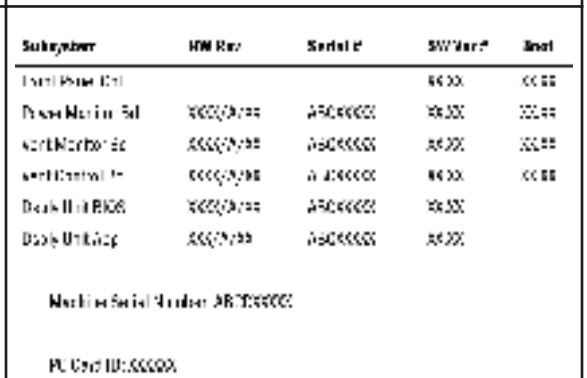
Display Diagnostics	**Action when selected**
Test LEDs	Selecting ***Test LEDs*** causes the red and yellow LEDS next to the **Silence Alarms** key to flash for 10 seconds.
Test Speaker	Selecting ***Test Speaker*** causes the speaker to sound for 5 seconds.
Test Backlight 1	Selecting ***Test Backlight 1*** turns backlight 2 off for 10 seconds. “If screen goes black during test, a backlight is out”
Test Backlight 2	Selecting ***Test Backlight 2*** turns backlight 1 off for 10 seconds. “If screen goes black during test, a backlight is out”
Test Keys	Selecting ***Test Keys*** brings up a representative display of the front panel controls. Pressing a softkey will cause the corresponding key text to be highlighted.
Main Menu	Selecting ***Main Menu*** returns to the Main Menu.

8.3 Special Functions

Selecting ***Special Functions*** on the Main Menu brings up the following menu selections in the left-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Special Functions	System Information
View Error Log	
View Alarm Log	
View Event Log	
View Revision Log	
Compatibility Table	
PC Card Install Log	
View Install Errors	
-> Main Menu	

Error, Alarm, Event Logs

In a functioning system, the Error, Alarm, and Event Logs are accessible on the system's Service Log menu (refer to *Section 4.4.6*). If a system comes up in a "Failed State", you can download the logs to the Service Application PC Card and view them on the Special Functions screen.

1. With the system still in the "Failed State", insert the Service Application PC Card into the Display Unit and press the "Help" softkey.
2. Wait approximately 60 seconds while the logs are downloaded to the card (no apparent activity).
3. Restart the system with the Service Application to view the logs.

Revision and PC Card Install Logs

Whenever a Software Download is completed, the specific software download is recorded in the Revision Log that resides on the system (Display Unit) and in the PC Card Install Log that resides on the PC Card.

Compatibility Table

The Compatibility Table lists the current software components that last downloaded on to the system. In essence, it is the latest listing that appears in the Revision Log, which allows you to view the current log directly without having to scroll to it.

8.3.1 View revision log

Selecting ***View Revisions Log*** brings up the Revision Log for the system. The log includes chronological entries for every Software Download that was completed to the system. Each entry includes two header lines and eight data lines in the following format:

View Revision Log

```
# Software configuration after download on (day) (date) (time)
# SvcApp Ver (XX.XX), Machine Serial Number (ABCDXXXXX) Card # XXXXXXX/
System Version XX.XX
EV FPC,                          *,  (Software Level),  (File Name)  (#---------)  Front Panel Cn
EV PMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Power Monitor
EV VCB,                          *,  (Software Level),  (File Name)  (#XXXXXX) Vent Control B
EV VMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Vent Monitor B
EV DUA,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit App
EV DUB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit BIO
EV DUF,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit Fon
```

Note The Stock Number listed is for the board assembly and may not represent an orderable service item. Refer to the parts lists in Section 10 for service level stock numbers.

The Front Panel Control (FPC), Display Unit Application (DUA), and the Display Unit Flash (DUF) reside, along with the Display Unit BIOS (DUB), on the Display Unit CPU board.

8.3.2 View PC Card install log

Selecting ***View PC Card Install Log*** brings up the PC Card Install Log for the software download card. The log includes chronological entries for every Software Download that was completed with the card. Each entry includes two header lines and eight data lines in the following format:

PC Card Install Log

```
INSTALLATION LOG for PC Card # XXXXXXX

# Software configuration after download on (day) (date) (time)
# SvcApp Ver (XX.XX), Machine Serial Number (ABCDXXXXX), Card # XXXXXXX/
System Version XX.XX
EV FPC,                          *,  (Software Level),  (File Name)  (#---------)  Front Panel Cn
EV PMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Power Monitor
EV VCB,                          *,  (Software Level),  (File Name)  (#XXXXXX) Vent Control B
EV VMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Vent Monitor B
EV DUA,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit App
EV DUB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit BIO
EV DUF,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit Fon
```

8.4 Software Download

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Selecting ***Software Download*** bring up the following information page:

ENTERING SOFTWARE DOWNLOAD MODE!

To return to Diagnostics: turn On/Standby switch to Standby, and turn off AC mains switch in rear. Wait 20 seconds, then turn on power with the AC mains switch and the On/Standby switch.

(Press ComWheel to continue with Download.)

Note You can not return to the Diagnostic section of the service application after entering the software download section. You must reboot the system to exit Software Download.

Entering software download brings up the Software Download menu.

Software Download	Remarks
Download New	Downloads only new software versions not found on the system and compatible with installed subsystem hardware.
Download All	Downloads all software subsystems.

Since downloading all the subsystem software can take an hour or more, you should normally choose “Download New” to install only the updated subsystem software or software required for newly installed subsystems.

Software Download
Download New
Download All

Software Download Status

Subsystem	HW Rev	Current SW Rev	New SW Rev	Status
Front Panel Cntl	- - -	XX.XX	XX.XX	Xxxxxxx
Power Monitor Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxxx
Vent Monitor Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxxx
Vent Control Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxxx
Dsply Unit BIOS	XXXX/A/XX	XX.XX	XX.XX	Xxxxxxx
Dsply Unit App	XXXX/A/XX	- - -	XX.XX	Xxxxxxx
Dsply Unit Fonts	XXXX/A/XX	XX.XX	XX.XX	Xxxxxxx

Loading Xxxx Xxxxxxxxx Xxxxx:
****

Notes about downloading software

If there is no Front Panel Control software installed in the system (as would be the case when the display units control board is replaced), the Service Application automatically downloads the Front Panel Controls software at startup. During the download the two display unit LEDs will flash and the display speaker will sound an alarm tone to indicate that Software Download is proceeding.
To ensure that all software versions on the system are compatible, the end result of "Download All" or "Download New" will be the same. The software loaded on the machine will exactly match what is on the card. Be sure to have the latest/correct version of software before attempting a download to avoid inadvertent overwrites of newer software with an older version.
If, during the "Download New" process, the compatibility checker detects a newer version of software component on the system, a "Notice" appears on the screen that asks you to confirm the downgrade.
"Download All" will download all compatible software from the card to the system without issuing a notice that newer version of software component may be on the system.

Download process

The PCMCIA card includes only the latest software for each subsystem along with the diagnostic application.

As each subsystem software segment is being downloaded, the following status messages note the state of each subsystem and the result of the download:

- ***Busy*** - System is running its application code; not ready for download.
- ***Ready*** - System is in its boot code; ready for download.
- ***CRCtest*** - System is analyzing the download CRC.
- ***Loading*** - System is accepting download data.
- ***Done*** - Software download has completed successfully.
- ***Fail*** - Software download did not complete successfully. A "Fail" message will require reloading of the software; or repair of the system may be necessary.
- ***Skipped*** - Software download was bypassed.
- ***Linked*** - System is communicating, but status is not yet known.
- ***Not Compatible*** - The software version on the PCMCIA card is not compatible with the subsystem.

If the subsystem is communicating but the HW Rev or current SW Rev are not known, the message ***Unknown*** will appear under the columns for those values. If the HW Rev or current SW Rev are not known, the download function will still be available.

As the software loads, an activity bar at the bottom of the screen shows the download progress for each subsystem.

Note If a Communication Failure occurs during software download, power down the system, wait for 20 seconds, and restart system.

Download complete

When all the required subsystem software is downloaded, the following message appears on the screen. You must shut down the system to exit the download function.

DOWNLOAD IS COMPLETE.
Remove PCMCIA card.
Turn OFF AC mains switch in rear.
Disconnect power cord.

Note After powering down the system, be sure to wait at least 20 seconds before restarting the system.

8.5 EC Service Application (PC based)

This section documents the EC Service Application that run on a Windows based computer and communicates with the EC ventilator through the serial port (Port 3).

To enable communication between the EC and the PC Service Application, the EC must be in the Service mode.

8.5.1 Port setup

When the EC serial port is enabled, the PC application presents a port setup menu that allows you to select a COM port for your PC. Select the appropriate COM port and click OK to continue.

Note: Ensure that no other application (such as PDA hot-sync) is using this port while the Service Application is running.

Menu Item	Selections	Default
Port	COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9, COM10	COM1

8.5.2 Main menu and system information

The Main Menu appears on the screen and includes the following selections as shown in the table below:

The main menu includes a Connection Status message area that shows whether or not the program is communicating with the EC.

The VCB and VMB Diagnostics pages can both be displayed at the same time.

Closing the main menu, closes the application.

Main Menu	Selections
VCB	Opens the VCB Diagnostics page.
VMB	Opens the VMB Diagnostics page.

Select Gas Supply units for gas units for display on the VMB screen or select PAW Units to display pressure units for display on the VCB and VMB screens.

Menu Item	Selections	Default
Gas Supply Units (VMB)	psig, kPa, bar	psig
PAW Units (VCB/VMB)	cmH2O, kPa, mbar	cmH2O

8.6 VCB Diagnostics and Calibration

Selecting ***VCB Diagnostics and Calibration*** on the Main Menu brings up the following page that contains five grouped area.

8.6.1 Sensirion sensors

The Sensirion (Inspiratory Flow) Sensors group shows the temperature and the flow through each flow sensor: Total flow, Oxygen, and Air.

Item	Total	Oxygen	Air
Temperature	XXX.X C	XXX.X C	XXX.X C
Flow ml/min	XXXXXX	XXXXXX	XXXXXX

8.6.2 VCB input signal latch

The VCB Input Signal Latch group shows the status of the displayed item.

Item	Description
Module Power	FAIL = Power to the monitor module has failed. OK = Module Power has not failed or module power has been manually shut off.
PSM Power	FAIL = Power to the Patient Side Module has failed. OK = PSM Pwr has not failed or PSM power has been manually shut off.
Insp Press Zero Valve	ON = Inspiratory pressure zero valve on. OFF = Inspiratory pressure zero valve off.
Aux Press Purge Valve	ON = Auxiliary pressure purge valve on. OFF = Auxiliary pressure purge valve off.
Exhalation Vlv Open	YES = VMB is commanding the exhalation valve open. NO = The valve is not opened.
VMB Buzzer On?	YES = VMB is activating the buzzer. NO = Buzzer is not active or is activated by the VCB.
Nebulizer Detected?	YES = Nebulizer is connected. NO = Nebulizer is not connected.
Buzzer Detected?	NO = Buzzer current is too low. Valid when buzzer should be on. YES = Buzzer is sensed. NA = Buzzer not being activated.
Over Pressure	DETECTED = Expiratory over-pressure detected. NOT DETECTED = Over pressure was not detected.
Vcb Pld Rev	Displays the revsion number of the Programmable Logic Device software.

8.6.3 VCB channel configurations

The VCB Channel Configurations group includes items that are measured from the VCB. If the item is within the acceptable range, “OK” is displayed next to the value. If the item is out of the acceptable range, “FAIL” is displayed instead.

Item	Description	Format	Units	Range
Auxiliary Press	Auxiliary pressure sensor measurement	XXX.XX	cmH2O	-20 to 120
Inspiratory Press	Inspiratory pressure sensor measurement	XXX.XX	cmH2O	-20 to 120
Exhalation Volt	Exhalation valve voltage	XXXXX	mV	0 to 12500
Exhalation Current	Exhalation valve current	XXX.X	mA	0 to 815
O2 Flow Current	O2 Flow Valve drive current	XXX.X	mA	0 to 198
Air Flow Current	Air Flow Valve drive current	XXX.X	mA	0 to 198
Nebulizer Power	Nebulizer power (when on) Nebulizer power (when off)	XXXXX XXX	mV mV	On:11500 to 12710 Off: 0 to 500
Ambient Temp	Ambient temperature near the valve drive circuits	XXX.X	C	0 to 55
Module Power	16 V Circuit breaker for module power	XXXXX	mV	15200 to 16800
12.5V Supply	12.5 V Supply Voltage	XXXXX	mV	12040 to 13330
5V Analog	5V analog supply voltage	XXXXX	mV	4800 to 5200
6V Analog	6V analog supply voltage	XXXXX	mV	5760 to 6240
-6V Analog	-6V analog supply voltage	XXXXX	mV	-6240 to -5760
5.5V Analog	5.5V analog supply voltage	XXXXX	mV	5280 to 5720
Insp Flow Power	9V power supply for the O2 and Air inspiratory flow sensors	XXXXX	mV	8530 to 9240
Total Insp Flow Pwr	9V power supply for the total inspiratory flow sensor	XXXXX	mV	8530 to 9240
4.096V Ref	Analog measurement of the independent 4.096V voltage reference	XXXXX	mV	4055 to 4137
Ground	Measurement of the analog ground at the A to D converter	XXXXX	mV	0 to 10

8.6.4 VCB outputs

The VCB Outputs group controls items that can be turned on or off. Items whose default state is “On”, initially have a checkmark in the checkbox. For items whose default state is “Off”, the checkbox is initially unmarked.

Item	Function	Default
Safe Valve Energized	Opens/Closes Safety Valve.	Not checked
Effort Valve Energized	Opens/Closes Inspiratory Effort Maneuver Valve.	Not checked
Nebulizer Enabled	Enables/Disables power to the Nebulizer.	Not checked
Module Reset	Resets modules residing in the module bay.	Not checked
Module Power On	Turns Module Bus power on/off.	Not checked
PSM Power On	Turns Patient Side Monitor power on/off	Not checked
Insp Press Zero	Inspiratory pressure zero valve on/off.	Not checked
Aux Press Purge	Auxiliary pressure purge valve on/off.	Not checked
Buzzer On	Controls the buzzer (On/Off) from the VCB.	Not checked
Air Flow Valve	Enables/Disables Air flow valve. Disabled while a calibration is running.	Checked
Air DAC	Set any DAC value from (decimal) 0 to 65535 for the Air Flow Valve.	0
O2 Flow Valve	Enables/Disables O2 flow valve. Disabled while a calibration is running.	Checked
O2 Dac	Set any DAC value from (decimal) 0 to 65535 for the O2 Flow Valve.	0
Exhal Flow Valve	Enables/Disables Exhalation flow valve. Disabled while a calibration is running.	Checked
Exh Dac	Set any DAC value from (decimal) 0 to 65535 for the Exhalation Flow Valve.	0
Dither Dac	DAC value that adjusts the amplitude of the dither signal to the exhalation valve.	5000
Nurse Call On	Controls the Nurse Call (On/Off) from the VCB. (Port 4, Pins 3, 10 and 11))	Checked

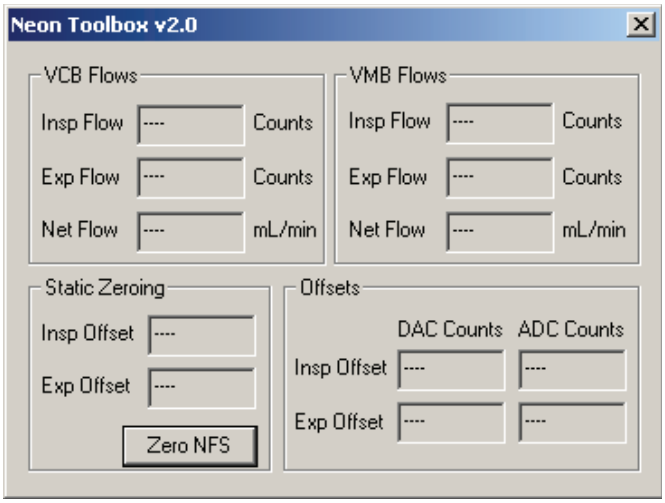
8.6.5 Calibrations and tests

The O2 Flow Valve DAC, Air Flow Valve DAC, and the Exhalation Flow Valve DAC return to their default values when a calibration completes.

Item	Description
Calibration Running	Shows the current calibration that is running.
% Done	The percentage of the calibration that is completed.
Start Paw Span	Starts airway pressure transducer zero and span for all three pressure transducers (Insp, Exp, and Aux).
End Paw Span	Ends airway pressure transducer zero and span for all three pressure transducers (Insp, Exp, and Aux).
Span DAC Value	Exhalation valve DAC counts for the Paw Span Test. Default = 0
Reset DAC	Sets DAC value to zero.
O2 Flow Valve	Runs O2 Flow Valve Test.
Air Flow Valve	Runs Air Flow Valve Test.
Exhal Valve	Runs Exhalation Flow Valve Test.
Cal Tables	Displays a new window showing the calibration tables of the Air Flow Valve, O2 Flow Valve, and Exhal Valve tests.
Zero Pressures	Zeros the Inspiratory and Expiratory pressure sensors.
Exh Flow	Exhalation flow sensor zero.
O2 Sensor	Runs the Paracube O2 sensor test.
Valve Sweep	Runs the Valve Sweep calibration.
Low P Leak	Runs Low Pressure Leak Test.
High O2 Leak	Runs High O2 Pressure Leak Test.
O2 Leak w/o filter	Displays the calculated vent engine high pressure O2 leak without a filter.
O2 leak w/ filter	Displays the calculated vent engine high pressure O2 leak with a filter.
O2 Flow Valve Leak	Displays calculated vent engine high pressure O2 Flow Valve leak.
High Air Leak	Runs High Air Pressure Leak Test.
Air Leak w/o Filter	Displays the calculated vent engine high pressure Air leak without a filter.
Air Leak w/ Filter	Displays the calculated vent engine high pressure Air leak with a filter.
Air Flow Valve Leak	Displays calculated vent engine high pressure Air Flow Valve leak.
Leak Result:	The measured leak from the last Low Pressure, High O2, and High Air leak tests.
Log Calibration results to file:	Enter file name (example D:\testlog1.log).
Find Log File	Searches for a log file that already exists.
Start Logging	Updates selected log as calibrations are completed. Note: The current log overwrites previous entries.
Stop Logging	Turns off the calibration log.

8.6.6 Neon tools

The Neon Toolbox group contains lists of counts, flows, and zero offsets related to the Neonatal Flow Sensor (NFS).



VCB flows

Item	Function	Unit
Insp Flow	Displays the Inspiratory Flow counts reported by the Neonatal Flow Sensor	Counts
Exp Flow	Displays the Expiratory Flow counts reported by the Neonatal Flow Sensor.	Counts
Net Flow	Net Flow is calculated from the counts reported by the Neonatal Flow Sensor and the current zero point. Inspiratory flow is displayed as positive net flow and expiratory flow is displayed as negative net flow.	mL/min

VMB flows

Item	Function	Unit
Insp Flow	Displays the Inspiratory Flow counts reported by the Neonatal Flow Sensor	Counts
Exp Flow	Displays the Expiratory Flow counts reported by the Neonatal Flow Sensor.	Counts
Net Flow	Net Flow is calculated from the counts reported by the Neonatal Flow Sensor and the current zero point. Inspiratory flow is displayed as positive net flow and expiratory flow is displayed as negative net flow.	mL/min

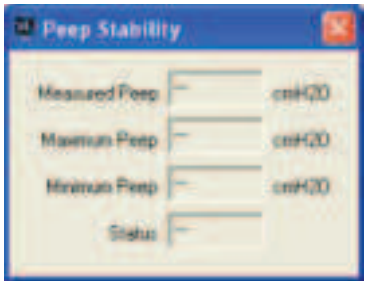
Static zeroing

Item	Function	Unit
Insp Offset	The inspiratory point of the DAC, recorded from the last static zero.	Counts
Exp Offset	The expiratory point of the DAC, recorded from the last static zero.	Counts
Zero NFS	When selected, the system performs a static zero of the Neonatal Flow Sensor.	

Offsets

Item	Function	Unit
Insp Offset (DAC Counts)	Displays the inspiratory DAC zero offset movement from the last recorded static zero. Updated by the dynamic zeroing.	Counts
Exp Offset (DAC Counts)	Displays the expiratory DAC zero offset movement from the last recorded static zero. Updated by the dynamic zeroing.	Counts
Insp Offset (ADC Counts)	Displays the calculated inspiratory zero offset since the last DAC zero movement. Updated by the dynamic zeroing.	Counts
Exp Offset (ADC Counts)	Displays the calculated expiratory zero offset since the last DAC zero movement. Updated by the dynamic zeroing.	Counts

8.6.7 Peep stability



The Peep Stability menu is used by manufacturing only.

8.6.8 Logging checkout results

The ventilator does not have to be in the Service Mode to log the checkout results.

- Power on the system and wait for the Patient Setup menu to display.

  Note: For systems with 4.2X software, wait for the Select Patient menu to display, then select ***Patient Setup menu*** .
- Connect a PC to the system and start the PC Application software (Revision 1.58 or higher).

1. Access the *Log Calibration result to file* area of the PC Service Application and select ***Find Log File***.
2. Select the desired folder from your PC hard drive to store Log Files.
   - Rename the file and select ***OPEN***.
     Suggested file naming convention: Serial Number +date+"ck.log"
   - If a Log File does not exist a message window displays. "Select ***Yes*** to create a Log File."
3. Verify the file address location displayed in the *Log Calibration results to file area* and select ***Start Logging***.
   - The Status Log window displays and indicates that the log has been initialized.
4. From the EC Ventilator, access the ***Patient Setup menu*** and select ***Checkout***.
   - Follow the screen instructions and select ***Start Checkout***.
     Information from the ventilator will begin loading into the log after a few seconds.
5. From the PC, select ***Stop Log*** from the Status Log window after checks are complete.
6. Select ***Save Log*** from Status Log window

As each system checkout occurs the Status Log will display Pass or Fail. If a checkout fails the log will record and display information about the exact parameter that failed. This information is essential in determining the cause for checkout failure(s). **Always include the Log file when iTrak quality reports are submitted.**

8.6.9 Logging Calibration Results

The ventilator must be in the Service Mode to log the calibration results.

- Power on the system and wait for the Patient Setup menu to display.

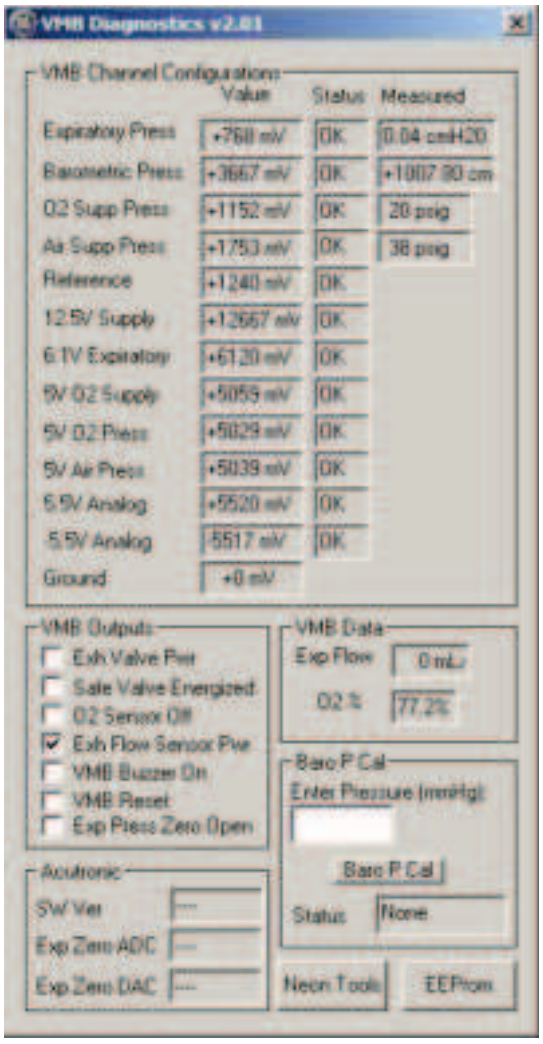
  Note: For systems with 4.2X software, wait for the Select Patient menu to display, then select ***Patient Setup menu*** .

1. Access the Service Calibration menu.
2. Connect a PC to the system and start the PC Application software (Revision 1.58 or higher).
3. Access the *Log Calibration result to file* area of the PC Service Application and select ***Find Log File***.
4. Select the desired folder from the PC hard drive to store Log Files.
   - Rename the file and select ***OPEN***.
     Suggested file naming convention: Serial Number +date+"cal.log"
   - If a Log File does not exist a message window displays. "Select ***Yes*** to create a Log File."
5. Verify the file address location displayed in the *Log Calibration results to file area* and select ***Start Logging***.
   - The Status Log window displays and indicates that the log has been initialized.
6. From the EC Ventilator, access the ***Calibrations menu*** from the ***Install/ Service*** menu.
   - Select each calibration and follow the screen instructions to complete the calibrations.
   - From the PC, select ***Save Log*** from the Status Log window after calibrations are complete. Select ***Ignore*** if "Debug Assertion Failed" message appears.

As each system calibration occurs the Status Log will display Pass or Fail. If a calibration fails the log will record and display information about the exact parameter that failed. This information is essential in determining the cause for calibration failure(s). **Always include the Log file when iTrak quality reports are submitted.**

8.7 VMB Diagnostics

Selecting ***VMB Diagnostics*** on the Main menu brings up the following page that contains five grouped areas.



8.7.1 VMB Channel Configurations

The VMB Channel Configurations group includes items that are measured from the VMB. If the item is within the acceptable range, “OK” is displayed next to the value. If the item is out of the acceptable range, “FAIL” is displayed instead.

Item	Description	Format	Units	Range
Expiratory Press	Expiratory Pressure sensor measurement	XXX.XX	cmH2O	-26.8 to 131.8
Barometric Press	Barometric pressure sensor measurement	XXX.XX	cmH2O	643.7 to 1182.0
O2 Supp Press	O2 supply pressure sensor measurement	XXX.XX	psig	-9.1 to 127.8
Air Supp Press	Air supply pressure sensor measurement	XXX.X	psig	-9.1 to 127.8
Reference	1.22V Reference	XXXXX	mV	1104 to 1338
12.5V Supply	12.5V Power supply to the VMB	XXXXX	mV	10900 to 13320
6.1V Expiratory	6.1V power supply to the expiratory flow sensor	XXXXX	mV	5770 to 6370
5V O2 Supply	5V power supply to the O2 sensor	XXXXX	mV	4720 to 5380
5V O2 Press	5V power supply to the O2 pressure sensor	XXXXX	mV	4680 to 5340
5V Air Press	5V power supply to the Air pressure sensor	XXXXX	mV	4680 to 5340
5.5V Analog	5.5V analog supply	XXXXX	mV	5140 to 5880
-5.5V Analog	-5.5V analog supply	XXXXX	mV	-6220 to -4440
Ground	Ground	XXXXX	mV	

8.7.2 VMB outputs

The VMB Outputs group controls items that can be turned on or off. Items whose default state is “On”, initially have a checkmark in the checkbox. For items whose default state is “Off”, the checkbox is initially unmarked.

Item	Function	Default
Exh Valve Pwr	Opens/closes the exhalation valve (opens when checked).	Not checked
Safe Valve Energized	Opens/closes the safety valve from the VMB (energized when checked).	Not checked
O2 Sensor Off	Turn oxygen sensor On (not checked) or Off (checked)	Not checked
Exh Flow Sensor Pwr	Turn exhalation sensor On (checked) or Off (not checked)	Checked
VMB Buzzer On	The VMB turns the buzzer On/Off.	Not checked
VMB Reset	Resets the VMB (disables the watchdog) when checked.	Not checked
Exp Press Zero Open	Opens/Closes the expiratory pressure zero valve. The valve will be opened when checked.	Not checked

8.7.3 VMB data

The VMB Data group shows the reported values for Expiratory Flow and O_2 concentration.

Item	Description	Format	Units
Exp Flow	Expiratory flow sensor measurement.	XXX.XX	mL/min
O2 %	Measured oxygen concentration from the oxygen sensor.	XXX	%

8.7.4 Baro P cal

Item	Description
Enter Pressure	Enter the local barometric pressure in mmHg. The Baro P Calibration will use this value to calibrate the barometric pressure transducer.
Baro P Cal	Starts the barometric pressure transducer calibration. The calibration will Fail if nothing is entered in the Enter Pressure box.
Status	Displays the results of the barometric calibration (Passed or Failed).

8.7.5 Acutronic

Item	Description
SW Ver	Software version of the acutronic Sensor software.
Exp Zero ADC	Displays the Analog to Digital Counter zero value fro the expiratory flow sensor.
Exp Zero DAC	Displays the Digital to Analog Counter used to zero the expiratory flow sensor.

8.7.6 EEProm

EEProm is used by manufacturing only.

9 Repair Procedures

In this section

⚠ **WARNING** To prevent fires:

- Use lubricants approved for O_2 environments, such as Krytox. Other lubricants may burn or explode in high O_2 concentrations.
- All covers used on the system must be made from antistatic materials. Static electricity can cause fires in high O_2 concentrations.

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

⚠ A movable part or a removable component may present a pinch or a crush hazard. Use care when moving or replacing system parts and components.

⚠ Some internal parts have sharp edges and can cause cuts or abrasions. Use care when servicing internal components.

⚠ When servicing the EC, extreme care must be taken to avoid introducing foreign debris into the pneumatic flow passages of the ventilator. This includes dust and contaminants on the vent engine and particularly metal chips generated by screw threads. Before removing components on the vent engine, secure a clean work area and thoroughly clean the vent engine to remove any contaminants. Failure to do so may result in damage to the internal components.

⚠ After repairs are completed, always perform the checkout procedure. Refer to Section 3 of this manual.

⚠ **CAUTION** Electrostatic discharge through circuit boards may damage the components on them. Wear a static control wrist strap before touching the circuit boards. Handle all circuit boards by their non-conductive edges. Use anti-static containers when transporting them.

9.1 Circuit Board Replacement precautions

The EC stores the system serial number and installed optional features (if any) in three locations:

- Display Unit CPU board
- Vent Control board (VCB)
- Power Monitor board (PMB)

Each time the system is powered up, the software checks to ensure that the information stored in these locations is the same.

If, on power up, only two of the three boards have matching information (such as would be if one of these boards is replaced), the software loads the information from the two matching boards to the third board. This scheme allows for replacement of these boards while retaining machine specific parameters.

Note: No checking or replication occurs when the Service App is loaded. The unit must be powered up with system software.

Caution Do not replace more than one of these boards at a time without first powering up the unit. Wait until the initial checkout menu appears to insure that the machine specific information has been replicated.

9.1.1 Software download

After replacing any of the following boards, download the current software for the newly installed subsystem (refer to Section 8.4):

- Display Unit CPU board (or a replacement HPDU)
- Power Monitor board (PMB)
- Vent Monitor board (VMB)
- Vent Control board (VCB)

9.1.2 Required calibrations

When repairs are complete, if either the VMB or the VCB were replaced, the following calibrations must be performed before completing the checkout procedure.

If the VMB is replaced,

- calibrate the airway pressure transducers (refer to Section 5.2.8).
- calibrate the barometric pressure transducer (refer to Section 8.7.4).

If the VCB is replaced,

- calibrate the airway pressure transducers (refer to Section 5.2.8).
- calibrate the flow control valves — O2 FCV, Air FCV, and Exhalation Valve (refer to Section 4.3).

9.2 How to bleed gas pressure from the machine

Before disconnecting pneumatic fittings, bleed all gas pressure from the ventilator.

1. Disconnect all gas supplies from the source.
2. Set the system switch to On.
3. Ensure that all pressures read zero.
4. Establish a flow for the affected gas to bleed down the pressure.
5. Set the system switch to Standby.

9.3 Accessing chassis components

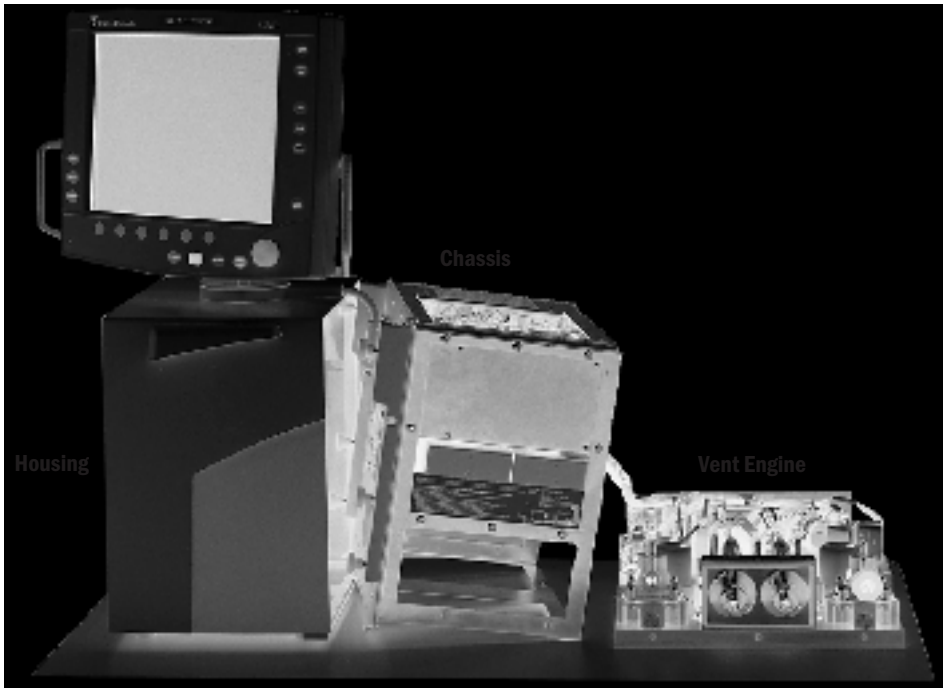
Most of the EC components are mounted to a two-tier chassis that slides out of the housing for access to the internal components.

The pneumatic (and related Vent Engine) components are mounted on a manifold that occupies the lower tier of the chassis. To access the pneumatic components, the entire manifold assembly can be removed from the chassis.

The electrical (and related circuit board) components occupy the upper tier.

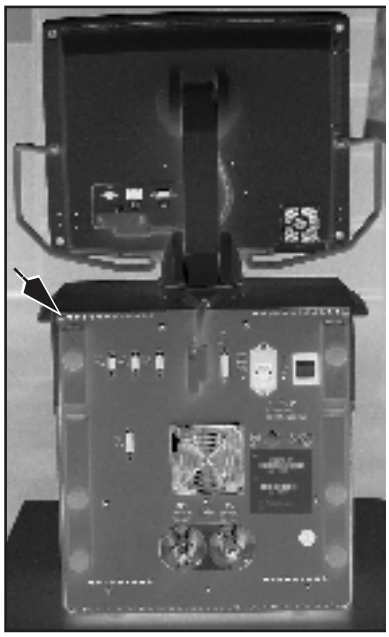
Electrical components on the Vent Engine connect to the Ventilator Control Board (VCB) and the Ventilator Monitor Board (VMB) through a single, two-connector harness.

To diagnose the operation of the EC while still disassembled, the components (Vent Engine, circuit boards, Display Unit) can be arranged and reconnected with existing harnesses. A separate Display Unit Cable can be used as a service tool to make the connection between the Chassis and the Display Unit less restricted.



9.3.1 To remove the chassis from the housing

1. To prevent the housing from tipping over when the chassis is removed, position the Display Unit (as shown) centered over the housing.
2. If applicable, remove any patient circuit components.
3. Remove the Exhalation Valve. The chassis can not be removed with the Exhalation Valve in place.
4. Disconnect the Display Cable from the chassis connector.
5. Loosen the four captured mounting screws at each corner of the back panel.
6. Slide the chassis out of the housing.



9.3.2 To remove the Vent Engine from the chassis

1. Remove the circuit board retainer.
2. Disconnect the engine harness connectors from the circuit boards.
3. Remove the four screws (two on each side) that hold the Vent Engine manifold to the chassis.
4. Slide the Vent Engine out of the chassis.

9.3.3 To replace chassis mounted components

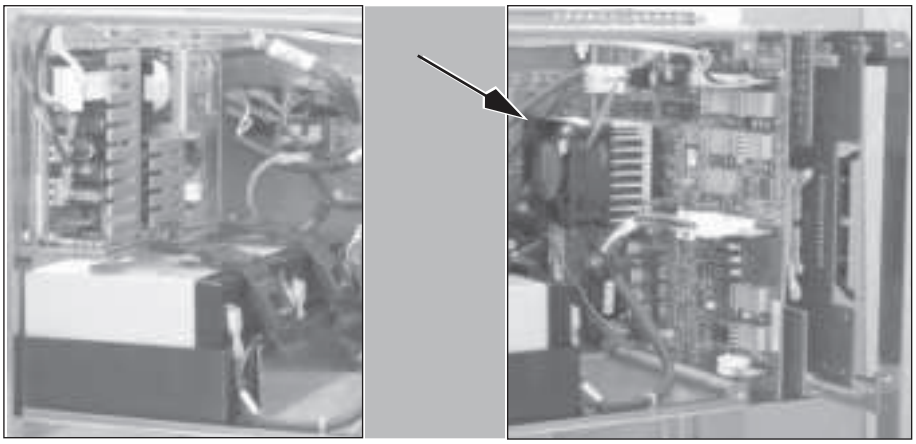
Most of the major components on the chassis can be replaced directly.

Only a few of the less accessible components require you to remove other components before they can be replaced.

When replacing the Power Management Board, transfer the existing heat sink and fan to the new board.

Note: Refer to Section 9.1 for precautions regarding board replacement.

After replacing a circuit board, download current software (refer to Section 9.1.1) and calibrate the system (refer to Section 9.1.2).



9.3.4 To replace vent engine components

⚠Warning When servicing the EC, extreme care must be taken to avoid introducing foreign debris into the pneumatic flow passages of the ventilator. This includes dust and contaminants on the vent engine and particularly metal chips generated by screw threads. Before removing components on the vent engine, secure a clean work area and thoroughly clean the vent engine to remove any contaminants. Failure to do so may result in damage to the internal components.

All mounting hardware for Vent Engine components can be accessed from the top.

When replacing a component, ensure that the o-ring or gasket under the component is properly seated in the manifold.

To remove the harness connector from the O_2 Sensor, release the retaining tab with a small, thin-blade screwdriver (twist the screwdriver slightly to release the tab).

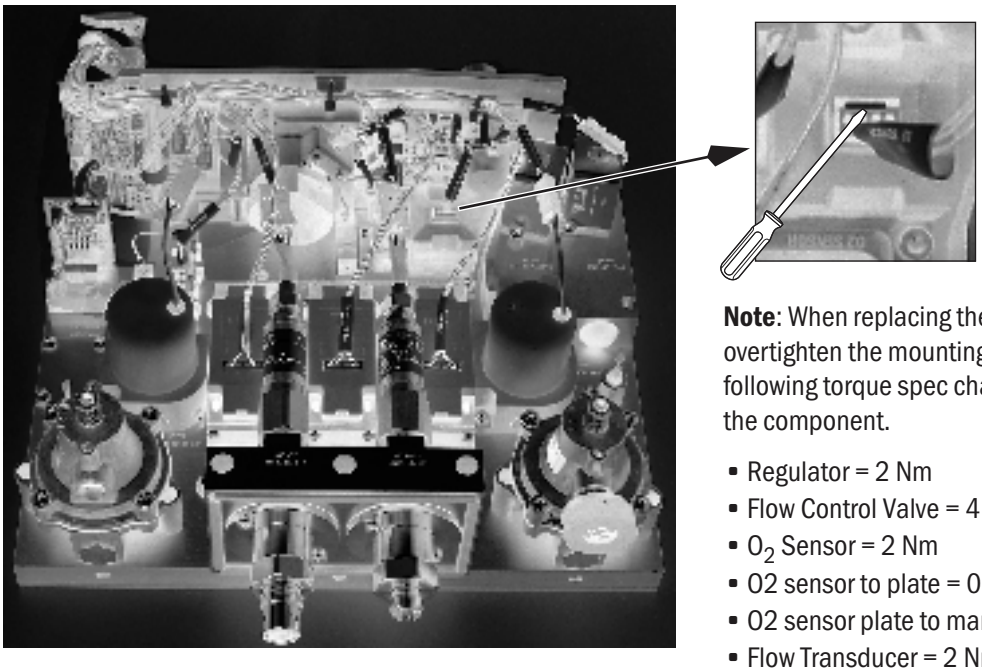
Always perform Vent Engine Debris Cleanout after replacing components. Refer to section 5.2.3.

Lubricate o-rings using a small amount (only enough to wet the surface of the o-ring) of Krytox prior to installation.

Vent engine clean repair procedure

1. Use compressed air to blow any loose particulates and dust from the manifold and components prior to loosening fasteners. Use caution around small parts and elastomers such as o-rings and diaphragms.
2. Obtain alcohol prep pads or similar damp cleaning wipes before removing components. Do not use materials that will lose fibers or leave a residue on components.
3. Completely remove all fasteners and place in a temporary container before moving the component.
4. Carefully lift the component straight up and away from the manifold. Check to make sure all necessary o-rings and gaskets are present. Store components in a temporary container and not on the workspace tabletop.
5. If the component is going to be re-installed, place it on the side or back on a clean surface to protect the mating surface.
6. Using an alcohol prep pad, damp wipe clean the manifold surface by starting at the opening and wiping away from it. This will reduce the risk of loose material dropping into the manifold.
7. Carefully inspect the opening in the manifold. If there is any visual sign of contamination or discoloration, the manifold and any upstream components must be replaced.
8. If the component removed is to be reinstalled, clean it in a similar manner by wiping from any gas stream access points toward the outside edge.
9. Carefully inspect the component and seal. If there is any sign of contamination, knicks, small tears, or discoloration, the component and or seal must be replaced.
10. Carefully set the component back on the manifold directly over and aligned with the attachments and avoid sliding the component once it is in contact with the manifold.
11. Reinstall the fasteners and torque it to the required specification as listed.

Note: Perform Vent Engine Debris Cleanout - Section 5.2.3 after replacement of vent engine components.



Note: When replacing the following items, do not overtighten the mounting hardware. Use the following torque spec chart to properly mount the component.

- Regulator = 2 Nm
- Flow Control Valve = 4 Nm
- O_2 Sensor = 2 Nm
- O2 sensor to plate = 0.5 Nm.
- O2 sensor plate to manifold = 2 Nm
- Flow Transducer = 2 Nm
- Inspiratory Valve Assembly Manifold = 4 Nm
- Inlet Manifold Sub-assembly = 4 Nm
- Outlet Manifold Sub-assembly = 4 Nm
- Pneumatic restrictor = 1 Nm
- Pneumatic Restrictor Plate = 2 Nm
- Legris Fitting 4MM = 4 nm
- Zeroing Valve mounting screws = 0.07 Nm
- Pressure Sensor Assembly = 1 Nm

9.3.5 To replace inspiratory valve assembly (1505-8502-000)

Safety valve alignment tool

1. Remove the chassis from the housing per Section 9.3.1.
2. Remove the Vent Engine from the chassis per Section 9.3.2.
3. Disconnect the wiring harness from the inspiratory valve and safety valve actuators.
4. Remove the four M4 X 12 socket head screw that secure the assembly to the main manifold and remove the Inspiratory Valve assembly.
5. Install the new Inspiratory Valve assembly to the main manifold using four M4 X 12 socket head screws. Torque = 2.0 Nm
   Note: On original main manifold without guide pins use “Safety Valve Alignment tool” (1505-8598-000) to align the inspiratory Valve Assembly to the main manifold.)
6. Transfer or install the new Safety Valve Actuator (M1114504 and Seal (1505-8600-000) to the new Inspiratory Valve Assembly. Apply a small amount (only enough to wet the surface) of Loctite 271 to screw. Torque = 2.0 Nm
7. Perform Service level tests and calibrations. Refer to section 5.2.3, 5.2.5, 5.2.9, 5.2.10, and 5.2.12.
8. Install Vent Engine assembly into chassis. Refer to section 9.3.2.
9. Install chassis into housing. Refer to section 9.3.1.
10. Perform Super User calibrations per Section 5.1.1.
11. Perform Automated Checkout per Section 3.2.

9.3.6 To replace free breathing valve (0211-1454-100)

1. Remove the chassis from the housing per Section 9.3.1.
2. Remove the Vent Engine from the chassis per Section 9.3.2.
3. Remove the Free Breathing Valve seat (1503-3204-000) from the main manifold.
4. Remove and discard Valve Flapper (0211-1454-100) and o-ring (1503-3208-000).
5. Clean the Free Breathing Valve seal and Valve Flapper using an alcohol prep pad.
6. Pull the Valve Flapper through the hole in the Free Breathing Valve seat and cut off tip of flapper to approximately 7mm.
7. Apply a thin film of Krytox to o-ring (only enough to wet the surface of the o-ring) and fit o-ring into the groove located on the Free Breathing Valve seat.
8. Install the Free Breathing Valve seat into the main manifold and tighten valve until it is flush with the manifold.
9. Perform Service level tests and calibration per Section 5.2.9.
10. Install Vent Engine Assembly into chassis. Refer to Section 9.3.7.
11. Install chassis into housing. Refer to Section 9.3.1
12. Perform Super-User calibrations per Section 5.1.1.
13. Perform an Automated Checkout per Section 3.2

9.3.7 To replace Vent Engine assembly, complete

1. Remove the chassis from the housing. Refer to Section 9.3.1.
2. Remove the Vent Engine from the chassis. Refer to Section 9.3.2
3. Replace the Vent Engine with new Vent Engine assembly and connect harness to the VCB and VMB.

Note: Do not install Vent Engine assembly into chassis until all tests and calibration in Step 4 have been completed.

4. Perform Service level tests and calibration. Refer to Section 5.2.
5. Install Vent Engine assembly into chassis. Refer to Section 9.3.2.
6. Install chassis into housing. Refer to Section 9.3.1.
7. Perform Super-User calibrations. Refer to Section 5.1.1.
8. Perform Automated Checkout. Refer to Section 3.2.

9.3.8 To replace Vent Engine, sub-assembly

1. Remove the chassis from the housing per Section 9.3.1.
2. Remove the Vent Engine assembly from the chassis. Refer to Section 9.3.2.
3. Remove the following components from the Vent Engine assembly:
   a. Harness (vent engine to VCB/VMB) - (1505-5706-000).
   b. Inspiratory Manifold Panel Assembly with safety valve (1505-8502-000).
   c. Outlet Manifold Panel Assembly (including all mounted components) - (1505-8505-000).
   d. O2 Pipeline Adapter (from inlet manifold) - (1505-3206-000).
   e. AIR Pipeline adapter (from inlet manifold) - (1505-3207-000).
4. Clean and install the above removed parts on the new Vent Engine sub assembly. Refer to Section 9.3.4.
5. Connect the new Vent Engine assembly harness to the VCB and VMB.

Note: Do not install Vent Engine assembly into chassis until all tests and calibration in Step 6 have been completed.

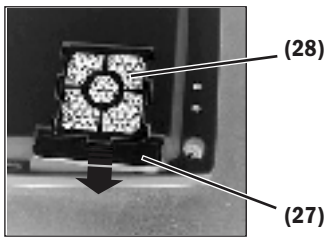
6. Perform Service level tests and calibration. Refer to Section 5.2.
7. Install Vent Engine Assembly into the chassis. Refer to Section 9.3.2
8. Install chassis into housing. Refer to Section 9.3.1.
9. Perform Super-User calibrations. Refer to Section 5.1.1.
10. Perform Automated Checkout. Refer to Section 3.2.

9.4 Servicing the Display Unit (DU)

Note The item numbers appearing in parenthesis in this section refer to items in the parts list in Section 10.9.

The fan filter **(26)** and the access door **(27)** to the PCMCIA interface can be replaced with the Display Unit in place.

To replace the filter, slide the filter capsule **(27)** downward to remove it from the Display Unit.

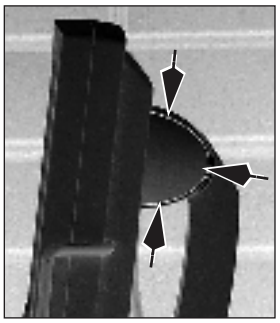


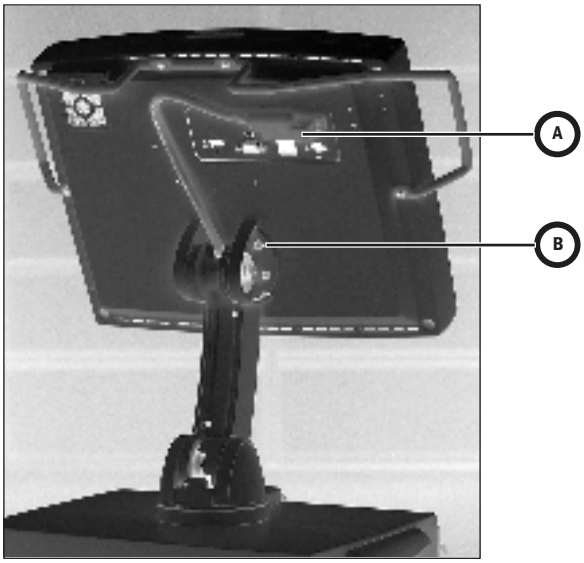
To service other components of the Display Unit, you must first remove the Display Unit from the machine.

9.4.1 Remove the Display Unit

The Display Unit attaches to the pivot arm with screws that are accessible under the pivot covers.

1. Remove the pivot arm covers on each side of the upper pivot.
   - The pivot covers are held in place by three tabs in the locations shown by the arrows.
   - Slide a thin blade between the cover and the pivot housing to release each tab.
2. Raise the DU so that it faces backwards.
3. Disconnect the display cable **(A)**.
4. Remove the four screws that hold the DU to the upper pivot **(B)**.

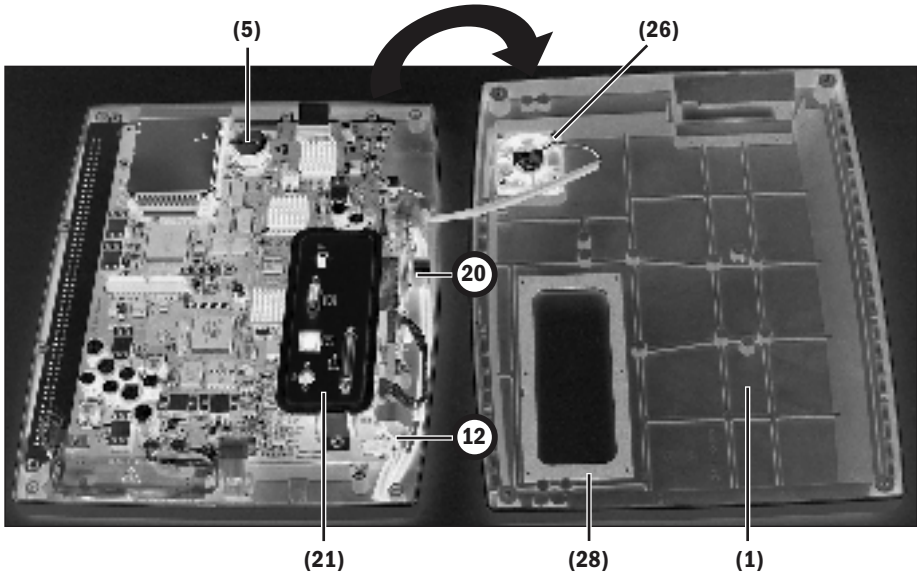




9.4.2 Disassemble the Display Unit

Place the Display Unit face down on an anti-static pad. Before removing the rear enclosure, ensure that the release tabs on the PCMCIA frame are fully depressed.

1. Loosen **(L)** the four captive screws at each corner of the rear enclosure.
2. Lift the rear enclosure slightly and pivot it away from the lower enclosure at the bottom side of the Display Unit.



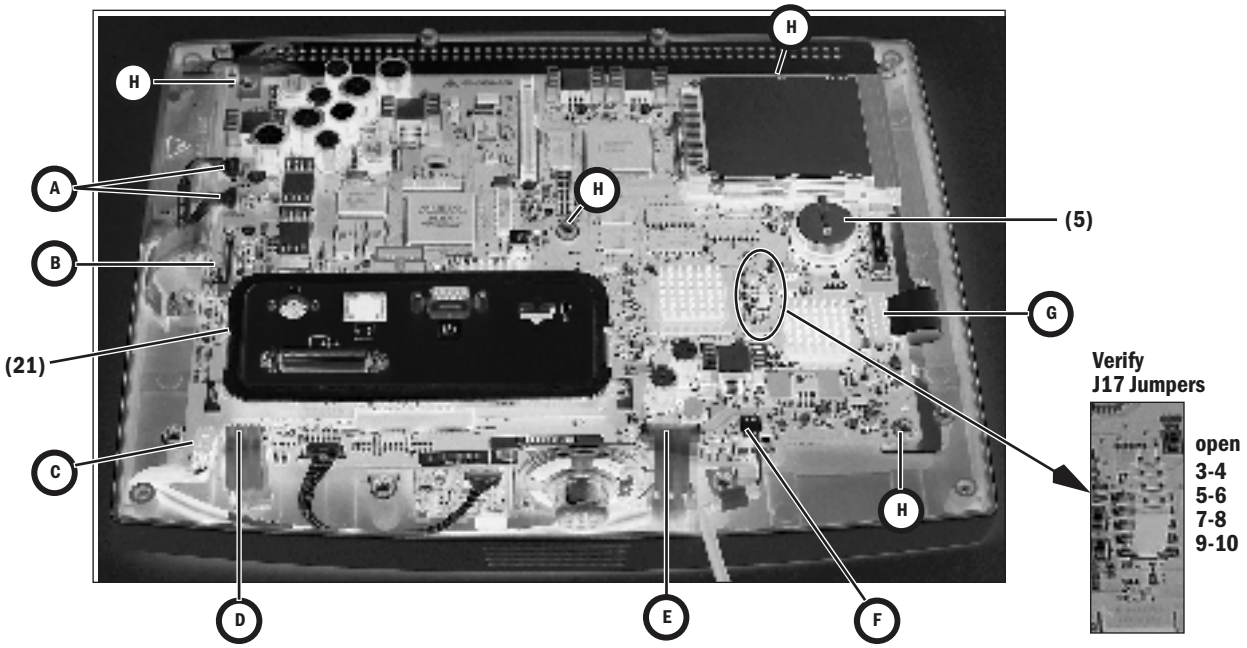
At this point, you can replace the following items (The item numbers refer to the parts list in Section 10.9):

- the **fan (26)**
- the **connector panel assembly (21)**
- the **encoder assembly (12)**
- the **battery (5)**
- the **speaker (20)** — To access the mounting screws for the speaker, you must first remove the ten screws that hold the mounting plate to the front enclosure so that you can raise the bottom edge of the assembly slightly — Refer to section 9.4.4.)
- the **rear enclosure (1)** — You can transfer the captive screws to the new enclosure. However, the **gasket (28)** is held in place with adhesive. When replacing the rear enclosure, also include a new gasket.

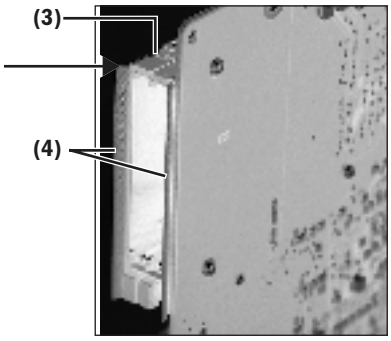
To replace the remaining items requires further disassembly.

9.4.3 To replace the CPU board

1. Remove the **connector panel assembly (21)** — two screws.
2. Disconnect the following cables:
   - Inverter harnesses **(A)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(B)**
   - Speaker cable **(C)**
   - Encoder assembly cable **(D)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(E)**
   - Fan cable **(F)**
   - LCD cable **(G)**



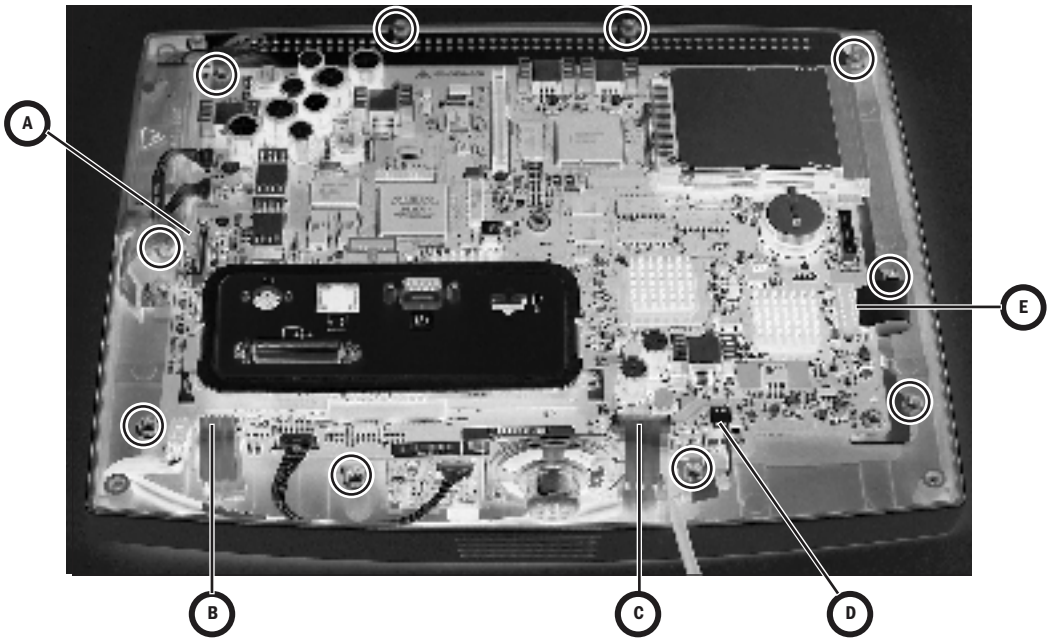
3. Remove the remaining four screws **(H)** that hold the CPU board to the mounting plate.
4. Remove the CPU board from the mounting plate.
5. If you are **replacing the PCMCIA frame (3)** on an existing CPU board (remove four screws on back of CPU board), you must also apply new gaskets **(4)** to the frame. Align the ends of the gaskets with the top edge of the frame.



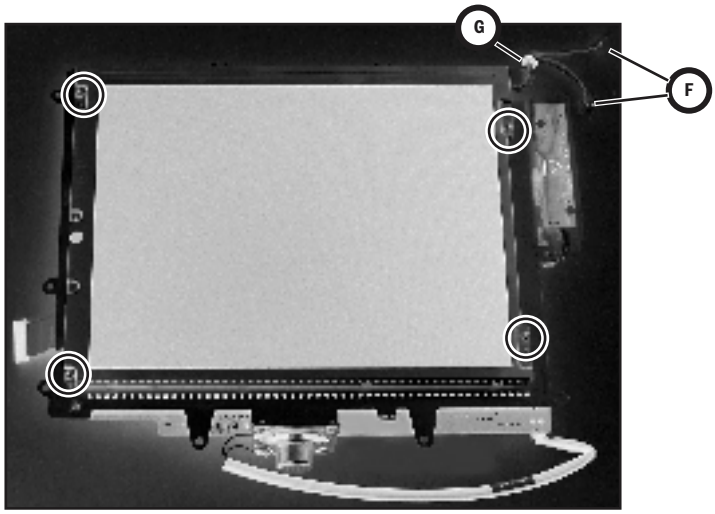
6. Transfer the battery **(5)** to the new CPU board.
7. Reassemble in reverse order.
8. Download latest software (Section 8.4).

9.4.4 To replace the LCD display

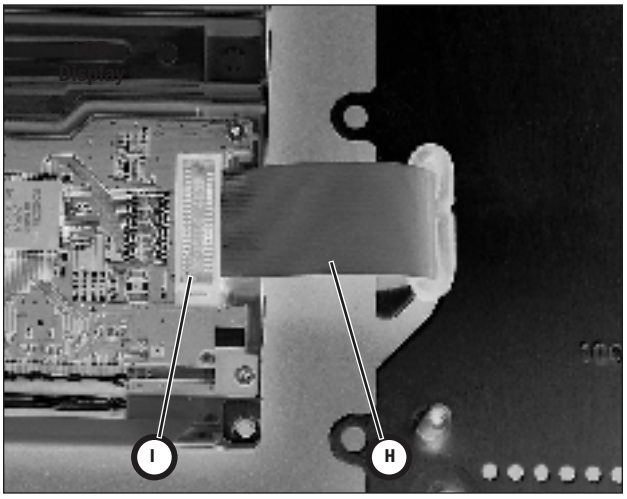
1. Disconnect the following cables:
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(A)**
   - Encoder assembly cable **(B)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(C)**
   - Fan cable **(D)**
   - LCD cable **(E)**
2. Remove the ten screws (**circled**) that hold the mounting plate to the front enclosure.



3. Remove the mounting plate assembly from the front enclosure.
4. Disconnect the backlight harnesses **(F)** from the inverter boards.
5. Slide the grommet **(G)** out of the mounting plate slot (transfer to new LCD).
6. Remove the four screws (**circled**) that hold the LCD to the mounting plate.



7. Lift the left side of the LCD display slightly away from the mounting plate to pull some of the display ribbon cable **(H)** to the top side of the plate. Flip the LCD over to the left of the assembly.
8. Disconnect the display ribbon cable **(I)**.



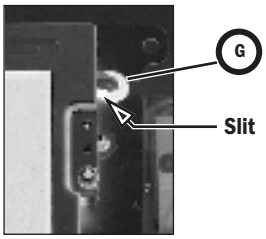
9. Reassemble in reverse order.

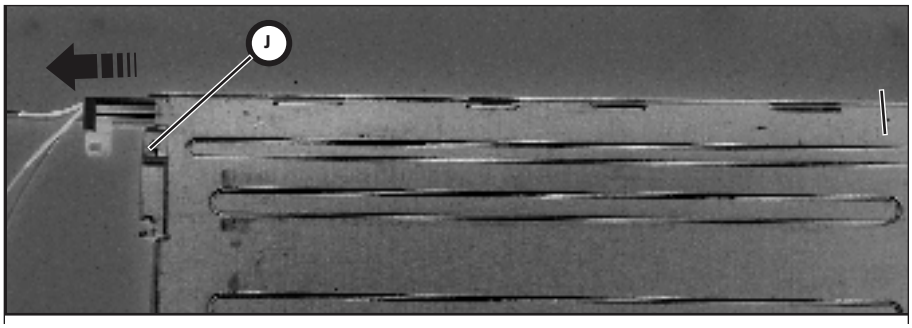
   Note: When replacing the LCD, pull the excess ribbon cable to the bottom side of the plate as you lower the LCD on to the plate. For the backlight harness grommet **(G)**, ensure that the slit in the grommet faces toward the inside of the keyhole.

9.4.5 To replace the backlights

The backlight replacement kit includes a backlight assembly (with two backlights) and two inverters with mounting hardware. To replace the backlight assembly follow the procedure in Section 9.3 to gain access to the assembly. To replace the inverters, follow the procedure in the next section.

1. Remove the one screw **(J)** that holds the backlight assembly to the LCD.
2. Slide the backlight assembly to the left to free it from the retaining tabs and then lift it out of the holder.





3. Transfer the grommet **(G)** to the new backlight assembly.
4. Reassemble in reverse order.

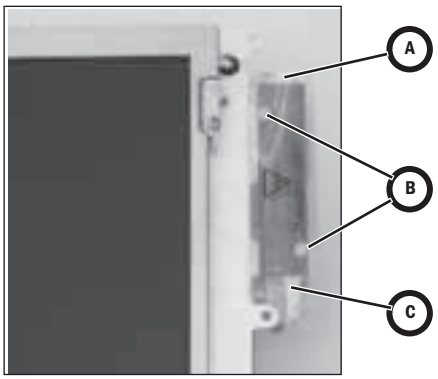
9.4.6 To replace the Inverters

The Display Unit includes two inverters (one for each backlight).

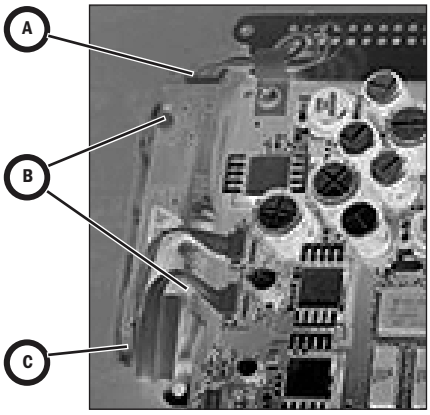
The inverters “sandwich” the mounting plate and use it as a heatsink. Follow the procedure in Section 9.4.4 to gain access to the inverters. Replace one inverter at a time.

1. Disconnect the backlight cable **(A)** from the inverter.
2. Remove the two Nylon screws **(B)** that hold the inverter to the backplate.
3. Slide the inverter out of the sleeve and disconnect it from the CPU harness **(C)**.
4. Reassemble in reverse order.

The “front” inverter



The “rear” inverter



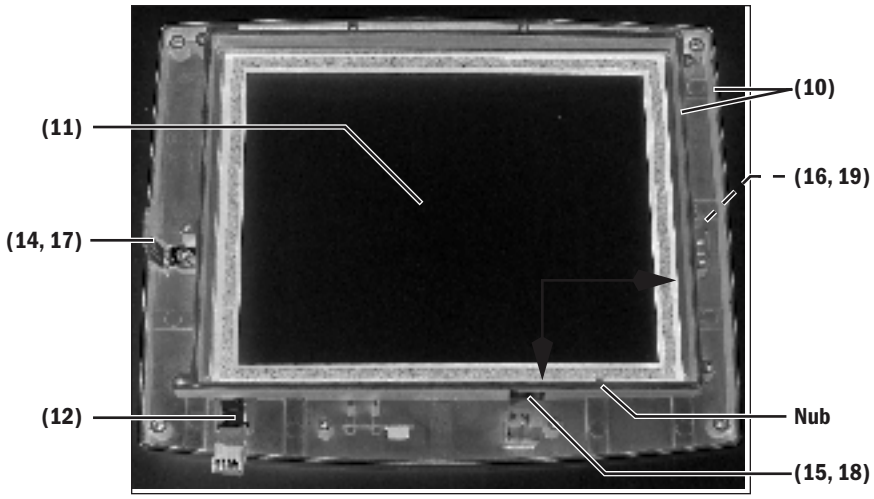
9.4.7 To replace the front enclosure or components

Disassemble the Display Unit following procedures in the previous sections to the point where you have removed the mounting plate assembly from the front enclosure.

If you are replacing the front enclosure, you can transfer the encoder **(12)** assembly to the new enclosure; but, you must build up the replacement enclosure with:

- a new window **(11)**
- new membrane switches — right-side **(14)**, lower **(15)**, left-side **(16)**
- new keypads - right-side **(17)**, lower **(18)**, left-side **(19)**
- new EMC gasket **(10)**

If you are replacing a keypad or a membrane switch, you must replace both items.



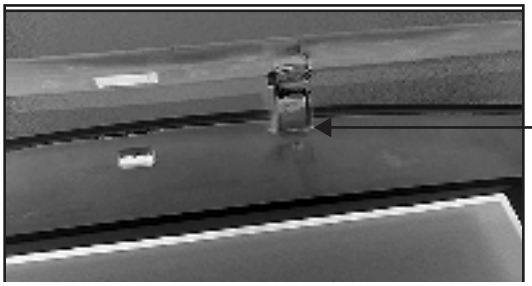
To replace the window

1. Place the front enclosure face up on a flat surface.
2. Press down on one corner of the window to free it from the enclosure.
3. Work your way around the window until you can get a hold of it from the back.
4. Slowly pry the window from the enclosure.
5. Place the front enclosure face down on a flat surface, taking care not to damage the encoder.
6. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
7. Remove the inside protective material from the front of the window.
8. Peel the front outside frame of the release liner.
9. Lower the window straight down in the enclose, noting the notch in the window and the matching nub on the enclosure.
10. Before seating the window, position it in contact with the bottom and right sides of the frame (see arrows) so that the larger gap between the window and the enclosure is at the top and left edges (as viewed from behind).
11. Remove the protective film from the back side of the window.

To replace a membrane switch and keypad

1. Remove the screw that attaches the grounding strap to the enclosure.
2. Pry the membrane switch and keypad from the enclosure.
3. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
4. Remove the backing from the membrane. Be sure to remove the small backing below the flex cable. For the lower membrane, remove the protective film from the IRDA window.

5. Insert the flex cable and ground strap through the slot in the enclosure. Ensure that all of the ground strap passes through the slot and does not remain folded over under the membrane.



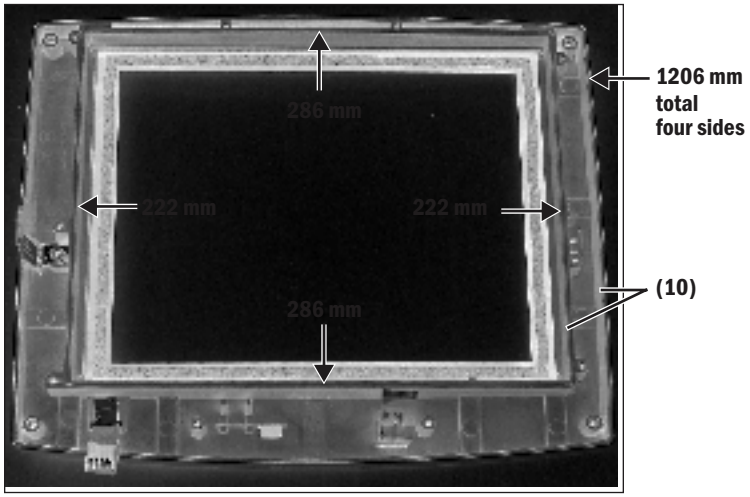
6. Carefully lower the membrane straight down to the enclosure. Seat the membrane in place.
7. Remove the backing from the keypad and install it over the membrane switches.
8. Attach the ground strap to the enclosure.

To install the EMI gasket

To fully seal the Display Unit enclosure, you will need approximately 2.3 meters of EMC gasket **(10)**. Cut the gasket into five strips shown below.

Insert a continuous length of gasket in the outside grove of the enclosure (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).

Insert individual lengths of gasket in the inside grove around the window (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).



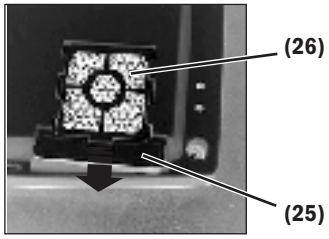
9.5 Servicing the High Performance Display Unit (HPDU)

Note To service the DU, refer to Section 9.4.

The item numbers appearing in parenthesis in this section refer to items in the parts list in Section 10.8.

The fan filter (26) and the access door (3) to the PCMCIA interface can be replaced with the Display Unit in place.

To replace the filter, slide the filter capsule (25) downward to remove it from the Display Unit.

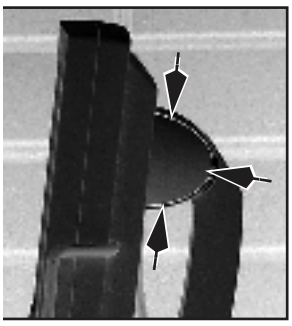


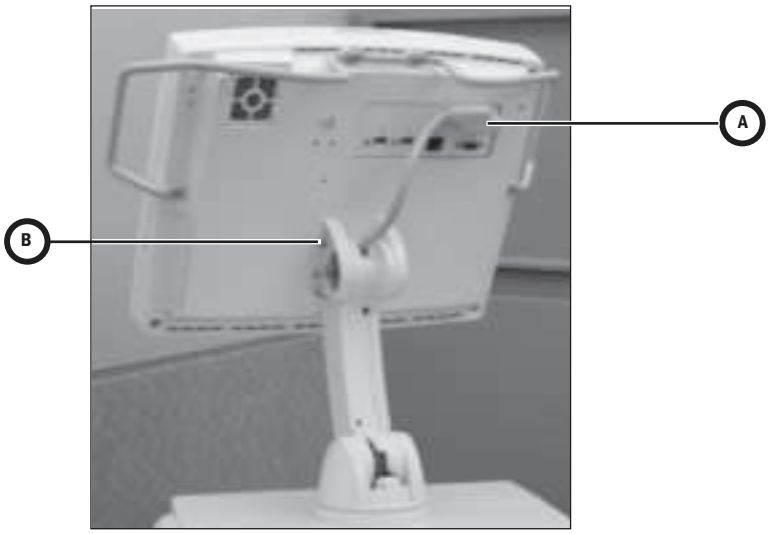
To service other components of the Display Unit, you must first remove the Display Unit from the machine.

9.5.1 Remove the Display Unit

The Display Unit attaches to the pivot arm with screws that are accessible under the pivot covers.

1. Remove the pivot arm covers on each side of the upper pivot.
   - The pivot covers are held in place by three tabs in the locations shown by the arrows.
   - Slide a thin blade between the cover and the pivot housing to release each tab.
2. Raise the DU so that it faces backwards.
3. Disconnect the display cable **(A)**.
4. Remove the four screws that hold the DU to the upper pivot **(B)**.

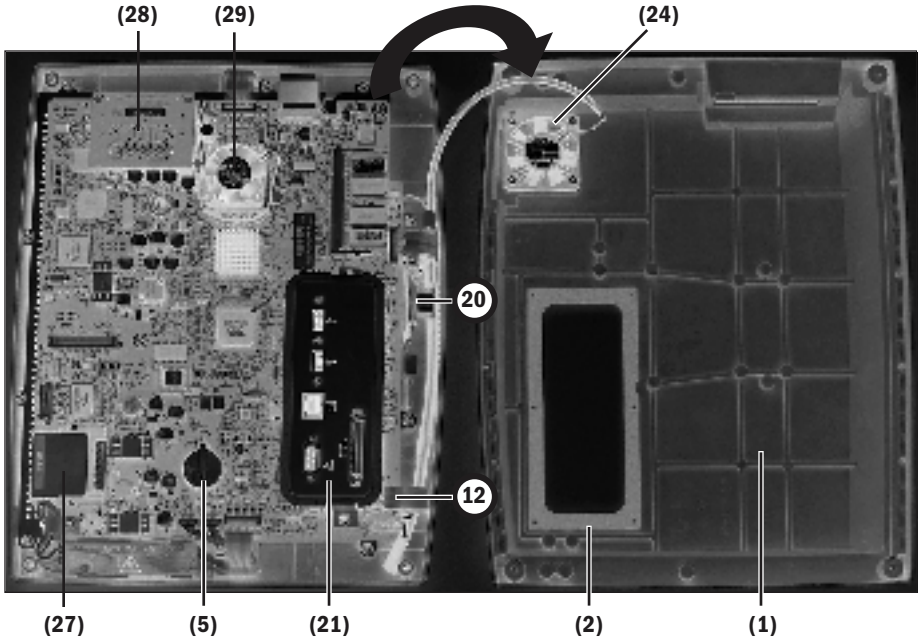




9.5.2 Disassemble the Display Unit

Place the Display Unit face down on an anti-static pad.

1. Loosen (**L**) the four captive screws at each corner of the rear enclosure.
2. Lift the rear enclosure slightly and pivot it away from the lower enclosure at the bottom side of the Display Unit.



At this point, you can replace the following items (The item numbers refer to the parts list in Section 10.8):

- the **internal Compact Flash card** (27)
- the **external Compact Flash Kit** (28)
- the **fan** (24) – for the HPDU this is a 12-volt fan
- the **connector panel assembly** (21)
- the **encoder assembly** (12)
- the **battery** (5)
- the **speaker** (20) – (To access the mounting screws for the speaker, you must first remove the ten screws that hold the mounting plate to the front enclosure so that you can raise the bottom edge of the assembly slightly – Refer to section 9.5.5.)
- the **rear enclosure** (1) – You can transfer the captive screws to the new enclosure. However, the **gasket** (2) is held in place with adhesive. When replacing the rear enclosure, also include a new gasket.

To replace the remaining items requires further disassembly.

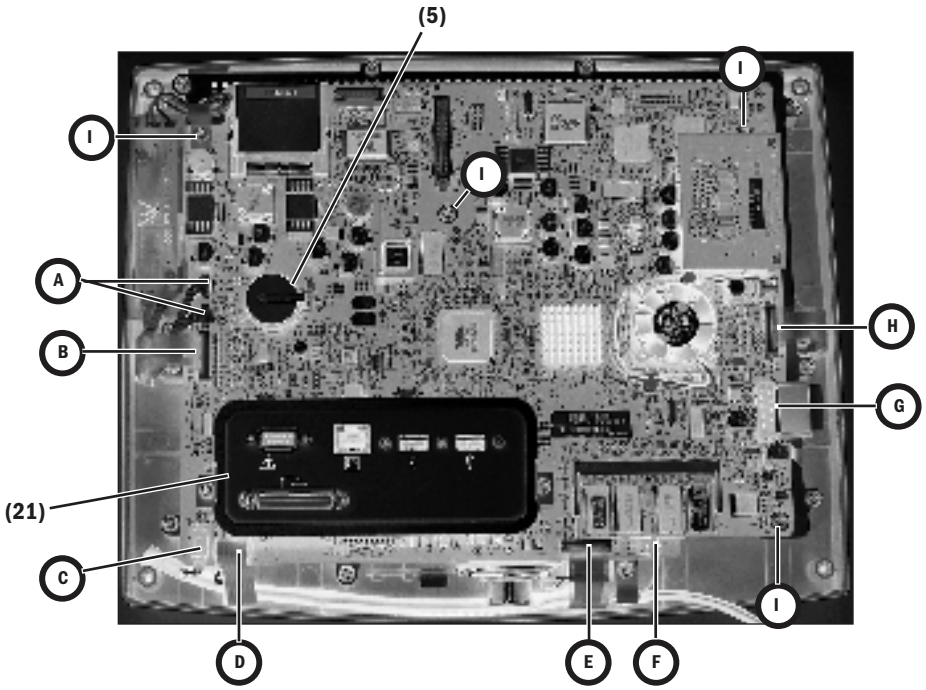
9.5.3 CPU Fan

⚠ **CAUTION**: Do not remove the heatsink from the CPU board.

1. Note the orientation of the fan harness.
   Disconnect the fan harness from the CPU board.
2. Remove the fan (29) from the CPU heatsink, leaving the heatsink in place.
3. Remove the heatsink (discard) from the replacement fan assembly.
4. Noting the orientation of the fan harness, secure the fan to the CPU heatsink.
5. Connect the fan harness to the CPU board.

9.5.4 To replace the CPU board

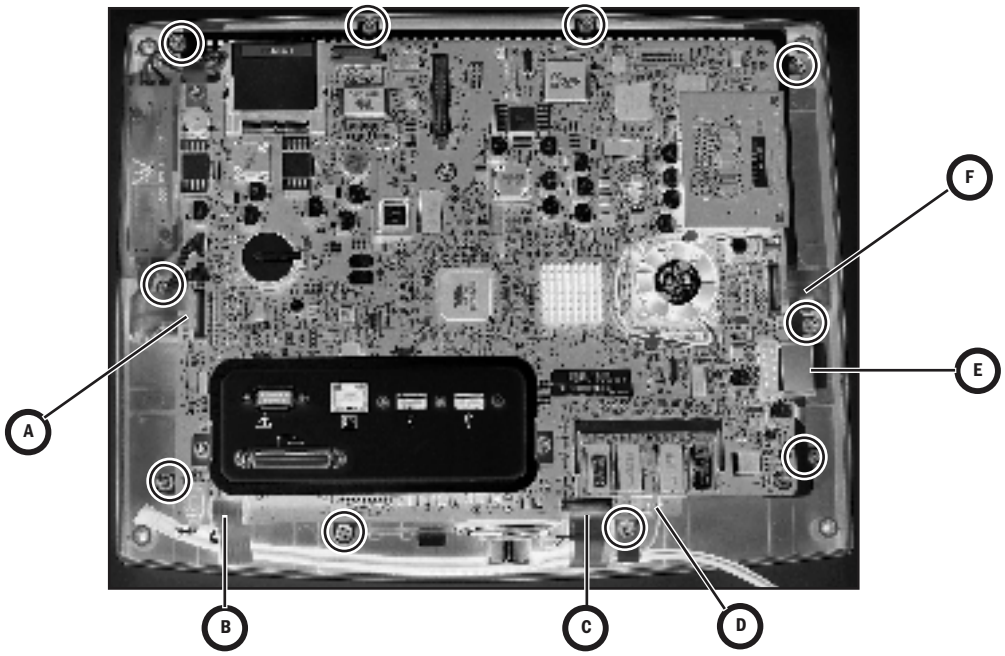
1. Remove the **connector panel assembly** (21) — two screws.
2. Disconnect the following cables:
   - Inverter harnesses (**A**)
   - Right membrane switch flex-cable at ZIF (zero insertion force) connector (**B**)
   - Speaker cable (**C**)
   - Encoder assembly cable (**D**)
   - Lower membrane switch flex-cable at ZIF (zero insertion force) connector (**E**)
   - Fan cable (**F**)
   - LCD cable (**G**) Make sure cable is plugged in securely, if not screen may display incorrectly (white).
   - Left membrane switch flex-cable at ZIF (zero insertion force) connector (**H**)



3. Remove the remaining four screws (**I**) that hold the CPU board to the mounting plate.
4. Remove the CPU board from the mounting plate.
5. Transfer the battery (5) to the new CPU board.
6. Reassemble in reverse order.
7. Download the latest software (Section 8.4).

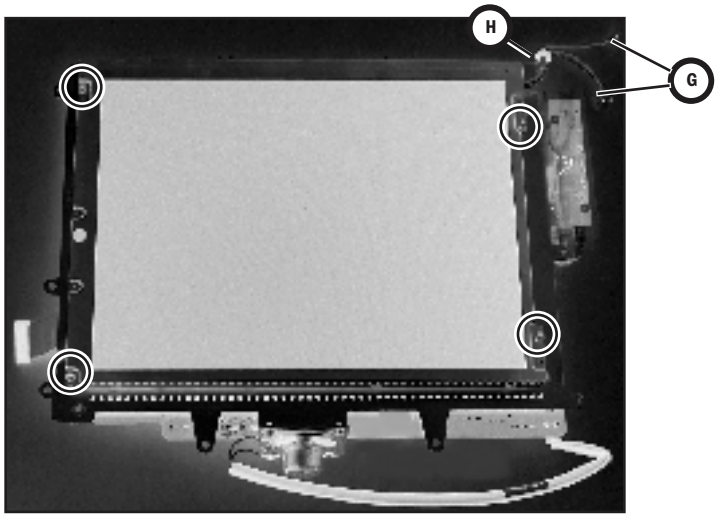
9.5.5 To replace the LCD display

1. Disconnect the following cables:
   - Right membrane switch flex-cable at ZIF (zero insertion force) connector (**A**)
   - Encoder assembly cable (**B**)
   - Lower membrane switch flex-cable at ZIF (zero insertion force) connector (**C**)
   - Fan cable (**D**)
   - LCD cable (**E**)
   - Left membrane switch flex-cable at ZIF (zero insertion force) connector (**F**)
2. Remove the ten screws (**circled**) that hold the mounting plate to the front enclosure.

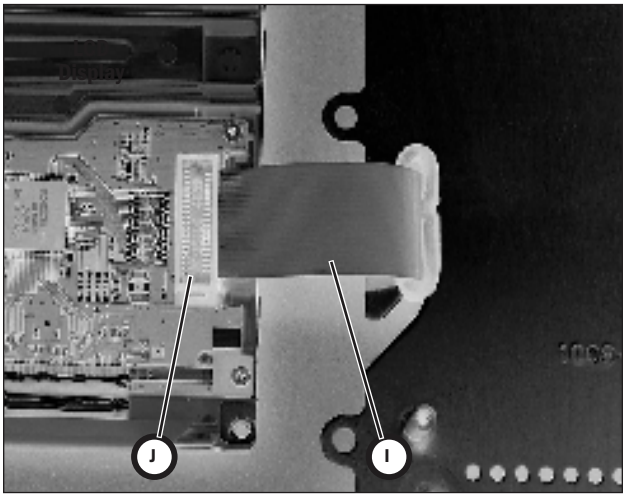


3. Remove the mounting plate assembly from the front enclosure.
4. Disconnect the backlight harnesses (**G**) from the inverter boards.
5. Slide the grommet (**H**) out of the mounting plate slot (transfer to new LCD).

6. Remove the four screws (**circled**) that hold the LCD to the mounting plate.



7. Lift the left side of the LCD display slightly away from the mounting plate to pull some of the display ribbon cable (**I**) to the top side of the plate. Flip the LCD over to the left of the assembly.
8. Disconnect the display ribbon cable (**J**).



9. Reassemble in reverse order.

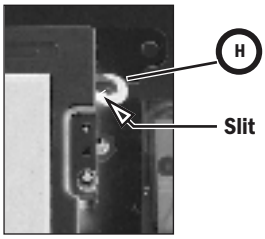
   Note: When replacing the LCD, pull the excess ribbon cable to the bottom side of the plate as you lower the LCD on to the plate. For the backlight harness grommet (**H**), ensure that the slit in the grommet faces toward the inside of the keyhole.

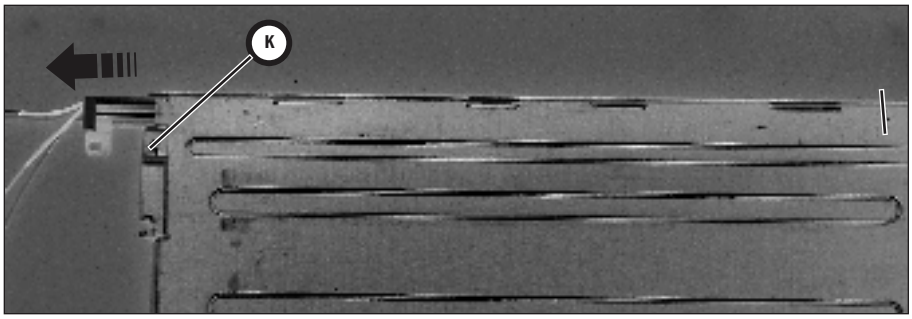
9.5.6 To replace the backlights

Note: When replacing a backlight or a backlight inverter, you must replace both inverters and the backlight assembly found in the Backlight Kit.

The backlight replacement kit includes a backlight assembly (with two backlights) and two inverters with mounting hardware. To replace the backlight assembly follow the procedure in Section 9.4.4 to gain access to the assembly. To replace the inverters, follow the procedure in the next section.

1. Remove the one screw (**K**) that holds the backlight assembly to the LCD.
2. Slide the backlight assembly to the left to free it from the retaining tabs and then lift it out of the holder.





3. Transfer the grommet (**H**) to the new backlight assembly.
4. Reassemble in reverse order.

9.5.7 To replace the Inverters

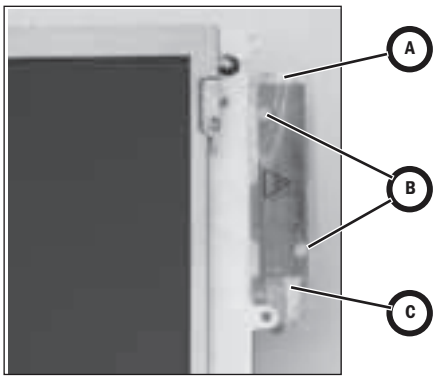
Note: When replacing a backlight or a backlight inverter, you must replace both inverters and the backlight assembly found in the Backlight Kit.

The Display Unit includes two inverters (one for each backlight).

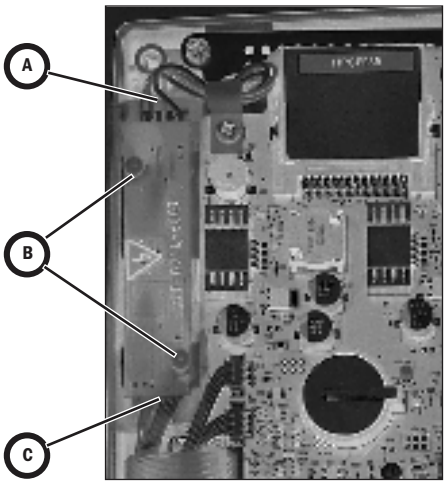
The inverters "sandwich" the mounting plate and use it as a heatsink. Follow the procedure in Section 9.5.5 to gain access to the inverters. Replace one inverter at a time.

1. Disconnect the backlight cable (**A**) from the inverter.
2. Remove the two Nylon screws (**B**) that hold the inverter to the backplate.
3. Slide the inverter out of the sleeve and disconnect it from the CPU harness (**C**).
4. Reassemble in reverse order.

The "front" inverter



The "rear" inverter



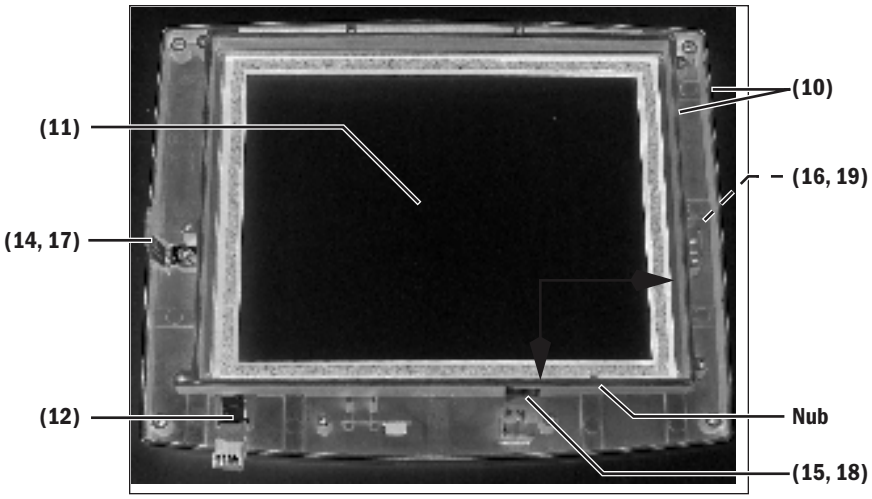
9.5.8 To replace the front enclosure or components

Disassemble the Display Unit following procedures in the previous sections to the point where you have removed the mounting plate assembly from the front enclosure.

If you are replacing the front enclosure, you can transfer the encoder (12) assembly to the new enclosure; but, you must build up the replacement enclosure with:

- a new window (11)
- new membrane switches — right-side (14), lower (15), left-side spacer (16)
- new keypads - right-side (17), lower (18), left-side blank (19)
- new EMC gasket (10)

If you are replacing a keypad or a membrane switch, you must replace both items.

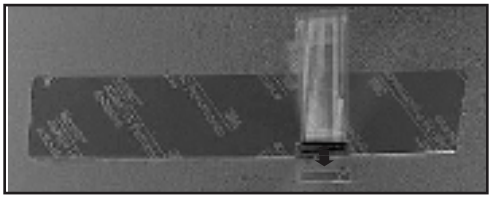


To replace the window

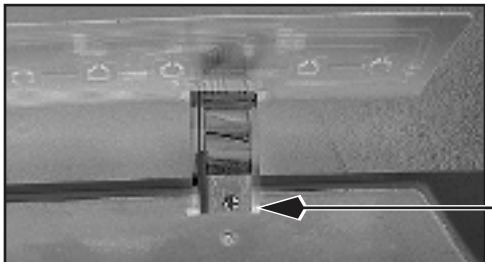
1. Place the front enclosure face up on a flat surface.
2. Press down on one corner of the window to free it from the enclosure.
3. Work your way around the window until you can get a hold of it from the back.
4. Slowly pry the window from the enclosure.
5. Place the front enclosure face down on a flat surface, taking care not to damage the encoder.
6. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
7. Remove the inside protective material from the front of the window.
8. Peel the front outside frame of the release liner.
9. Lower the window straight down in the enclose, noting the notch in the window and the matching nub on the enclosure.
10. Before seating the window, position it in contact with the bottom and right sides of the frame (see arrows) so that the larger gap between the window and the enclosure is at the top and left edges (as viewed from behind).
11. Remove the protective film from the back side of the window.

To replace a membrane switch and keypad

1. Remove the screw that attaches the grounding strap to the enclosure.
2. Pry the membrane switch and keypad from the enclosure.
3. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
4. Remove the backing from the membrane. Be sure to remove the small backing below the flex cable. Be careful not to allow the ribbon cable to adhere to the backing.



5. Insert the flex cable and ground strap through the slot in the enclosure. Ensure that all of the ground strap passes through the slot an does not remain folded over under the membrane.



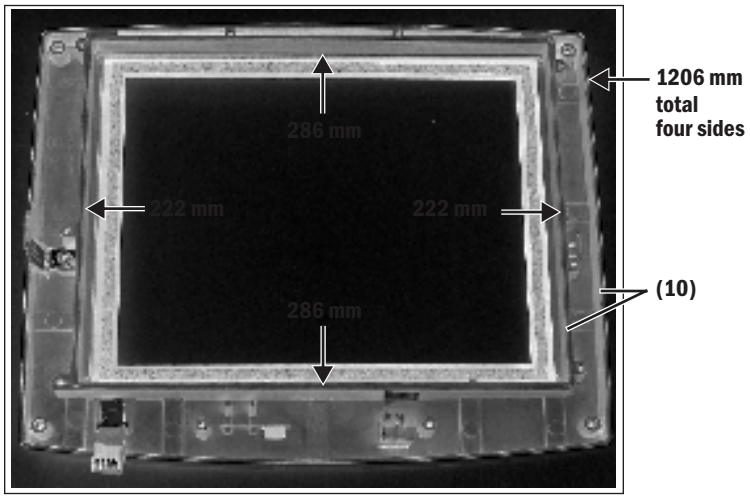
6. Carefully lower the membrane straight down to the enclosure. Seat the membrane in place.
7. Remove the backing from the keypad and install it over the membrane switches.
8. Attach the ground strap to the enclosure.

To install the EMI gasket

To fully seal the Display Unit enclosure, you will need approximately 2.3 meters of EMC gasket (10). Cut the gasket into five strips shown below.

Insert a continuous length of gasket in the outside grove of the enclosure (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).

Insert individual lengths of gasket in the inside grove around the window (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).



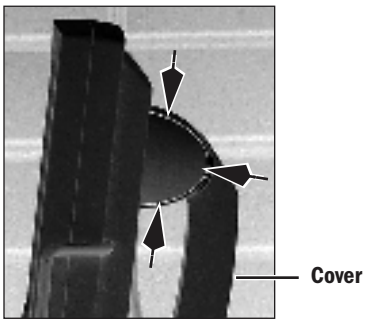
9.6 Adjusting the display arm

The display arm includes three pivot points that allow the Display Unit to be positioned for optimal viewing:

- the upper pivot allows for tilting the display
- the lower pivot allows for raising or lowering the display
- the arm mounts to the chassis on a bearing that allows the display to be moved side to side.

To access the adjustment hardware for the upper and lower hardware, remove the pivot arm covers on each side of the pivot.

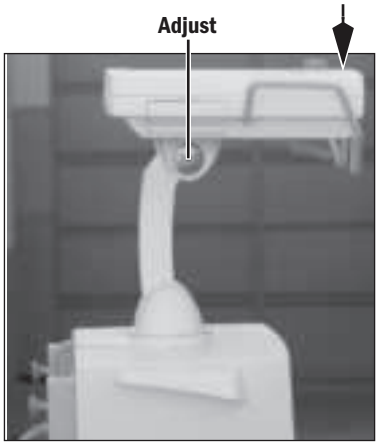
- The pivot covers are held in place by three tabs in the locations shown by the arrows.
- Slide a thin blade between the cover and the pivot housing to release each tab.



To access the adjustment screw for the arm mount bearing, remove the display arm cover.

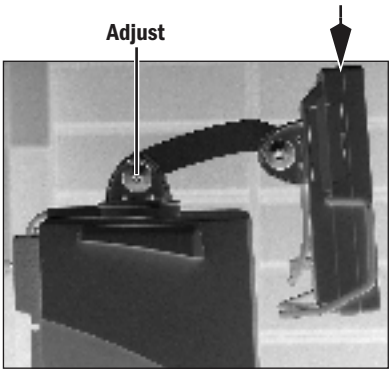
9.6.1 Adjust upper pivot

1. Position the DU as shown:
   - Arm vertical
   - DU horizontal
2. Release the DU.
   - Verify that the DU does not sag from its own weight.
3. Push down slightly at the front of the DU.
   - The DU should remain in place.
4. Verify that the DU can be tilted without excessive force.
5. Adjust the upper pivot as necessary.



9.6.2 Adjust lower pivot

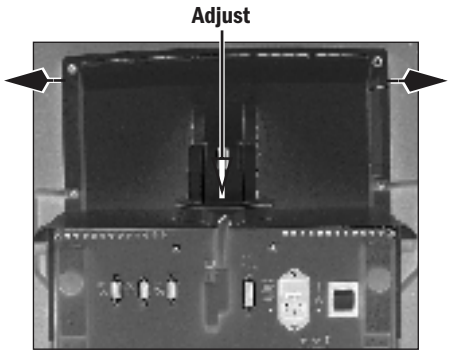
1. Position the DU as shown:
   - Arm forward
   - Upper and lower pivots in line horizontally
   - DU vertical
2. Release the DU.
   - Verify that the DU does not sag from its own weight.
3. Push down slightly at the top of the DU.
   - The DU should remain in place.



4. Verify that the DU can be raised and lowered without excessive force.
5. Adjust the lower pivot as necessary.

9.6.3 Adjust arm bearing

1. Position the DU as shown above:
   - Arm forward
   - Upper and lower pivots in line horizontally
   - DU vertical
2. Move the DU side to side.
   - Verify that the DU can be moved without excessive force and that it remains in place with slight sideways pressure.
3. Adjust the bearing as necessary.



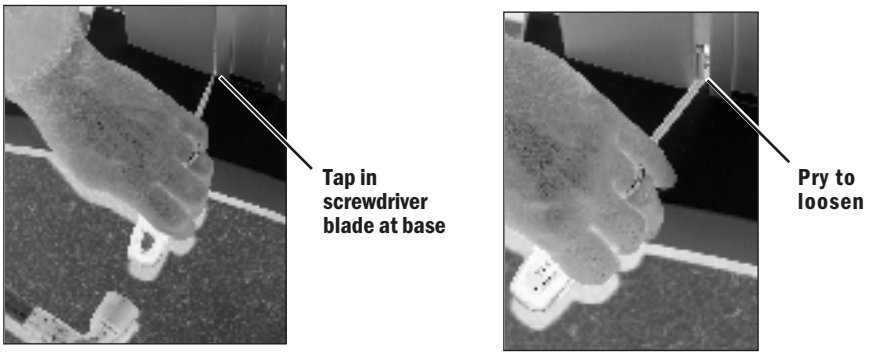
9.7 Removing a compressor from the cart

In routine cases, the compressor can be serviced without removing it from the cart. Refer to the EVair03 Air Compressor Technical Reference manual (6189655).

In situations where greater access to components is required, the compressor can be removed from the cart for service.

⚠ **WARNING** To avoid personal injury, two people are required to remove and install the compressor.

1. Remove the trim pieces from the side extrusions.



2. Remove the compressor mounting hardware from each side of the cart.
3. Screw in a lifting handle (service tool #5370055) into each side of the compressor.

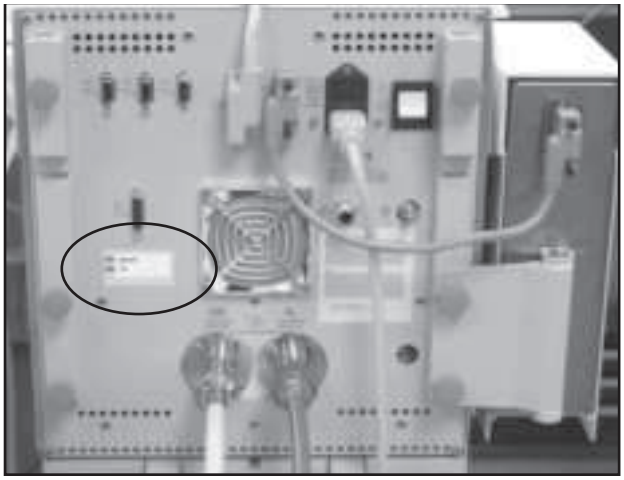
4. With a person on each side of the cart, lift the compressor slightly and slide it forward out of the cart.

⚠ **CAUTION** To avoid tipping, use care when moving the ventilator with the compressor removed from the cart.

9.8 Attaching Labels

9.8.1 Key/BID label

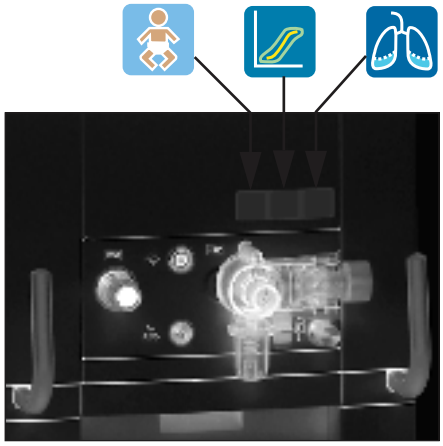
1. If present, remove the existing Key/BID label from the back of the machine.
2. Clean the area with Isopropyl alcohol.
3. Affix the new Key/BID label to the machine



9.8.2 Feature label

Use the feature label to attach FRC, SpiroDynamics, or Neonatal

1. Affix the Feature Label holder to the front of the machine as shown.
   - Align the right edge of the label approximately 6 mm from the right edge of the outlet manifold.
   - Align the bottom edge of the label approximately 15 mm from the top edge of the outlet manifold.
2. Affix the Feature Specific label in the square recesses in the label holder.
   - install the labels starting with the right-most available recess.



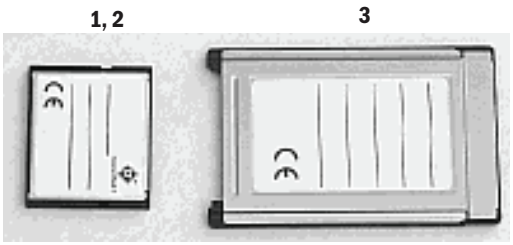
10 Illustrated Parts

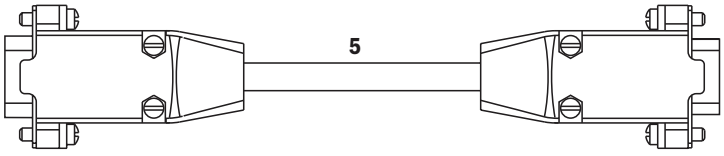
In this section

10.1 Service tools

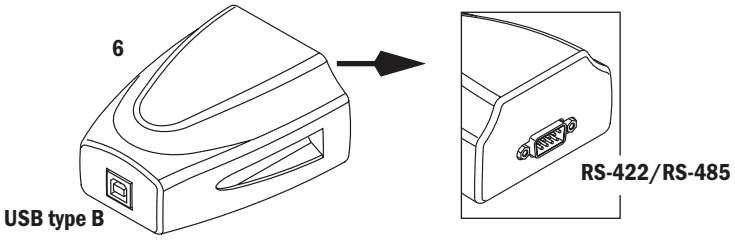
10.1.1 Software tools

Item	Description	Stock Number
1	Service Application/System Software 2.X (on Compact Flash card - DU) Note: For Standard Display Unit (DU)	1505-8000-000
2	Service Application/System Software 4.X (on Compact Flash card - HPDU) Note: For High Performance Display Unit - HPDU	M1079267
3	Compact Flash Adapter, PCMCIA carrier Note: For Standard Display Unit only (DU)	1009-5874-000
4	Windows based EC Service Application	1505-8001-000
5	Cable, USB Converter to EC	1505-8587-000
6	Converter, USB to RS-422/RS-485 (includes USB cable)	1505-8586-000



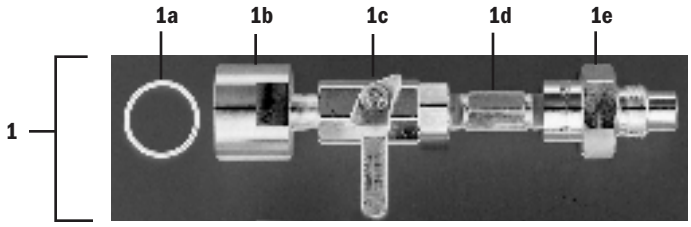


Male pin end (9-pin DSUB)	Female pin end (9-pin DSUB)	Port 3 (9-pin)
7	1	TX+
8	2	TX+
9	3	RX+
6	4	RX-
3	5	GND



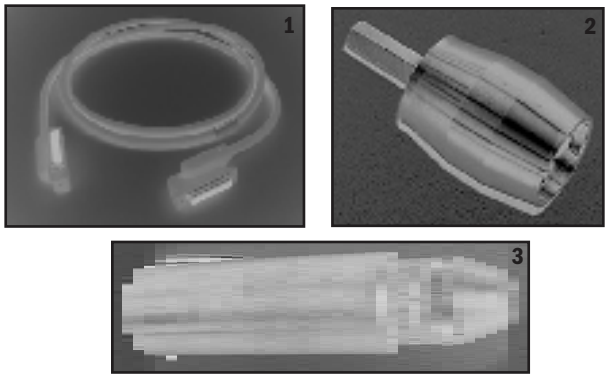
10.1.2 Manual shut-off valves

Item	Tool	Stock Number
1	Manual shut-off valve – O_2	1505-8578-000
	Manual shut-off valve – Air	1505-8579-000
	1a – O-ring,	1006-3614-000
	1b – Adapter, O_2 M18	1505-8576-000
	1b – Adapter, Air M16	1505-8577-000
	1c – Valve, two-way	0207-6023-300
	1d – Nipple, 1/8 NPTM 1 L – O_2	0213-5025-335
	1d – Nipple, 1/8 NPTM 1.5 L – Air	0213-5026-500
	1e – Filter body, M18 – O_2	1001-5921-000
	1e – Filter body, M16 – Air	1001-5923-000



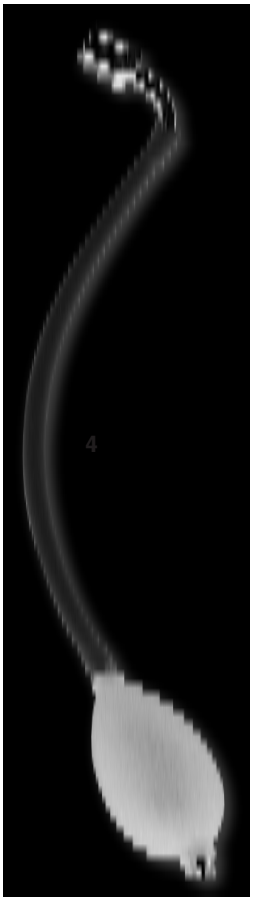
10.1.3 Special tools

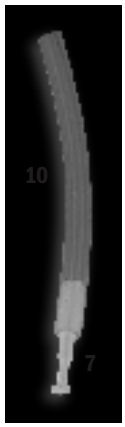
Item	Description	Stock Number
1	Cable, Remote Display Unit (2 meters) For connect DU to EC chassis when disassembled for repair and evaluation - Refer to section 9.3	M1063496
2	Tool, Nebulizer connector - Refer to section 10.13	1505-8506-000
3	Safety Valve alignment tool (For early manifolds only) Refer to Section 9.3.5 :	1505-8598-000
	Handle, Service EC Air Compressor – two required Refer to section 9.7	5370055



10.1.4 Leak test devices

Item	Tool	Stock Number
	Leak test device kit (includes items 1 through 10)	1505-8590-000
1	Syringe, 60 cc	1505-3061-000
2	Clamp, tubing	7000-0000-097
3	Tee, 1/8 inch barb	7000-0000-186
4	Negative low-pressure leak test device	0309-1319-800
5	Tee, sensing 22-mm to 15-mm	0212-0763-100
6	Connector, Endo tube	0219-5060-530
7	Plug, 4-mm	1006-3530-000
8	Plug, stopper (2)	2900-0001-000
9	Silicone tubing 3/16 ID	1006-3666-000
10	Tubing, clear 0.125 ID	1605-1001-000





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