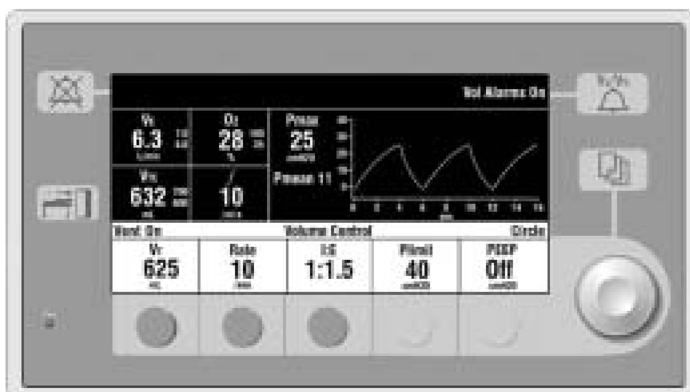
Aestiva/5 7900 Anesthesia Ventilator

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.

AAA A 12345

This alpha character indicates the year of product manufacture and when the serial number was assigned;
"D" = 2000, "E" = 2001, "F" = 2002, etc.
"I" and "O" are not used.

CE
0197

05/04 1006-0453-000

Aestiva 7900 Anesthesia Ventilator
Software Revisions 1.X, 3.X, and 4.X

Important

The information contained in this service 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 service 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 service 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 service 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 service 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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1 Introduction

In this section

1.1 What this manual includes

This manual covers the service information for the Aestiva 7900 SmartVent Anesthesia Ventilator which is an integral component in the Aestiva Anesthesia Machine.

The Aestiva Anesthesia Machine has its own service manual (Stock Number 1006-0452-000).

Special notice

Some information in this manual can possibly point the reader to electronic troubleshooting and component/repair replacement level of service. This information, when supplied, is only supplied to add clarity to service or troubleshooting statements. Datex-Ohmeda Service Personnel are mandated by Company Policy to service electronic equipment to a board replacement level only.

- Read completely through each step in every procedure before starting the procedure; any exceptions can result in a failure to properly and safely complete the attempted procedure.
- Unless otherwise specified, values in this manual are nominal.
- Sections in this manual begin on odd numbered or right-hand pages. If there is no text on the preceding, backup even numbered page, it is labeled “Notes” for your use if you wish.
- Figures that require more than one page have the title and main text on the left (even numbered) page. Additional figure information is on the facing (odd numbered) page.

1.1.1 Software versions

The revision level is displayed on the ventilator start-up menu. This manual includes test and calibration procedures for Revision 1.X, 3.X, and 4.X software.

1.2 Standard service procedures

1.2.1 Operation manuals

You must have, and be familiar with, the Operation manuals for this product. Study the Aestiva Operation manuals if you need further information about the operation of the system.

1.2.2 Service manuals

You must determine where a problem is located before you can determine which service manual to use:

- Use this manual for 7900 Ventilator related problems.
- Use the Anesthesia Machine service manual (1006-0452-000) for all other components of the Aestiva Anesthesia Machine.

1.2.3 Ventilator tests

Service calibration functions let Datex-Ohmeda trained users and Datex-Ohmeda service personnel perform ventilator setup functions, tests, calibration and measurements from the front panel display.

Normal operational tests, calibration, and troubleshooting can be performed on your Aestiva 7900 Ventilator without removing components from the system. Repair may require removing the ventilator components from the anesthesia machine.

⚠ **WARNING** Section 4, *"Service Mode Tests and Calibration"* must be performed whenever you access any internal component of the Ventilator to verify that all critical parts of the Ventilator are still operational and within specification.

⚠ **WARNING** After the Ventilator has been serviced, you must perform *"Post -Service Checkout"* to verify the entire Anesthesia System is properly functioning before the system can be returned to clinical use.

⚠ **WARNING** Do not perform testing or maintenance on this instrument while it is being used to ventilate a patient, possible injury may result.

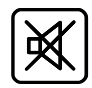
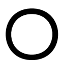
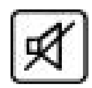
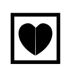
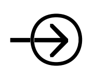
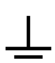
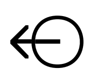
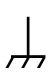
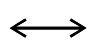
1.3 Symbols used in the manual or on the equipment

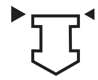
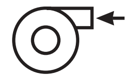
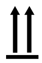
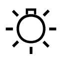
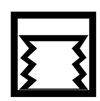
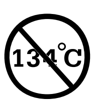
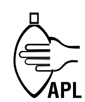
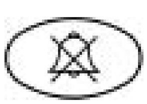
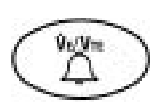
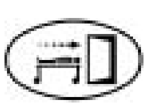
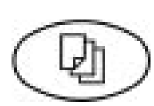
 Warnings and  Cautions tell you about dangerous conditions that can occur if you do not follow all instructions in this manual.

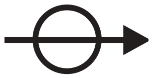
Warnings tell about a condition that can cause injury to the operator or the patient.

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

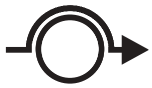
Other symbols replace words on the equipment or in Datex-Ohmeda manuals. No one device or manual uses all of the symbols. These symbols include:

|	On (power)		Alarm silence button
	Off (power)		Alarm silence touch key (Tec 6).
	Standby		Type B equipment
	Standby or preparatory state for part of the equipment		Type BF equipment
	"ON" only for part of the equipment		Type CF equipment
	"OFF" only for part of the equipment		Caution, ISO 7000-0434
	Direct current		Attention, refer to product instructions, IEC 601-1
	Alternating current		Dangerous Voltage
	Protective earth ground		Input
	Earth ground		Output
	Frame or chassis ground		Movement in one direction
	Equipotential		Movement in two directions
+	Plus, positive polarity	REF	Stock Number
-	Minus, negative polarity	SN	Serial Number

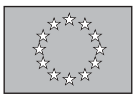
	Variability		Read top of float.
	Variability in steps		Vacuum inlet
	This way up		Suction bottle outlet
	Lamp, lighting, illumination		Cylinder
	Lock		Isolation transformer
	Unlock		Linkage system
	Close drain		Risk of Explosion.
	Open drain (remove liquid)		Low pressure leak test
134°C	Autoclavable		Mechanical ventilation
	Not autoclavable		Bag position/ manual ventilation
	Inspiratory flow		Expiratory flow
O_2%	O_2 sensor connection.	**O_2+**	O_2 Flush button
	Alarm silence touch key.		Volume alarms On/Off touch key.
	End case touch key		Menu touch key.



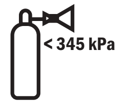
Absorber on.



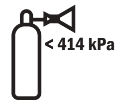
Absorber off (CO_2 Bypass active).



CE European Union Representative.



The primary regulator is set to pressure less than 345 kPa (50 psi).



The primary regulator is set to pressure less than 414 kPa (60 psi).

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

2 Theory of Operation

In this section

This section provides functional descriptions and theory of operation for the major components of the Aestiva 7900 Ventilator.

2.1 General description

The Aestiva 7900 Ventilator is a microprocessor based, electronically-controlled, pneumatically-driven ventilator with built in monitoring systems for inspired oxygen, airway pressure and exhaled volume. The ventilator is designed to be used as a medical device assisting in the delivery of anesthesia and is part of the Aestiva Anesthesia Machine.

2.2 Aestiva 7900 Ventilator features

- Sensors in the breathing circuit are used to control and monitor patient ventilation and measure inspired oxygen concentration. This lets the ventilator compensate for compression losses, fresh gas contribution, valve and regulator drift and small leakages in the breathing absorber, bellows and system.
- Positive End Expiratory Pressure (PEEP) is regulated electronically. During mechanical ventilation the software maintains the set airway pressure. PEEP is not active when mechanical ventilation is off.
- User settings and microprocessor calculations control breathing patterns. User interface settings are kept in non-volatile memory.
- Mechanical ventilation is started with the Bag/Vent switch on the breathing system.
- The Aestiva 7900 Ventilator reads the status of the Bag/Vent switch and the breathing circuit type (Circle, Bain-Mapleson D). The operator does not have to set the breathing circuit type from a menu.
- The Aestiva 7900 Ventilator has an operator-selectable Heliox mode to permit gas composition compensation when Heliox gas is used.
- All Aestiva 7900 Ventilators have minimum monitoring and alarms managed on the ventilator panel (there is no other panel for safety relevant alarm management, etc.).
- Ventilator hardware is regularly monitored by software tests.
- An RS-232 serial digital communications port connects to and communicates with external devices.
- An exhalation valve modulates flow in the pressure mode.
- Pressure and volume modes are selectable by the operator.
- All pneumatic components are located on one manifold.
- Exhausted drive gas and bellows pressure relief valve gases are mixed and go through the ventilator exhalation valve.
- Exhalation valve block is autoclavable.
- Excess fresh gas released from the bellows and ventilator drive gas is transferred from the exhalation valve to the Anesthesia Gas Scavenging System (AGSS).
- Optimized for service with a low number of components.

2.2.1 Safety features

- Dual redundant airway overpressure protection, linked to Pmax setting.
- Volume over-delivery limits and protection.
- Proprietary hose connections and fixed manifolds.
- 10 VA electrical power limiting to potential oxygen enriched environment.
- 150 psi burst overpressure protection.

2.3 Aestiva 7900 Ventilator components

Components of the ventilator are found in different locations on the Aestiva Anesthesia Machine. The ventilator package consists of:

1. Ventilator control electronics
2. Control panel and display (two mounting options shown)
3. Sensor interface board (SIB)
4. Pneumatic engine

Note For the Aestiva/5 MRI machine, the display is centrally mounted above the flowhead.

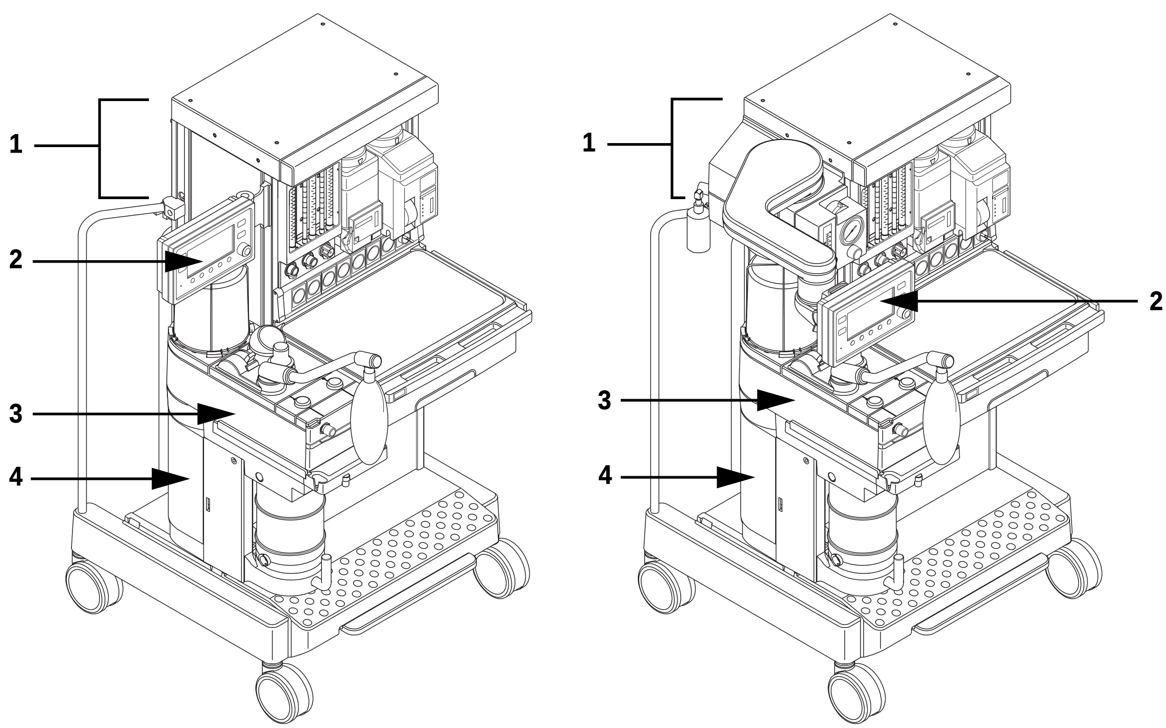


Figure 2-1 • Aestiva Anesthesia Machine with hinged and outboard arm options

2.3.1 Ventilator control electronics

The ventilator control electronics is found in the electrical enclosure of the Aestiva machine behind the AC Inlet module.

In the original Aestiva machines, the power supply and the CPU are on separate boards, as shown in Figure 2-2.

The ventilator control electronics includes the power supply and the CPU. The power supply receives AC power from the machine's AC Inlet module. All the power necessary to operate the ventilator and light package comes from the power supply. The CPU controls operation of the ventilator.

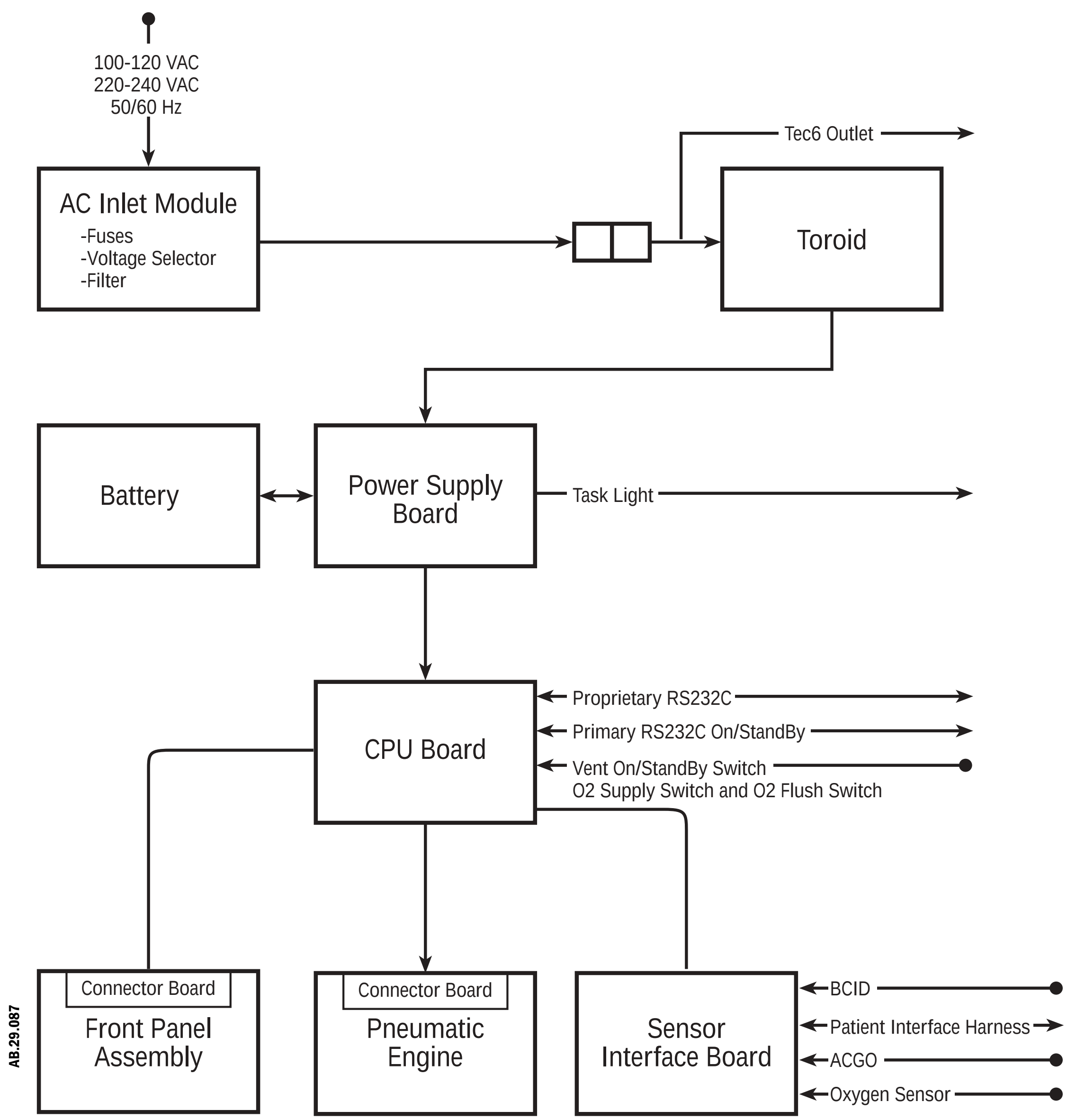


Figure 2-2 • Aestiva 7900 Ventilator functional block diagram (Original CPU)

In current Aestiva machines, the regulated power supplies and the CPU are included on a single board (Integrated CPU Board), as shown in Figure 2-3.

A universal power supply is used to convert AC to DC that feeds into the power supply circuits of the integrated CPU board. The universal power supply eliminates the need for the toroidal transformer.

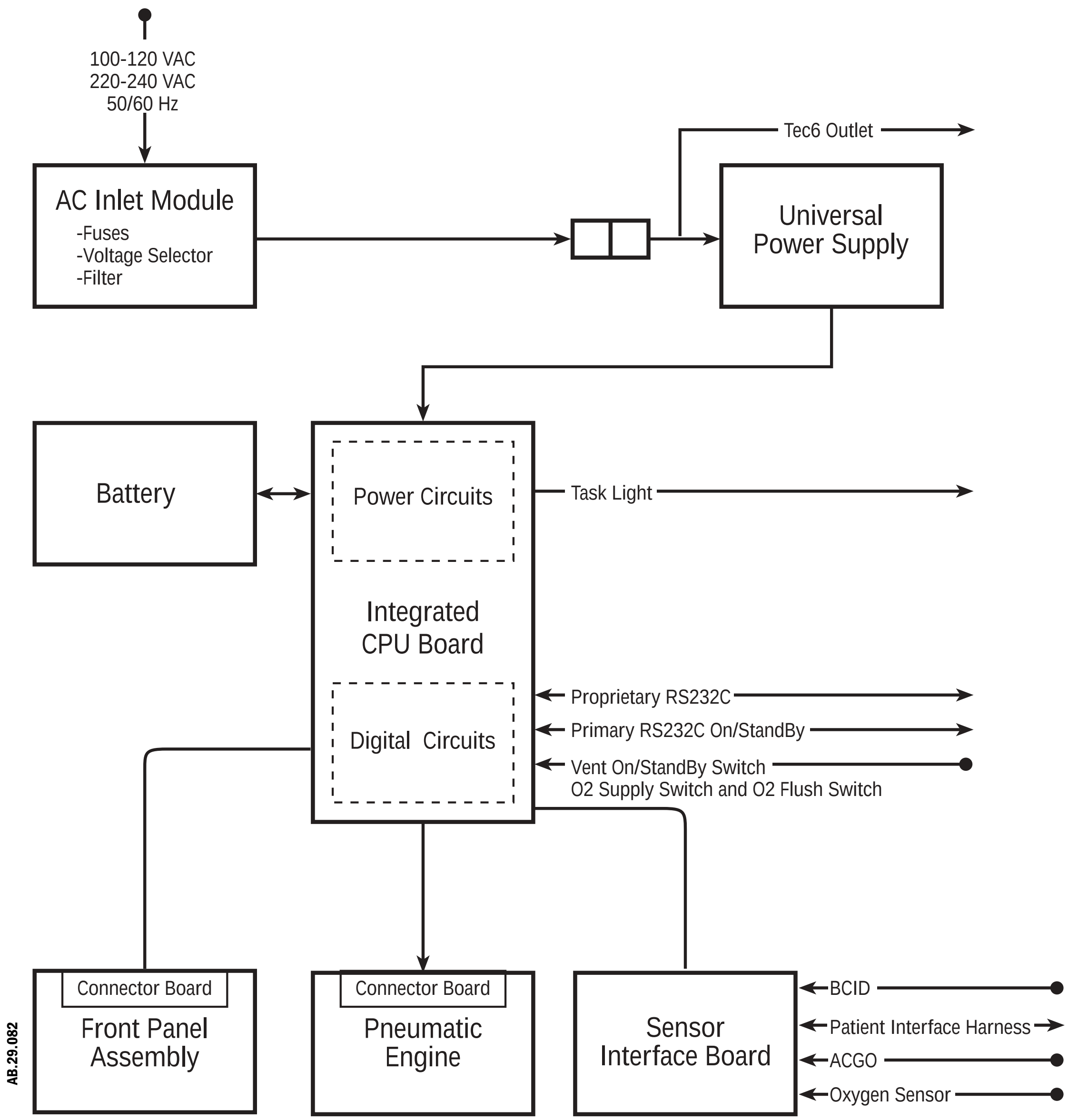


Figure 2-3 • Aestiva 7900 Ventilator functional block diagram (Integrated CPU)

2.3.2 Control panel and display

The control panel on the Aestiva 7900 Ventilator is either outboard (on an arm) or on a hinge to fold flat against the machine (depending on the option ordered) and is made to permit you to grip the panel and push the buttons with your thumbs. The ventilator control panel position is easily adjusted.

For the Aestiva/5 MRI machine, the display is centrally mounted above the flowhead.

The front panel assembly has four submodules:

- The electroluminescent (EL) display
- The keyboard front panel
- A rotary encoder
- A speaker

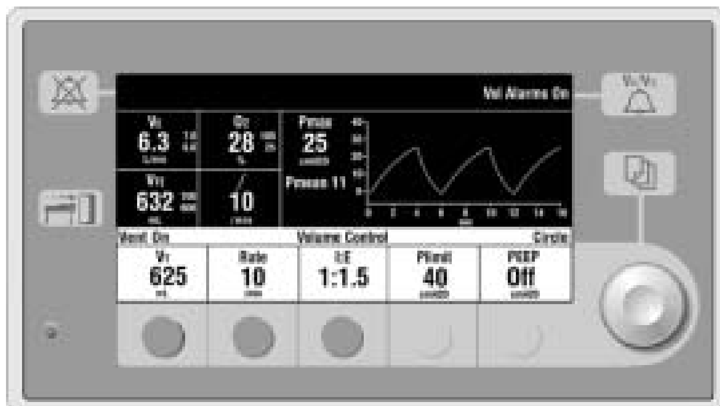


Figure 2-4 • Ventilator control panel with software version 4.X

The keyboard and rotary encoder are used to control the operations of the ventilator. The front panel uses a three step — selection, change, and approve — setting scheme to prevent unwanted selections. The speaker supplies audio input to the operator.

Logical layout of primary controls is left to right in the sequence: tidal volume or inspiratory pressure level, respiratory frequency, I:E ratio, maximum inspiratory pressure, and PEEP (positive end expiratory pressure).

Primary Ventilator interfaces include:

- Display
- Soft keys
- Rotary encoder (control wheel)
- Knob button (control wheel)
- LED
- Audio

2.3.3 Sensor Interface Board (SIB)

A Sensor Interface Board (SIB) serves as the interface between the ventilator CPU board and the breathing circuit sensors.

The SIB processes signals from the:

- Inspiratory and expiratory flow transducers
- O_2 sensor
- Auxiliary Common Gas Outlet (ACGO) switch (optional)
- Module ID board
- Canister release switch
- Absorber CO_2 Bypass switch
- Bag/Vent switch
- Control panel switch
- Drive Pressure Limit (DPL) switch
- Manifold pressure transducer
- Patient airway pressure transducer

The SIB for the Aestiva 7900 Ventilator is located in the cable duct under the rear subfloor of the breathing circuit chassis. The SIB uses a 50-conductor cable that supplies the link between the Aestiva 7900 Ventilator CPU and the breathing system signals.

Figure 2-5 • Sensor Interface Board (SIB)

2.3.4 Pneumatic Engine

The pneumatic engine enclosure is located in the back chamber of the breathing system and is shielded to contain EMI emissions. The enclosure includes the Pneumatic Engine and a Pneumatic Engine Connector Board.

The Pneumatic Engine comprises the hardware that drives the ventilator bellows. It includes:

- a 5-micron inlet filter
- a gas inlet valve (GIV)
- a pressure regulator
- a flow control valve
- a drive gas check valve
- a mechanical over-pressure relief valve
- a differential pressure relief valve
- a free-breathing check valve

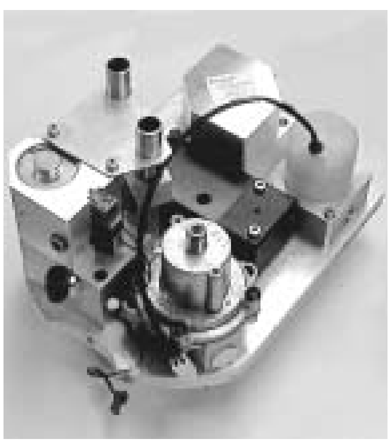


Figure 2-6 • Pneumatic Engine

2.4 Electrical

2.4.1 Electrical (original)

The original (non-integrated) Aestiva 7900 Ventilator electronic/electrical subassemblies or modules include:

- Power entry toroid
- Power supply board
- CPU board
- Display and front panel assembly
- Sensor interface board
- Sealed lead acid battery

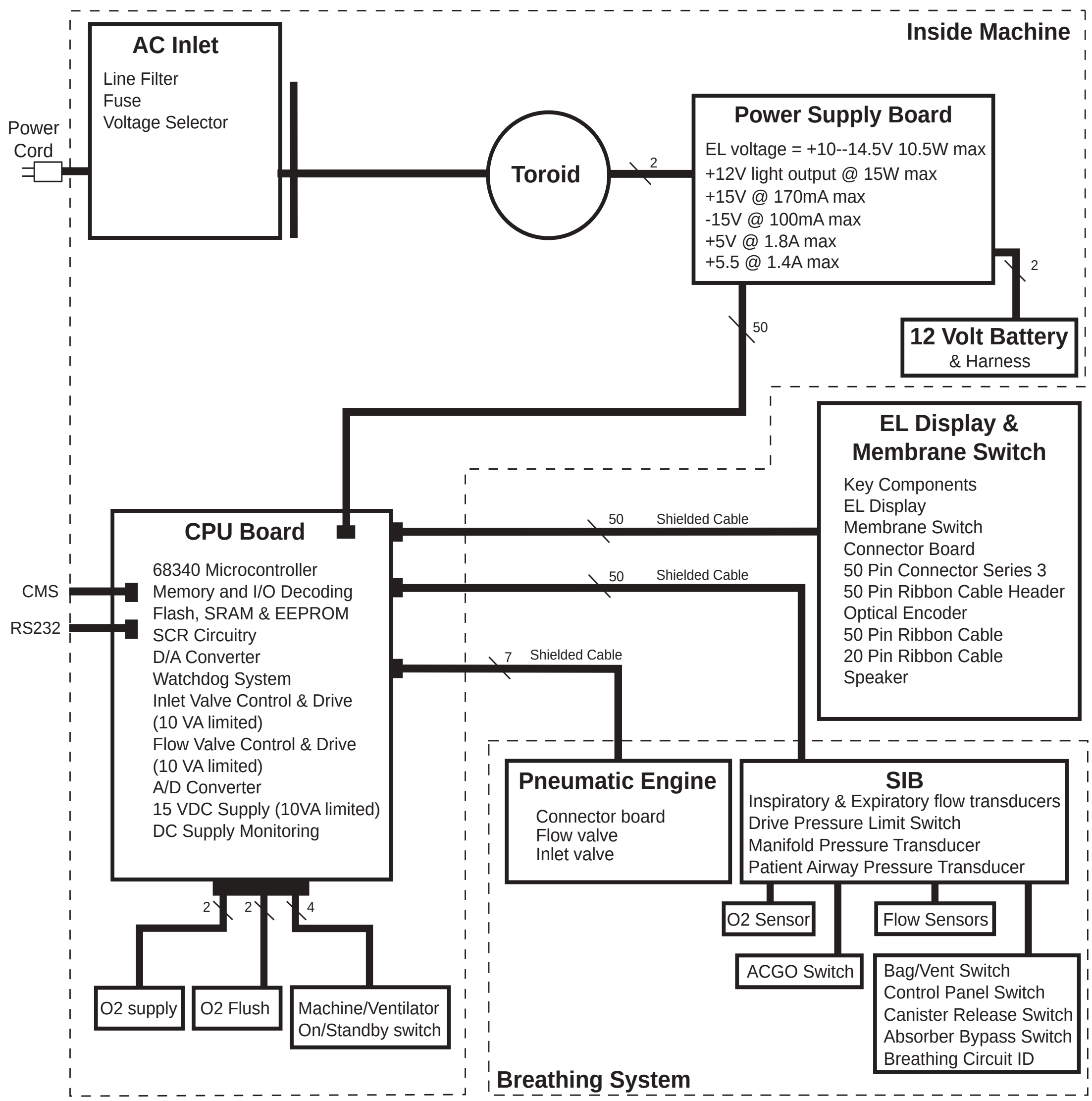


Figure 2-7 • Electronic functional block diagram (Original CPU)

2.4.2 Electrical (integrated)

The integrated Aestiva 7900 Ventilator electronic/electrical subassemblies or modules include:

- Universal power supply (AC to DC converter)
- CPU board (with power supply and digital circuits)
- Display and front panel assembly
- Sensor interface board
- Sealed lead acid battery

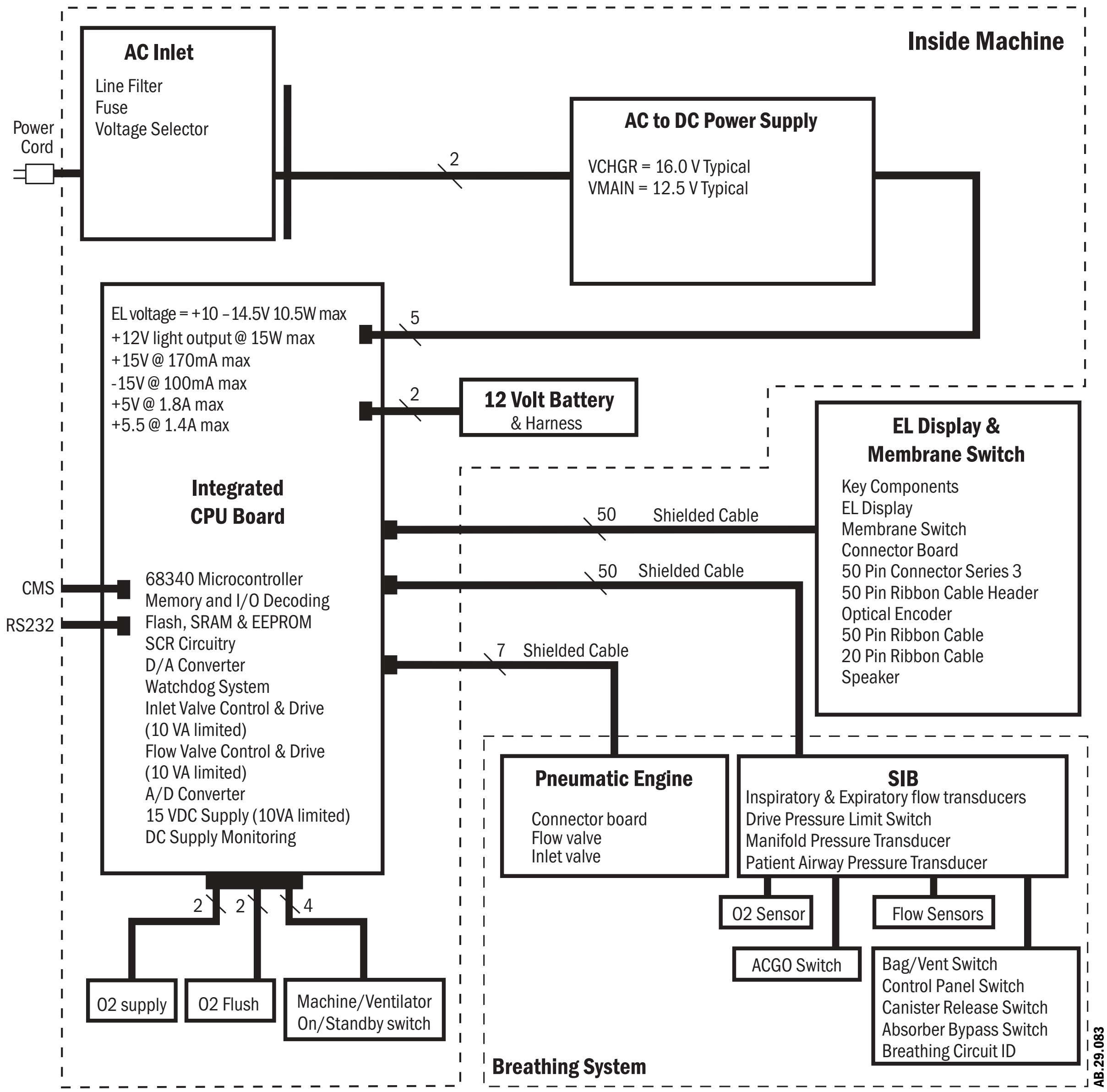


Figure 2-8 • Electronic functional block diagram (Integrated CPU)

2.4.3 Power supply (original)

The power supply performs seven functions:

- AC to DC converter
- DC to DC step-down converter
- Battery charger
- Multiple output DC regulator
- Battery charge/discharge current monitor
- Battery voltage monitor
- Task light power supply 12V

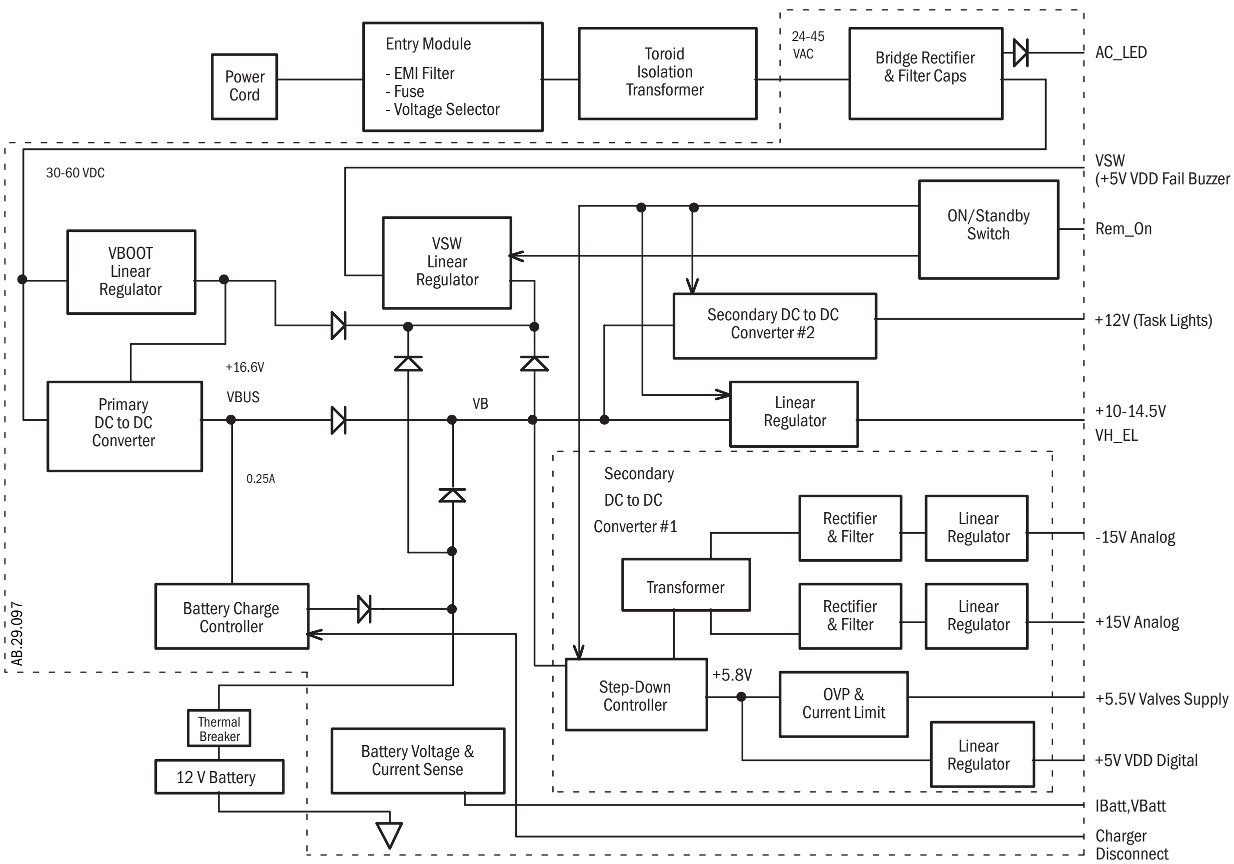


Figure 2-9 • Ventilator power supply (Original CPU)

2.4.4 Power supply (integrated CPU)

Aestiva machines with an integrated CPU board use a universal power supply for AC to DC conversion. The remainder of the power supply functions are derived in the power supply circuits on the integrated CPU:

- DC to DC step-down converter
- Battery charger
- Multiple output DC regulator
- Battery charge/discharge current monitor
- Battery voltage monitor
- Task light power supply 12V

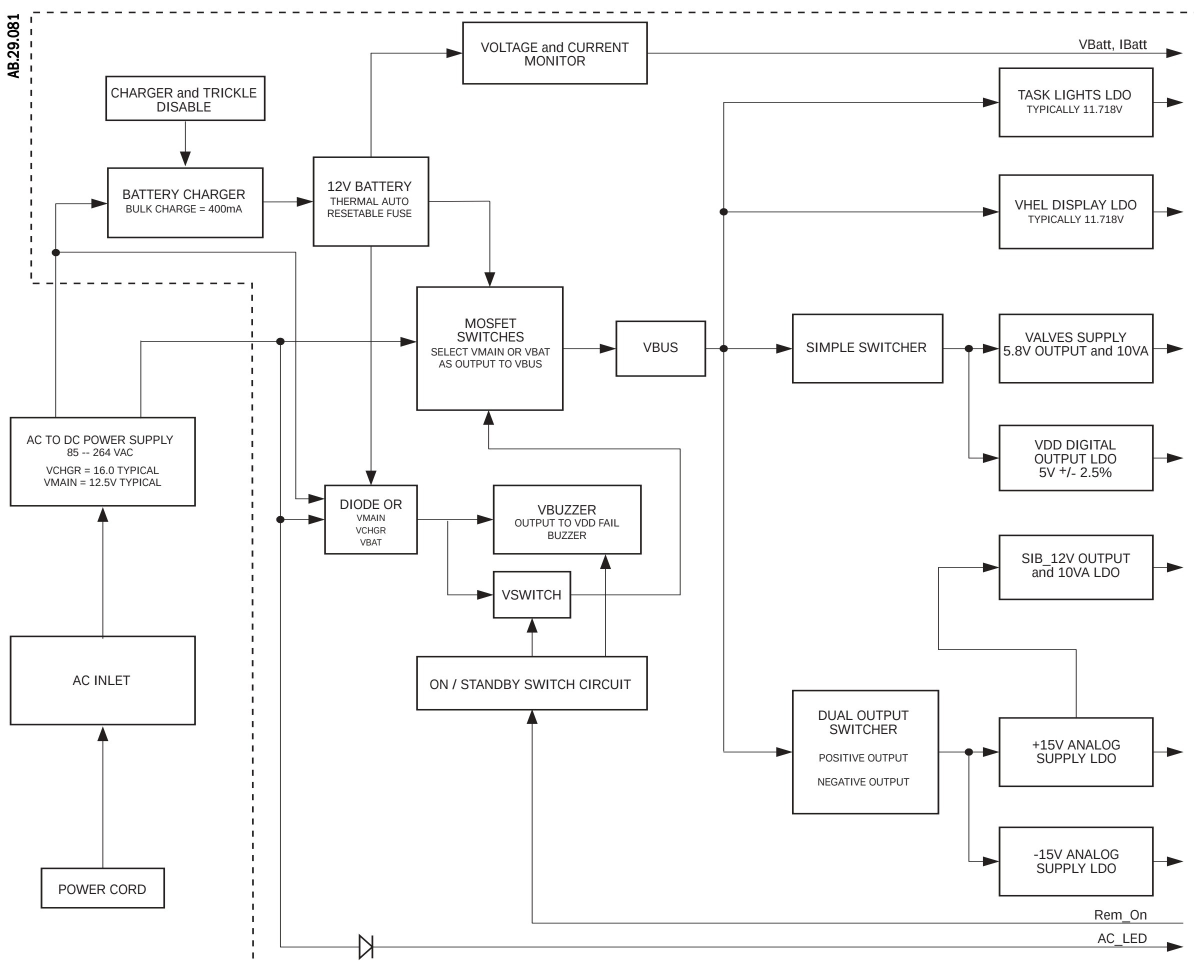


Figure 2-10 • Ventilator power supply (Integrated CPU)

2.4.5 Sealed lead acid battery

A sealed lead acid battery supplies battery backup for the Aestiva 7900 Ventilator. The Aestiva 7900 Ventilator is not a portable unit. Batteries for the ventilator are used as back up power in case of a power failure. Thus the battery is in a float charge state most of the time. Batteries meet the following:

- Capacity to operate unit for 30 minutes.
- Long float charge life.
- Battery pack is internally fused - in line replaceable.
- Battery terminals and connecting wires are protected against short circuits.

Input

Nominally 13.7 VDC at 25°C during float charge.

Output

+10V to +14.8VDC during discharge

2.4.6 CPU assembly

The CPU assembly contains all of the major circuit functions necessary to control ventilator operation. In the original Aestiva 7900 machines, these functions are on a separate CPU board. For current machines, they are part of the digital circuits section of the integrated CPU board.

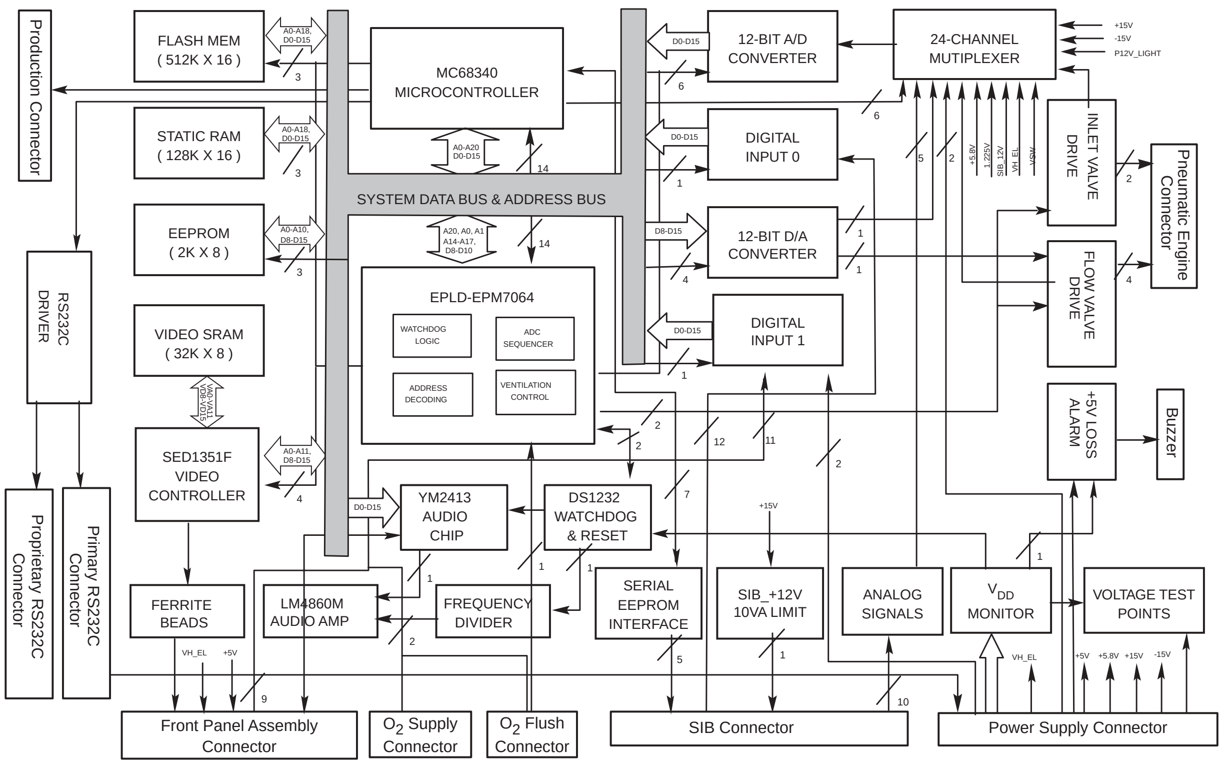


Figure 2-11 • Ventilator CPU block diagram

Motorola 68340 processor core

The CPU core consists of the following internal functions:

- Bus access control signals for all memory and peripheral devices
- Interrupt handling
- Clocks and timers for the system
- Background software development mode
- Two RS232C serial I/O ports
- Baud rate generator for serial ports
- Hard (power-up) and soft (watchdog error) reset generation
- Data bus buffers
- Memory and I/O decoding
- Program memory
- Safety Relevant Computing (SRC)
- Watchdog system
- Data acquisition
- Flow valve control
- Inlet valve drive
- Front panel interface
- Audio alarm
- Regulator output/manifold pressures

System clock

An external 32.768 kHz crystal is used with the internal clock synthesizer to generate a 24.12 MHz system clock.

Periodic interrupt timer

The periodic interrupt timer is the time base for the Real Time Operating System.

Software watchdog timer

The software controlled internal watchdog timer guards against program execution going astray.

External bus interface

The external bus interface handles the transfer of information between the CPU32, external memory and peripherals.

Serial communications module

Timing reference

An external 3.6864 MHz clock oscillator is used as the timing reference for the Baud Rate Generator.

Configuration

Both of the serial communication channels are configured as full-duplex asynchronous RS232C ports. The internal Baud Rate Generator establishes the communication baud rate, with a higher limit of 19.2k Baud.

Special operating modes

The serial channels are capable of operating in various looping modes for self testing as well as for remote testing of serial communications. These tests include automatic echo, local loop-back, and remote loop-back.

Memory and I/O decoding

Microprocessor Chip Selects

The four programmable chip selects from Motorola 68340 access external memory and peripheral circuits, providing handshaking and timing signals as well as a wait state generation, watchdog logic and ventilation control signals.

I/O lines

Spare I/O lines are used for digital control and/or sense lines.

Timer modules

Counter/timer #1

The first counter/timer module is used to monitor the MC68340 system clock frequency. The external 3.6864 MHz baud rate clock is the time base for this measurement.

Counter/timer #2

The second counter/timer module can be used as desired by the application software. The time base for this timer is the internal 24.12 MHz system clock.

Program memory

Flash memory

Two 512K x 8 Flash memory devices are used. This memory contains the real time operating system (RTOS) and software code. The Flash memory devices are socketed.

System RAM

This memory consists of two 128 K x 16 CMOS static RAMs with on-board expansion capability to 512K x 16 SRAMs.

Non-volatile memory

This memory consists of a single 2K x 8 EEPROM and stores information which needs to be retained when the system is powered down. This includes user selectable operating parameters and a system error log.

Safety Relevant Computing (SRC)

This section addresses the Safety Relevant Computing (SRC) requirements of DIN V VDE 801. The electronic hardware design provides the necessary capability for meeting these requirements. This includes:

- Digital monitoring of selected control signals.
- Analog monitoring of supply voltages, internal control voltages, feedback signals from the flow and inlet valves, and battery voltage.
- Automatic switch-over to battery operation in the event of an interruption in ac power.
- Use of the software watchdog timer in the 68340 processor for temporal monitoring, with direct de-energizing of the flow and inlet valves in the event of a non-recoverable error.
- Use of an operating mode watchdog for logic and timing monitoring, with direct de-energizing of the flow and inlet valves in the event of a non-recoverable error.
- Monitoring of the system clock to detect an operating frequency out of an acceptable range.
- Use of a redundant high pressure limit safety switch in the bellows drive circuit which directly de-energizes the flow valve.

Watchdog systems

MC68340 software watchdog timer

Each mode of ventilator operation has a unique watchdog toggle channel that is initialized at the legal program entry for that mode. The watchdog is then toggled by writing that channel number to the watchdog check address during any program paths that occur only in the selected mode of operation. An error is detected if program flow is disrupted and an illegal sequence tries to toggle the watchdog with its own different channel number. Each mode includes multiple accesses to its watchdog channel number to improve detection of incorrect program flow.

Watchdog operation

The channel number must be the same for both watchdog initialization and toggle channel number. A difference is detected as errant program execution and causes an immediate level 7 interrupt (IRQ7).

A legal watchdog toggle must occur at least once every 35 msec to prevent a time-out and subsequent level 7 interrupts.

A system reset will occur between 62.5 msec and 250 msec if no legal toggle addresses occur by that time. Multiple level 7 interrupts will occur prior to a reset. The output of this watchdog is connected to IRQ7 on the 68340 processor.

Error response sequence

Errors detected by either watchdog are handled in the following sequence:

- At the first detection of any error, a watchdog responds by issuing an IRQ7 interrupt.
- If the exception handler software for IRQ7 cannot correct the error, then the next detection of an error causes a soft system reset.
- If the error still cannot be corrected, then an audio alarm sounds (independent of processor interaction) and a cyclic soft reset continues until the error is corrected or the system is powered down.

DATA acquisition

The data acquisition system for the Aestiva 7900 Ventilator consists of two major building blocks. The first is an analog to digital converter (ADC) system and the second is a digital to analog converter (DAC) system.

This portion of the Aestiva 7900 Ventilator allows the microprocessor to interface with valves and pressure transducers. The data acquisition system is also used for internal monitoring of safety relevant signals.

The ADC system is designed to meet the following specifications:

Resolution	12 Bits
Input Voltage Range	0 - 4.095 Volts (1mV/LSB)
Number of Channels	24
Total Conversion Time	8 to 8.63 µsec max
Integral Nonlinearity	± 1 LSB max
Differential Nonlinearity	± 1 LSB max (guaranteed monotonic)
Full-Scale Error	± 6 LSB max
Unipolar Offset Error	± 3 LSB max

The DAC system is designed to meet the following specifications:

Resolution	12 Bits
Number of Channels	1
Settling time to 0.01%	30 µsec max
Output Voltage Range	0 - 4.095 Volts (1mV/LSB)
Integral Nonlinearity	± 1 LSB max
Differential Nonlinearity	± 1 LSB max (guaranteed monotonic)
Full-Scale Error	± 9 LSB max
Zero-Scale Error	+ 4 LSB max

Analog to digital converter System

A 24 channel multiplexer and buffer amplifier precedes the A/D converter. The manifold pressure, patient pressure, inspiratory flow and expiratory flow signal inputs to the multiplexer are filtered with an antialiasing filter. Other inputs are filtered by low pass filters.

Signals that are monitored by the ADC system include:

- Patient Pressure
- Manifold Pressure
- Inspiratory Flow Sensor
- Expiratory Flow Sensor
- Flow Current sense
- Flow DAC output
- Inlet Valve Current sense
- O_2 Concentration
- Power Supplies
- Battery Backup system

The ADC system is based around a 12 bit A/D converter. It operates from ± 15V power supplies except for the A/D converter. The 12-bit converter is powered by a filtered +5V supply and protected from over-voltage.

Multiplexer and buffer amplifier

The multiplexer settles quickly, within 8 µ sec to 0.01%, to be stable for the ADC 12-Bit conversion and to maintain the overall 20 µ sec conversion time. The system bandwidth requirement is from dc to 20Hz. The multiplexer is an 8 channel fault protected device and the amplifier used as a buffer to drive the A/D converter (AD822AR).

A/D converter

The MAX191BCWG is a 12-Bit converter that operates from a single 5 Volt power supply. The clock frequency to run the A/D converter is 1.507MHz. It is derived from the microprocessor system clock.

With a 1.507MHz clock, the conversion time of the A/D converter is 13 clock periods or 8.63 µ sec.

The MAX191BCWG has the following unadjusted dc accuracy specifications:

Integral Nonlinearity	± 1 LSB max
Differential Nonlinearity	± 1 LSB max (guaranteed monotonic)
Full-Scale Error	± 3 LSB max
Unipolar Offset Error	± 2 LSB max

Voltage reference

The MAX191BCWG has an internal 4.096 Volt ±1 mV voltage reference that can be adjusted with a potentiometer. This reference voltage is buffered and used for the digital to analog converter reference.

Flow valve control

The flow valve control circuit consists of a D/A converter and a voltage to current conversion circuit.

D/A conversion

The D/A conversion for the flow valve drive circuit is based around the MAX530 12-Bit DAC. The output of the DAC is fed to an input of the A/D converter multiplexer allowing the microprocessor to monitor the DAC output.

The MAX530 operates from the same 5V power supply as the A/D converter. The output voltage range of the converter is 0 to 4.095V (1mV per LSB).

The MAX530BCWG has the following dc accuracy specifications:

Integral Nonlinearity	± 1 LSB max
Differential Nonlinearity	± 1 LSB max (guaranteed monotonic)
Full-Scale Error	± 1 LSB max
Zero-Scale Error	+ 4 LSB max

Flow valve drive circuit

The flow valve drive circuit does a voltage to current conversion of the DAC output voltage signal FLW_DAC. With a 0 to 4.000 Volts input, the drive circuit outputs 0 to 1.0 Amps typical into a 3 ohm load. This current is passed to the flow valve and is used to proportionally control the flow valve during mechanical ventilation. This circuit does not require adjustment and is accurate within ± 2% of full scale.

This circuit also limits the flow valve output to less than 10VA under normal operation and under a single fault condition. This is a requirement of the international regulation IEC 601-2-13.

A signal proportional to the actual drive current is input to the A/D converter to permit the processor to monitor the current and detect fault conditions.

Gas inlet valve drive circuit

This circuit consists of a low-dropout regulator providing a regulated 5 Volts to the inlet valve when enabled by the microprocessor. The SHUTDOWN pin of the regulator provides on/off control.

This regulator has an output current of 250mA. It has an internal current limit of 530mA max. This keeps the output under 10VA in a single fault condition.

A current sensing circuit is included to let the processor monitor the inlet valve current via the A/D converter system and detect fault conditions.

Front panel display interface

All signals to and from the Front Panel are protected from ESD through the use of transient suppression devices and appropriate filtering. All of these signals are routed through a single connector from the microcontroller board to the front panel assembly.

EL display controller

The S-MOS SED1351F flat panel display controller drives 480 horizontal pixels by 240 vertical pixels of the EL display. Ferrite beads filter the signals from the display controller to the display.

Video display memory

This memory consists of one high speed 32K x 8 CMOS static RAM directly connected to the display controller. The video memory is mapped into memory space, but access is controlled by the display controller to ensure that the EL display is not disturbed during an access by the processor.

Membrane switch inputs

These signals are electronically debounced by an RC filter and sampled by the 68340 processor.

LED driver outputs

The AC ON LED is turned on directly from the AC power applied.

Rotary encoder input

This quadrature signal is debounced and routed to a quadrature clock converter which interrupts the 68340 processor at each detent position.

Audio alarm

The circuit consists of a programmable sound generator and a LM4860M audio amplifier. The sound generator interfaces directly to the CPU and the audio amplifier drives an 8 ohm speaker. It is normally powered from the low dropout regulator using the 5.8 V supply. In the event of a loss of the 5.8 V supply, the sound generator will be powered by the VDD supply to prevent loading of the processor data bus.

External interface

The external interface of the ventilator is an important design task from the standpoint of Electromagnetic compatibility (EMC). It is important to protect the ventilator from conducted and radiated Electromagnetic Interference (EMI) and from Electrostatic Discharge (ESD). In addition, EMI design precautions are taken to control the emission of EMI via cabling and access ports.

Communication interface (RS232C)

There are two RS232C interfaces. Each channel is configured for full-duplex asynchronous operation at communication rates up to 19.2k baud. The isolated interfaces help eliminate the possibility of ground loops. The RS-232 inputs and outputs completely conform to all EIA RS-232C and CCITT V28 specifications.

2.4.7 Sensor Interface Board (SIB)

The breathing circuit Sensor Interface Board, (SIB), is the connection between the flow transducers, patient airway pressure transducer, manifold pressure transducer, oxygen sensor, and ventilator control module. It also passes different switch functions through to the ventilator control module. These switches are used to show the position of covers, breathing circuit modules and pneumatic controls in the breathing circuit.

Respiratory gas flow, to and from the patient, is monitored by measuring the differential pressure across a variable orifice in each flow sensor. The pressure transducers for measuring the differential pressure are on the Sensor Interface Board, (SIB). The patient airway pressure and the pressure in the ventilator manifold are measured by pressure transducers on the SIB. Conditioning circuitry is supplied for these transducers and for the Oxygen sensor used in the breathing circuit.

The SIB for the Aestiva 7900 Ventilator is located in the cable duct in the bottom of the breathing circuit chassis. Input gas hoses and signal cables are routed from the sensors and switches in the breathing circuit to the SIB. A 50-conductor cable is used to transfer power and signals to and from the Aestiva 7900 Ventilator CPU board.

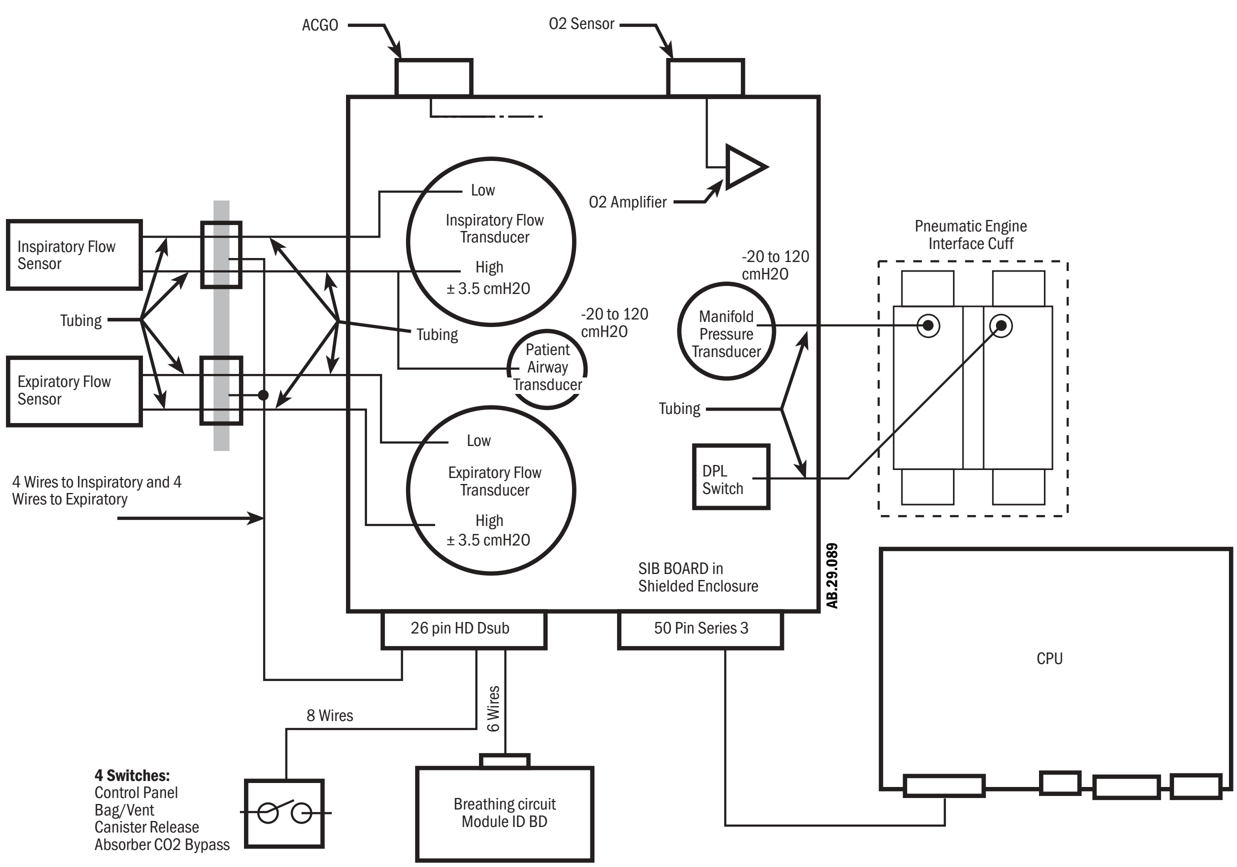


Figure 2-12 • Breathing Circuit Sensor Interface Board (SIB)

Functional description

Power supply regulators

The SIB power supply is a 10VA limited +12V to +15V supply from the Aestiva 7900 Ventilator CPU board. The supply is filtered at the SIB.

There are two regulators on the SIB that are supplied by the 12V to 15V supply. A digital +5V is supplied by a low dropout regulator. This supply is used to power the flow sensor EEPROMs. The +5V to the EEPROMs can be shut down by pulling the /SHUTDOWN control on the regulator low.

A +6.7V is supplied by another low dropout regulator. This voltage is used to power all of the operational amplifiers and pressure transducers on the SIB. The +6.7V is necessary for the AD707 bipolar OPAMP to allow for enough overhead voltage. This supply is also used to power a switched mode capacitor based inverter.

The voltage inverter supplies -6.7V for analog circuits. This supplies the AD707 OPAMP and permits it to operate to ground. The ADM660 switches at 25 kHz.

Patient airway pressure measurement

Patient airway pressure is measured at the high side (patient side) of the inspiratory pressure transducer. A pressure range of -20 to + 120 cm H_2O supplies a proportional DC output voltage in the range of 0.3 volts to 3.8V, with zero pressure supplying 0.8V. The transducer is filtered by an RC filter with a pole frequency of 1 kHz and buffered by an OPAMP. The output of the OPAMP is driving a 0.001 mF capacitor. The capacitor is used to keep a low output impedance at RF frequencies to improve EMI immunity.

Manifold pressure measurement

The manifold pressure is measured from a port on the ventilator pneumatic engine. A pressure range of -20 to + 120 cm H_2O produces a proportional DC output voltage in the range of 0.3V to 3.8V, with zero pressure supplying 0.8V. This pressure transducer is also filtered and buffered in the same manner as the patient airway pressure transducer.

Oxygen concentration measurement

The oxygen sensor is connected to the SIB by a 6-pin, 4-conductor modular jack. The oxygen sensor supplies a linear output voltage in proportion to the O_2 concentration being measured. The oxygen sensor supplies an output of 3 to 15 mV DC in air (21% O_2). It supplies an output of 14 to 72 mV DC in 100% oxygen concentration.

The oxygen sensor output is filtered for EMI, protected against ESD and amplified by a factor of 35 by an OPAMP. The amplified signal is then sent to the Aestiva 7900 Ventilator CPU board after being buffered by an OPAMP.

The O_2 OPAMP is bias current compensated. The filter at its positive input is a combination of a T-type EMI filter and RC filter. The RC filter has a pole frequency of 2 kHz. The RC filter in the AD707 feedback has a pole frequency of 47 Hz.

A “DISCONNECT” signal, in the form of a grounded wire, is sent through the O_2 cell and to the Aestiva 7900 Ventilator CPU board. This signal is used to sense if a cell is connected to the cable. The CPU board has a resistor pull up to the +5V (VDD) supply and monitors this signal on an I/O port.

Drive pressure limit switch

The drive pressure limit switch, found on the SIB, is used to monitor the drive gas pressure from the ventilator pneumatic engine. This normally closed switch signal is sent to the Aestiva 7900 Ventilator CPU board. The switch will open if the drive gas pressure is more than 104 +5/-4 cm H_2O. The activation of the switch will stop mechanical ventilation, stop the flow valve drive circuit, and close the gas inlet valve.

Chassis ground connection

The shell of the 50-pin connector is a continuation of the machine chassis. It supplies the connection to the SIB shielding box. A mounting hole on the SIB is attached to the shell of the 50-pin connector and to the SIB shielding box. A 27.4K ohm resistor in parallel with a 0.01 mF capacitor supplies a DC and AC path to chassis ground for the SIB signal ground.

Inspiratory and expiratory flow measurement

Differential pressure levels in the range of -3.5 cm H_2O to +3.5 cm H_2O are applied to the differential pressure transducers by the flow of gasses past the variable orifice in the flow sensor. This gives DC output voltages in the range of 0.3V to 3.8V, with zero pressure producing 2.05V. The output of the pressure transducers are buffered with an OPAMP in the same manner as the patient airway pressure transducer.

The block diagram shows the pneumatic and electrical connections to the variable orifice flow sensors. Calibration data for the flow sensor is stored in an EEPROM in each of the sensors. When directed by system software, a logic 1 enable signal turns on 5 VDC power to the EEPROM. A differential clock signal is sent to the SIB where it is transformed into a single ended clock by the MAX488 for the EEPROMs. The EEPROM data lines are open drain signals, one for each EEPROM. When the data has been read by the Aestiva 7900 Ventilator CPU board, the power and signals are turned off. This helps to protect the EEPROM data when the flow sensors are plugged and unplugged from the system while it is in operation. The signals and power supply to the flow sensor EEPROMs are filtered for EMI immunity and protected against ESD.

Other connections

The SIB is used as a connection point for the different switches that show the state of moveable elements within the breathing circuit. The connections are made using the 26-pin high density connector, which is also used to connect to the flow sensors. The switches include:

- Canister release
- Absorber bypass
- Bag to vent
- Control panel cover micro switches
- Four optical switch signals from the circuit module identification board

There is a 3-pin connector for the connection of the optional ACGO switch. All of the switch signals are filtered for EMI immunity and protected against ESD.

2.5 Mechanical subsystems

Refer to the system connection block diagram in Section 9 of the Aestiva Anesthesia Machine Service Manual for the complete pneumatic/mechanical subsystem.

The mechanical subsystem includes:

Pneumatic Engine

- Drive gas inlet filter
- Gas inlet valve
- Supply gas pressure regulator
- Flow control valve
- Drive gas check valve
- Mechanical Overpressure Valve (MOPV)
- Bleed resistor
- Free breathing valve

Drive gas pressure limit switch

Exhalation valve

Breathing circuit flow sensors

Bellows assembly

2.5.1 Supply gas

Supply gas (can be selected from O_2 or Air) is supplied from the anesthesia machine at a pressure of 241 to 690 kPa (35 to 100 psi). This supply gas is filtered through the 5 micron filter to remove any minute particles of contaminate. The filter does not significantly lower the output pressure on the downstream side of the filter.

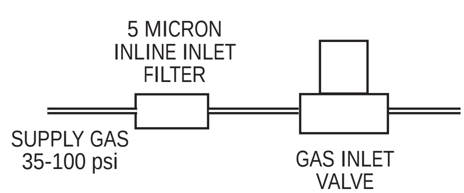


Figure 2-13 • Inlet filter and Gas Inlet Valve (GIV)

2.5.2 Gas Inlet Valve (GIV)

During normal operation the Gas Inlet Valve (GIV) is open to let supply gas flow to the ventilator manifold. This valve provides a shutoff of the supply gas to the ventilator when the ventilator is not in use. This valve also shuts off supply gas to the ventilator under failure conditions detected by the CPU or over-pressure switch. The output from the GIV stays at the filtered supply gas pressure 241 to 690 kPa (35 to 100 psi).

Pressure regulator

The pressure regulator is a non-relieving pressure regulator that regulates high pressure filtered supply gas, oxygen or medical air, down to 172 kPa (25 psi).

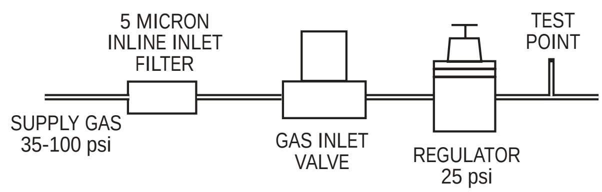


Figure 2-14 • Pressure regulator

2.5.3 Flow control valve

The flow control valve is controlled by the CPU. Signals are sent to the flow control valve of the necessary flow determined by ventilator settings and sensor signals. The flow control valve modulates the incoming 172 kPa (25 psi) drive gases to an output from 0 to 120 liters per minute at pressures ranging from 0 to 100 cm H_2O.

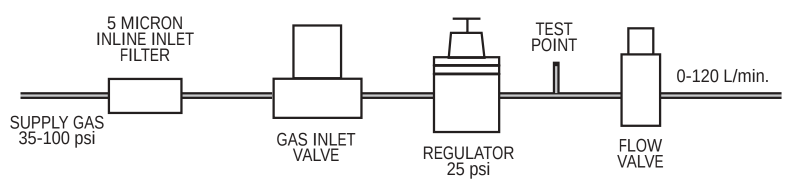


Figure 2-15 • Flow control valve

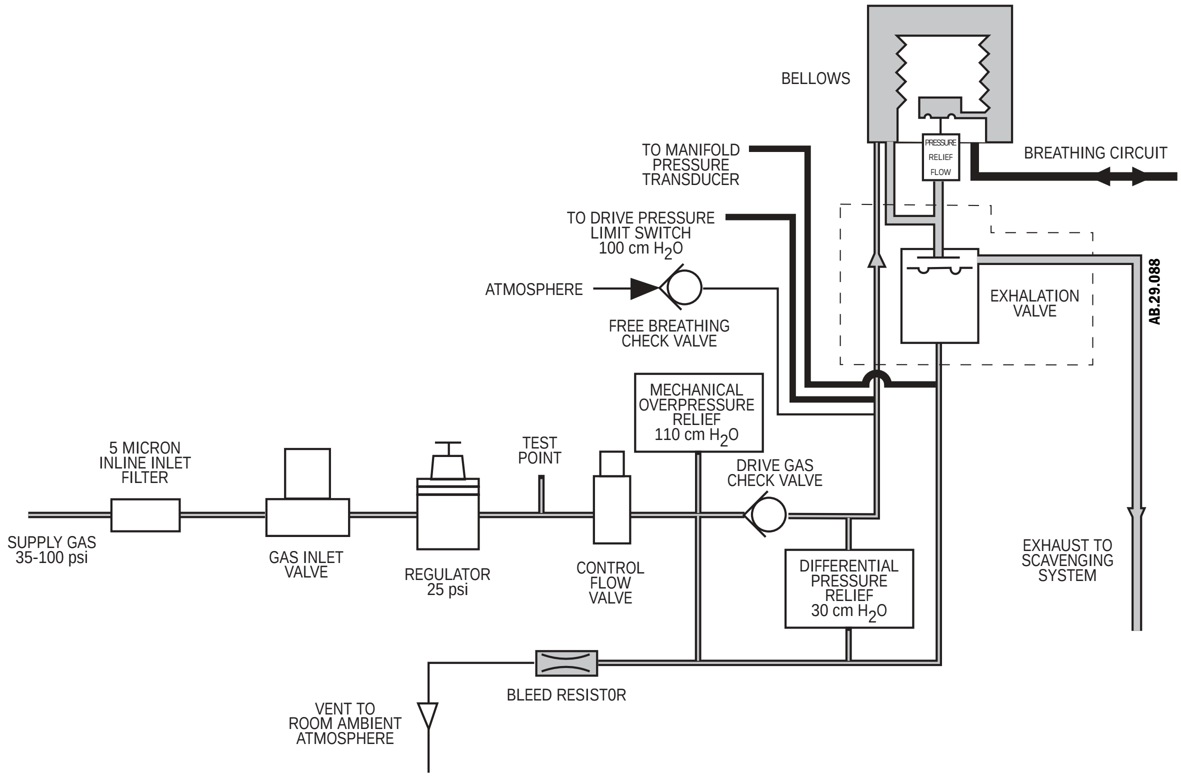


Figure 2-16 • Exhalation manifold

2.5.4 Drive Gas Check Valve (DGCV)

The Drive Gas Check Valve (DGCV) is used downstream of the flow control valve to create the pilot pressure for closing the exhalation valve during inspiratory phases, The DGCV valve is biased shut by an integral weight that supplies approximately 3.5 cm H_2O of bias pressure before permitting flow downstream to the breathing circuit. When the ventilator is exhausting flow from the breathing circuit, the DGCV permits the exhalation valve pilot pressure to be de-coupled from the circuit pressure. This permits the exhalation valve to open and lets gas flow to the exhaust and the gas scavenging system.

2.5.5 Bellows Pressure Relief Valve

The Bellows assembly is the interface between drive gas and patient gas in the breathing system. The exhalation valve and pressure relief valve (or pop-off valve) in the bellows assembly control the pressure in the two gas circuits and exhaust drive gas and excess fresh gas.

The Bellows Pressure Relief Valve (PRV) is normally closed, maintaining approximately 1.5 cm H_2O in the breathing circuit in a no flow condition, enough to keep the bellows inflated. It is piloted closed during inspiration and remains closed until the bellows is refilled during exhalation. It will exhaust ≤ 4 L/min excess fresh gas flow at ≤ 4 cm H_2O.

2.5.6 Exhalation valve

The autoclavable exhalation valve manifold contains an elastomeric diaphragm that is used along with the flow valve to control the pressures in the breathing circuit. The manifold contains two male ports on the bottom for:

- Bellows drive gas
- Exhalation valve pilot

The manifold contains two female ports on top for:

- Drive gas (pass through)
- Drive gas return
- Bellows exhaust tube.

The female AGSS port comes out horizontally.

Pilot control of the exhalation valve is done with pneumatic connections internal to the Aestiva 7900 Ventilator main pneumatic manifold. The valve is normally open. Approximately 2 cm H_2O of pilot pressure is necessary to close the valve. When the exhalation port is open, gas flows from the bellows housing to the scavenging port.

2.5.7 Mechanical Overpressure Valve

The Mechanical Overpressure Valve (MOPV) is a mechanical valve that operates regardless of electrical power on or off. This valve has two functions.

First, it functions as a third level of redundancy to the ventilator's pressure limit control functions, supplying pressure relief at approximately 110 cm H_2O.

Second, the MOPV valve functions as a backup in the event of a complete blockage of the exhalation valve system, relieving circuit pressure at approximately 30 cm H_2O under such failure conditions.

2.5.8 Bleed resistor

The bleed resistor is a “controlled leak” from 0 to 10 L/min in response to circuit pressures from 0 to 100 cm H_2O. The small quantity of pneumatic flow exhausting through the bleed resistor permits control of the exhalation valve's pilot pressure by modulation of the valve output. The bleed resistor exhausts only clean drive gas and must not be connected to a waste gas scavenging circuit. The output is routed away from the electrical components to make sure that systems using oxygen drive gas meet the 10VA limitation requirement for oxygen enrichment.

2.5.9 Free breathing valve

The free breathing valve helps assure the patient can spontaneously breathe. The ventilator is programmed to supply a specified number of breaths per minute to the patient. If, in between one of these programmed cycles, the patient needs a breath (spontaneous), the free breathing valve permits the patient to inhale. The free breathing valve is closed on mechanical inspiration.

2.5.10 Breathing circuit flow sensors

Two flow sensors are used to monitor inspiratory and expiratory gas flow. The inspiratory flow sensor is downstream of the gas system inspiratory check valve. Feedback from the inspiratory transducer is used to supply tidal volumes that make allowances for the effects of fresh gas flow and circuit compressibility. The expiratory flow sensor is located at the input to the gas system expiratory check valve. Feedback from the expiratory flow sensor is used to supply signals for expiratory tidal volume monitoring and the breath rate.

Notes

3 Post-Service Checkout

In this section

3.1 Post-service checkout

After servicing the Aestiva 7900 Ventilator, run the service menu tests that are pertinent to the components replaced. Perform calibration on flow sensors, pressure sensitivity, flow valve and bleed resistor.

Then you must complete the checkout procedure for the entire machine:

- the Aestiva 7900 Ventilator,
- the Aestiva Anesthesia Machine,
- and all the accessories and options.

⚠ **WARNING** You must perform all post-service checks after maintenance or service of the ventilator. Failure to do so may result in patient injury.

⚠ **WARNING** All components and accessories must be connect correctly. All hoses and cables must be properly connected before returning the anesthesia machine to clinical use. Failure to do so may result in patient injury.

3.1.1 Test the Aestiva 7900 Ventilator

Perform the Preoperative Checkout Procedure in Part 1 of the Aestiva Operation Manual.

3.1.2 Test the Aestiva Anesthesia Machine

The Aestiva 7900 Ventilator is an integral part of the complete Aestiva Anesthesia Machine. To be certain the ventilator is functioning correctly, test the entire system. Refer to the Aestiva Anesthesia Machine Service Manual for the proper checkout procedures.

4a Tests and Calibration — Software Revision 4.X

⚠ **WARNING** Post-Service Checkout is required after you complete this section. You must perform *Section 3.1 Post-service checkout* after performing any maintenance, service or repair. Failure to do so may result in patient injury.

⚠ **CAUTION** Section 4a should only be used with version 4.X software. Tests and Calibrations for versions 1.X and 3.X software are located in section 4b.

In this section

To ensure proper operation, the Aestiva 7900 Ventilator includes several tests that run automatically (self tests) and a series of menu pages that a qualified service person can use to test, calibrate, or troubleshoot ventilator related components in the Aestiva machine (Service Mode).

4a.1 Self tests

The Aestiva 7900 Ventilator software includes self tests that determine whether or not the operating software is functioning properly and whether or not the electronic circuits on the circuit boards are functional.

The self tests include:

- Powerup tests
- Continuous tests
- Periodic tests

Powerup tests

The following is a list of the tests run at powerup:

- Sequential watchdog
- Logical watchdog
- Data RAM walking pattern test
- FLASH ROM CRC verification
- Gas inlet valve test (electrical and pneumatic)
- Calibration of the manifold sensor

If one or more of these tests fail, the display provides a readout of the problem.

The On and Off states of the Gas Inlet Valve (GIV) are tested at power up. The manifold pressure will be tested to determine pass/failure. If the GIV causes the self test to fail on power up, an alarm sound and the message “Gas Inlet Valve Failure” is displayed.

If the calibration of the manifold sensor fails on power up, an alarm sounds and the message “Manifold Pressure Sensor Failure” is shown.

Continuous tests

These tests are run continuously during normal operation and alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area.

- Flow valve electrical feedback
- Supply voltage checks
- Battery voltage checks

The flow valve feedback signal is tested in non-mechanical and mechanical ventilation states. The flow valve is closed in non-mechanical ventilation.

Periodic tests

These tests are run every 30 seconds during normal operation. Alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area.

- CPU Test
- Display RAM walking pattern test
- Data RAM walking pattern test
- FLASH ROM CRC verification

4a.2 Service Mode Confirmation menu

The service calibration mode tests and/or calibrates hardware necessary to prepare a ventilator manufactured for shipment and to service a ventilator in the field.

There are two ways to enter the service mode:

- If the machine is turned off, push and hold in the adjustment knob while setting the system switch to On. Hold the adjustment knob pushed in until the “Service Mode Confirmation” menu appears. Use the adjustment knob to highlight “Service Mode”, then push the adjustment knob to confirm the selection.
- If the machine is already in normal operation, set the Bag/Vent switch to Bag. Press End Case key, press the V_T/Pinsp, the PEEP, and the menu switches at the same time to reset the software (powerup). Push and hold the adjustment knob until the “Service Mode Confirmation” menu appears.

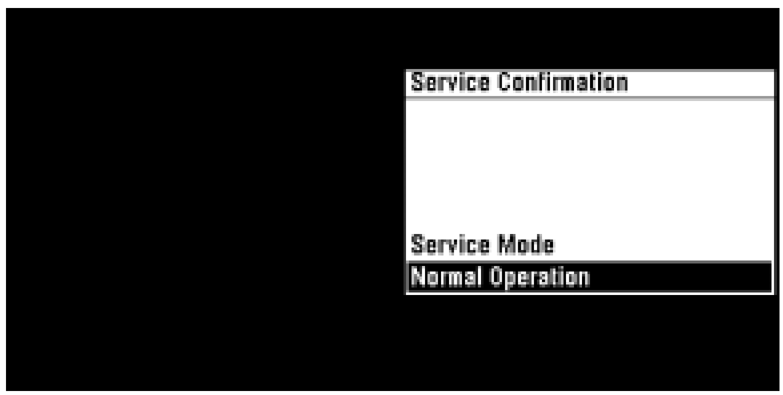


Figure 4-1 • Service confirmation menu

From this menu you can go to the Service Mode or into Normal Operation.

4a.3 Main Menu - Service Mode

The service mode is entered from the service confirmation menu. Select "Service Mode" and push the adjustment knob. The Service Mode main menu allows navigation to the individual menus for alarm or error logs, calibrations, system configurations, diagnostic tests and tools, and user selected defaults.

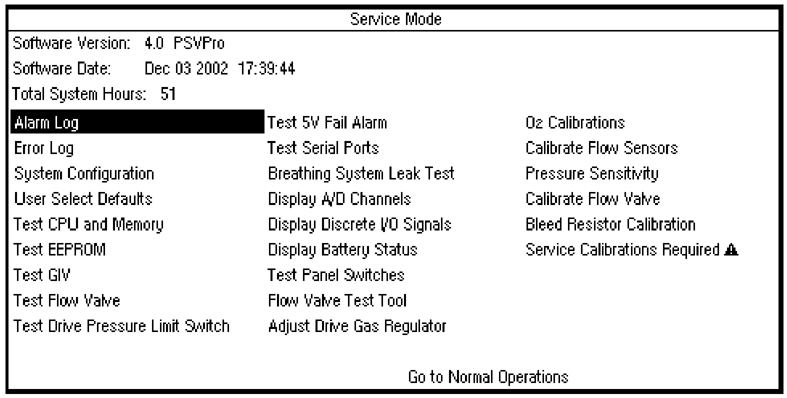


Figure 4-2 • Service Mode main menu

Any menu can be selected by pressing the control knob. The software version, software date, and total system hours at the top of the Service Mode main menu are not selectable.

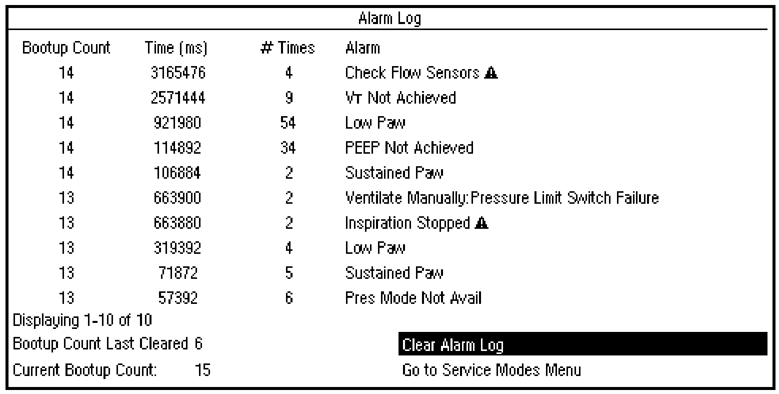
Go to Normal Operations

Provides the means to exit the service mode via a hardware reset.

4a.3.1 Alarm Log

The Alarm Log displays up to 10 of the most current alarm messages that have been logged. Each log entry shows:

- **Bootup Count** - number (the bootup count is incremented each time the machine is turned on).
- **Time (ms)** - the time in milliseconds since bootup when the latest alarm condition occurred.
- **# Times** - the number of times that the specific alarm condition has occurred during the noted bootup count.
- **Alarm** - message associated with the particular alarm condition.



Alarm Log

Bootup Count	Time (ms)	# Times	Alarm
14	3165476	4	Check Flow Sensors ⚠
14	2571444	9	VT Not Achieved
14	921980	54	Low Paw
14	114892	34	PEEP Not Achieved
14	106884	2	Sustained Paw
13	663900	2	Ventilate Manually:Pressure Limit Switch Failure
13	663880	2	Inspiration Stopped ⚠
13	319392	4	Low Paw
13	71872	5	Sustained Paw
13	57392	6	Pres Mode Not Avail

Displaying 1-10 of 10
Bootup Count Last Cleared 6
Current Bootup Count: 15
Clear Alarm Log
Go to Service Modes Menu

Figure 4-3 • Alarm Log menu

The bottom left corner of the screen displays additional information:

- Bootup Count Last Cleared
- Current Bootup Count

Clear Alarm Log

Select to clear the alarm log. The system will ask you to confirm that you want to clear the log.

Remarks

After the Alarm Log is cleared:

- the Bootup Count Last Cleared number will be reset to the Current Bootup Count number.
- the menu will show the message “No entries in log!”.

4a.3.2 Error Log

There are two special types of alarms:

- Minimum monitoring alarms that stop mechanical ventilation
- Minimum system shutdown alarms that stop mechanical ventilation and monitoring.

An alarm message that results from these special types of alarms is considered an error alarm.

The Error Log displays up to 10 of the most current error messages that have been logged.

Each log entry shows:

- **Bootup Count** - number (the bootup count is incremented each time the machine is turned on).
- **Time (ms)** - the time in milliseconds since bootup when the latest error condition occurred.
- **Address** - the place in the software sequence where the last occurrence of the error took place.
- **Error** - message associated with the particular error condition.

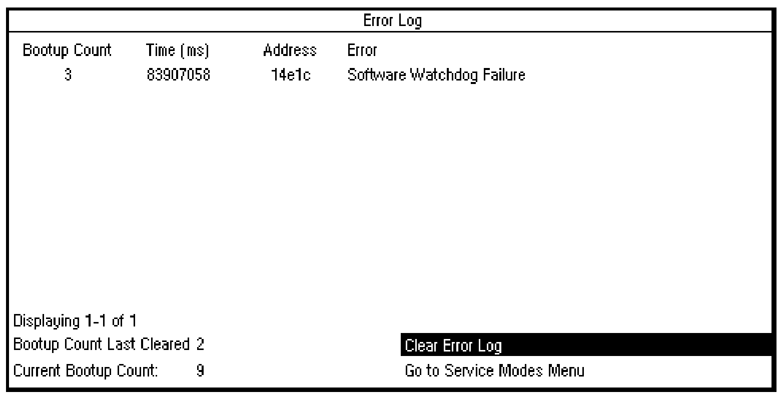


Figure 4-4 • Error Log menu

The error address and software revision are important pieces of information to note if technical support is required.

The bottom left corner of the screen displays additional information:

- Bootup Count Last Cleared
- Current Bootup Count

Clear Error Log

To clear the error log, select “Clear Error Log”. The system asks you to confirm that you want to clear the error log.

Remarks

After clearing the error log:

- the Boot Count Last Cleared number will reset to the Current Boot Count number.
- the menu will show the message “No entries in log!”.

4a.3.3 System Configuration

The System Configuration menu includes settings that are tailored to the specific machine.

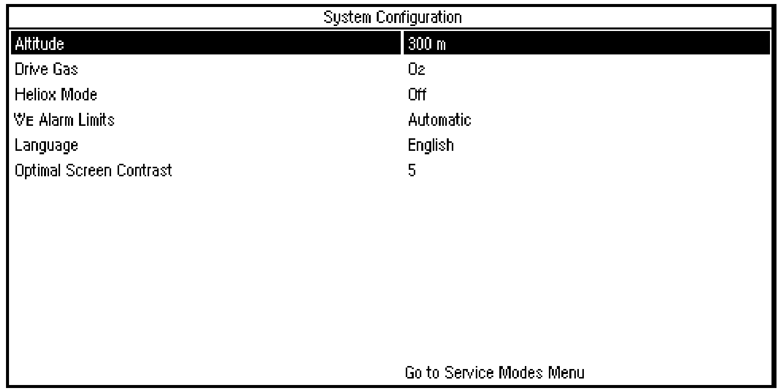


Figure 4-5 • Calibrations/System Configuration menu

4a.3.3.1 Altitude

The accuracy of some of the ventilator measurements is altitude sensitive. To ensure the specified accuracy, the altitude setting should be set to the specific altitude where each machine is located.

Altitude settings range from -400 to 3600 meters in increments to 100 meters.

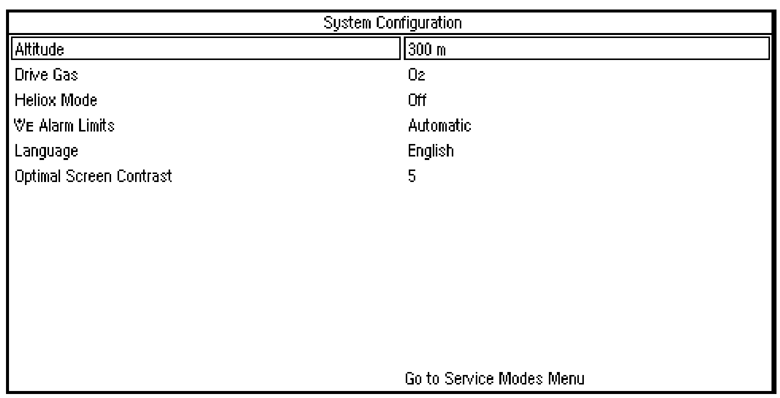


Figure 4-6 • Altitude menu item

4a.3.3.2 Drive Gas

Either O2 or Air can be used as the drive gas for the ventilator's pneumatic engine. To compensate volume calculations for the specific density of the drive gas used, the drive gas selection on this menu must match the actual drive gas.

To change the actual drive gas, refer to section 4.1.9 of the Aestiva Anesthesia Machine Service Manual.

⚠ CAUTION If you change the drive gas, you must also change the drive gas selection on this service setup screen. If the drive gas selection and the actual drive gas do not agree, volumes will not be correct.

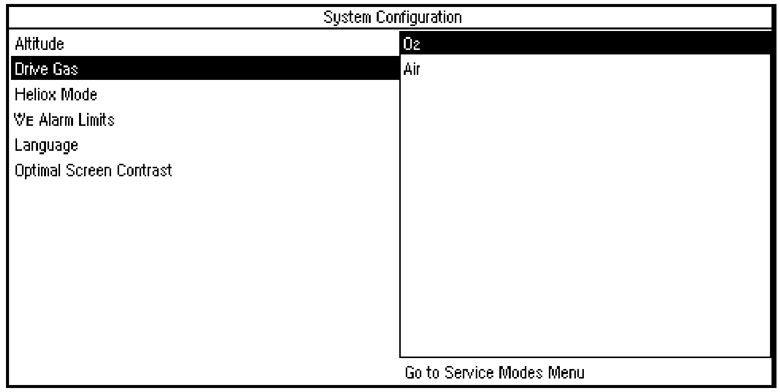


Figure 4-7 • Drive Gas menu item

4a.3.3.3 Heliox Mode

Aestiva machines can be configured to deliver Heliox. These machines should have the Heliox Mode “On”. With the Heliox Mode On, the operator can choose to turn the Heliox On or Off in the Setup/Calibration menu.

If the machine is not configured to deliver Heliox, the Heliox Mode should be set to “Off”. With the Heliox Mode Off, the Setup/Calibration menu will not include the Heliox option.

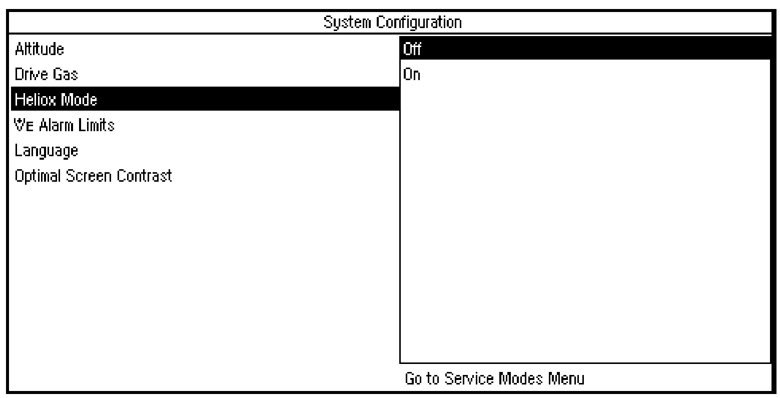


Figure 4-8 • Heliox Mode menu item

4a.3.3.4 VE Alarm Limits

The setting for VE Alarm Limits determines how the VE Alarm Limits are set:

- If VE Alarm Limits is set to User Adjustable, the user sets the limits on the Alarm Settings menu.
- If VE Alarm Limits is set to Automatic, the ventilator software calculates the high and low VE alarm limits and sets them to ±20% of the set VE. The user is still able to change the limits through the Alarm Settings menu in the Main Menu.

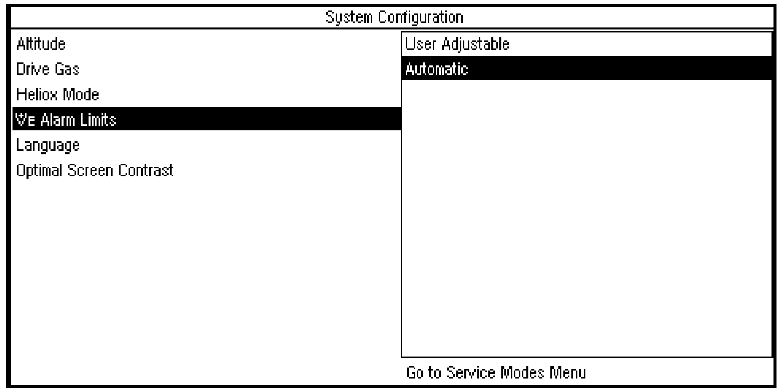


Figure 4-9 • VE Alarm Limits menu item

4a.3.3.5 Language

The text shown in the normal mode of operation is language sensitive. However, the majority of service confirmation and calibration modes are shown in English. The other language choices are shown in specific language text with the exception of Japanese which is shown in English.

- Dutch. . . . . . Nederlands
- English. . . . . English
- French. . . . . .Français
- German. . . . .Deutsch
- Italian. . . . . . Italiano
- Japanese. . . Japanese
- Polish. . . . . . Polski
- Portuguese. .Português
- Spanish. . . . Español

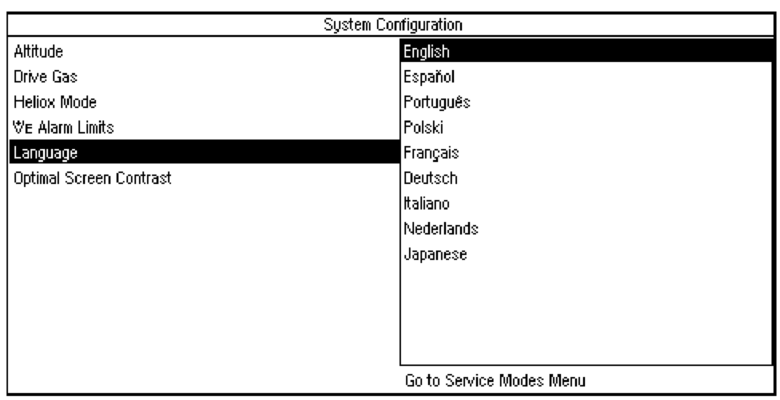


Figure 4-10 • Language menu item

4a.3.4.6 Optimal Screen Contrast

The Screen Contrast menu is used to select the display brightness. The values range from 1 to 10, with 10 having the most screen contrast.

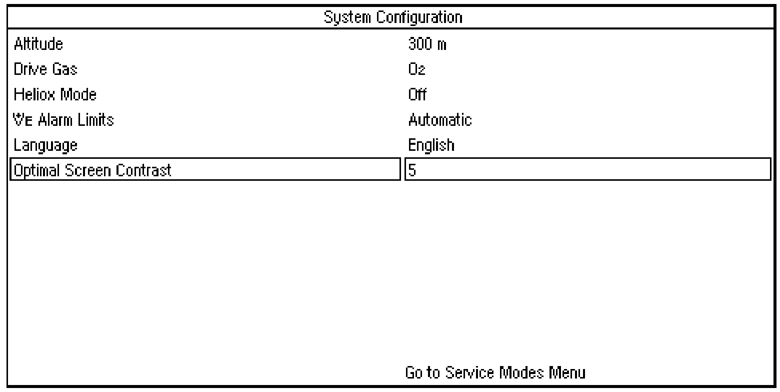


Figure 4-11 • Optimal Screen Contrast menu item

4a.3.4 User Select Defaults

The User Select Defaults menu determines the control settings used by the system at power up.

Settings related to optional ventilation modes will only appear in the User Select Defaults if the optional modes are active. These settings include:

- Rate for SIMV and PSVPro
- Trigger Window
- Flow Trigger Level
- Insp. Termination Level
- Tinspired

User Select Defaults — Page 1 of 2

Parameter (Range)	Current Value
Powerup/End Case Settings:	Last Case
Ventilation Mode	Volume Control
V_T (20-1500 mL)	500 mL
Pinspired (5-60 cm H_2O)	5 cm H2O
Rate for Vol Cntrl and Pres Cntrl (4-100 breaths/min)	12 breaths/min
Rate for SIMV and PSVPro (2-60 breaths/min)	12 breaths/min
I:E (2:1 - 1:8)	1:2
Plimit (12-40 cmH_2O)	40 cm H2O
Inspiratory Pause (Off, 5-60%)	Off

More Defaults
Go to Service Modes Menu

Figure 4-12 • Page 1 of User Select Defaults menu

User Select Defaults — Page 2 of 2

Parameter (Range)	Current Value
Low O_2 alarm limit (18 - 99%)	21%
High O_2 alarm limit (21 - 99%, Off)	Off
Low V_E alarm limit (Off, 0.1 - 10 L/min)	2.0 L/min
High V_E alarm limit (0.5 - 30 L/min, Off)	10.0 L/min
Low V_{TE} alarm limit (Off, 5 - 1500 mL)	Off
High V_{TE} alarm limit (20 - 1600 mL, Off)	1000 mL
Trigger Window (0 - 80%)	25%
Flow Trigger Level (1 - 10 L/min)	2.0 L/min
Insp. Termination Level (5 - 50%)	30%
Tinspired (0.2 - 5.0 sec)	1.5 sec

More Defaults
Go to Service Modes Menu

Figure 4-13 • Page 2 of User Select Defaults menu

Powerup/End Case Settings

If Last Case is selected, the system saves settings when the unit is turned off and powers up with the same settings. If Facility Defaults is selected, the system powers up with the default facility settings and returns to default settings when End Case is selected.

⚠ CAUTION Ask the customer BEFORE changing any default settings. Make sure that they understand these options can only be set in Service Mode.

The following parameters may be set in User Select Defaults:

- Ventilation Mode
- Tidal Volume (VT)
- Inspired Pressure (Pinspired)
- Respiratory Rate
- I:E Ratio
- Pressure Limit (Plimit)
- Inspiratory Pause
- Low O_2 Alarm Limit
- High O_2 Alarm Limit
- Low VE Alarm Limit
- High VE Alarm Limit
- Low VTE Alarm Limit
- High VTE Alarm Limit
- Trigger Window (optional)
- Flow Trigger Level (optional)
- Inspiratory Termination Level (optional)
- Tinspired

4a.3.5 Test CPU and Memory

The software checks the CPU, ROM, RAM, and display RAM through this menu. When Start Test is selected the series of tests begins to run. When each test is running, the word "Testing. . ." appears after the test name.

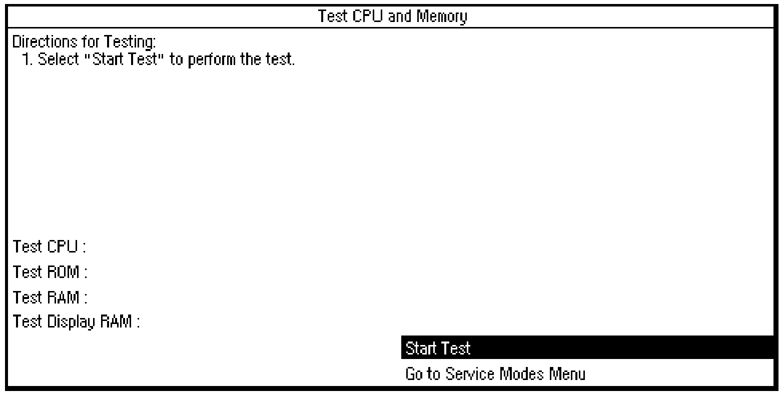


Figure 4-14 • Test CPU and Memory menu

First the software tests the CPU integer instruction set and the CPU register(s). If this test fails, the CPU did not perform the integer instruction set correctly, or the CPU register(s) have failed.

Next, the software tests the Flash ROM via a CRC check (Cyclic Redundancy Check). A CRC value has been calculated for the Flash ROM memory and this value is stored in the Flash ROM. This test recalculates the CRC for the Flash ROM and compares it to the value stored in Flash ROM. If the value that was calculated does not equal the value that was stored in Flash ROM, the test will fail.

Finally, the software tests all the external and display RAM memory with a walking bit pattern test. It writes a certain bit pattern to a block of memory and then reads that block of memory. If the bit pattern what it wrote is not the same bit pattern that it reads back, the test fails.

When the test is complete and has passed, the word "Pass" appears after the name of the test, as in Figure 4-15.

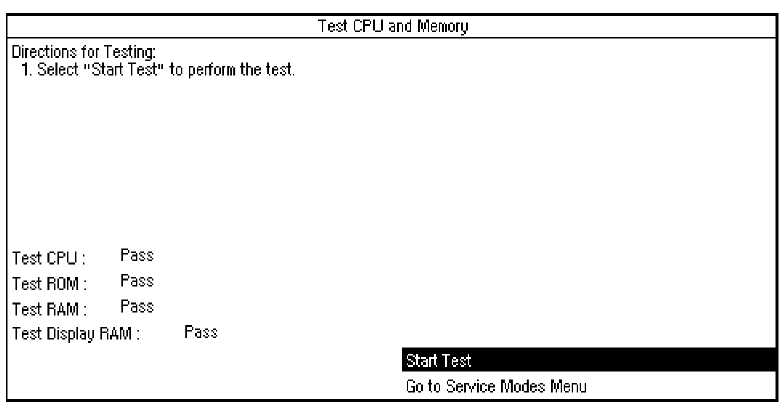


Figure 4-15 • Test CPU and Memory menu after all the tests have passed

4a.3.6 Test EEPROM

The software tests all the EEPROM memory via a bit pattern test. It writes a certain pattern to a block of memory and then reads back that block of memory. If the bit pattern that was written is not the same bit pattern that it reads back, the test fails.

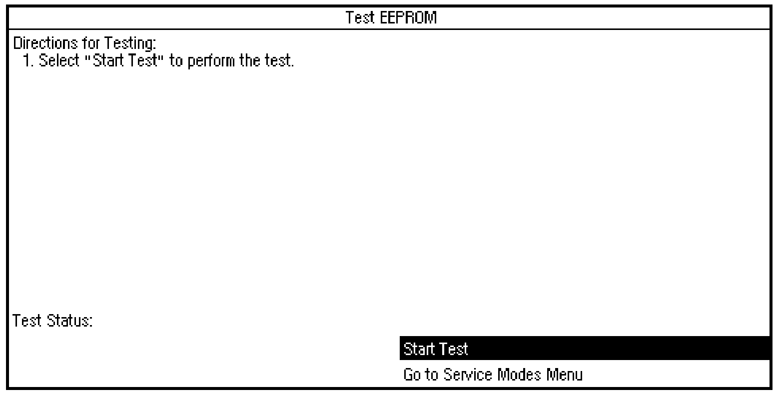


Figure 4-16 • Test EEPROM menu

4a.3.7 Test GIV

To test the GIV (gas inlet valve) the software first closes the GIV. It reads the A/D channel for the GIV. If the A/D channel for the GIV does not read closed, the test fails; otherwise, the test continues.

The software then opens the flow valve to the calibrated flow of the bleed resistor and waits for the flow to stabilize (about 2 seconds). Once the flow is stabilized the software checks to see if manifold pressure has dropped to less than 0.5 cm H_2O. If manifold pressure does not drop below 0.5 cm H_2O, the test fails; otherwise, the test continues.

The software then closes the flow valve and opens the GIV. It reads the A/D channel for the GIV. If the A/D channel for the GIV does not read open, the test fails.

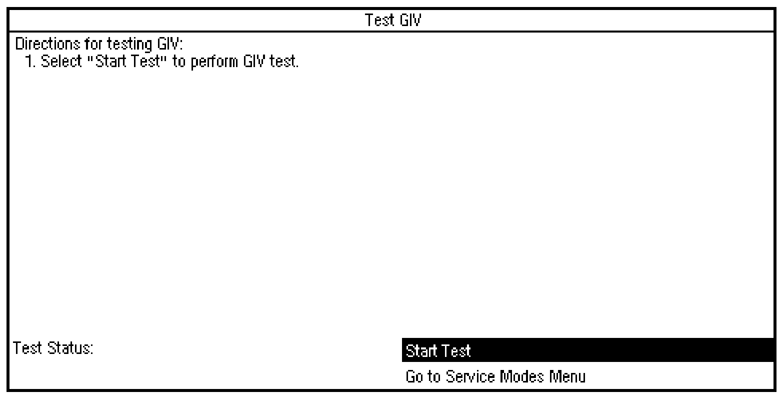


Figure 4-17 • Test GIV menu

GIV Test FAIL instructions

Failure can be caused by the valve or the CPU board malfunctioning.

Use a multimeter to measure the resistance of the GIV solenoid. It should be approximately 25 ohms. If necessary, replace the GIV solenoid (see section 7).

Use a multimeter to measure the voltage at the inlet valve connector on the pneumatic connection board. The voltage should be 4.5 volts when the GIV is open.

- If the voltage is 4.5 volts or greater, service the GIV (see section 7).
- If the voltage is less than 4.5 volts replace the CPU board (see section 7).

4a.3.8 Test Flow Valve

To test the flow valve the software starts by closing the flow valve. It then opens the flow valve in increments until the flow valve is completely open. At each of the settings of the flow valve the A/D (Analog/Digital) channel for Flow DAC (Digital to Analog Converter) Feedback and Flow Current Sense will be read. If the A/D for the Flow DAC Feedback and Flow Current Sense are not within the correct tolerance the test fails.

After setting the Bag/Vent switch to Vent, disengage the drive gas from the breathing system by removing the bellows housing.

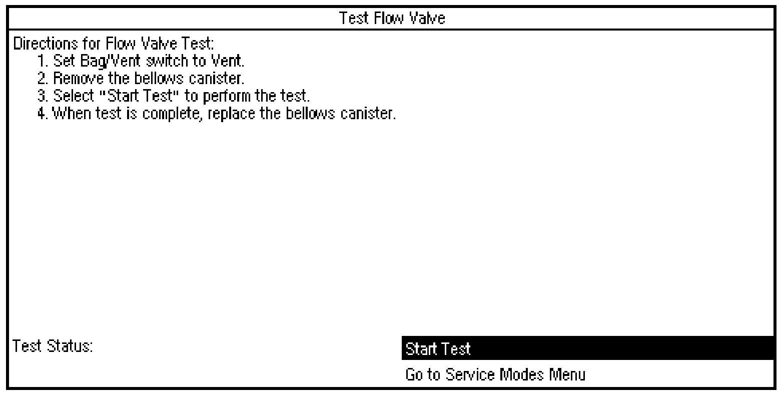


Figure 4-18 • Test Flow Valve menu

Flow Valve Test FAIL instructions

A failure can be caused either by the drive circuit or a flow valve malfunction.

Go to the “Flow Valve Test Tool” menu to check the drive circuit for proper voltage output.

Set the flow control to output 120 liters per minute. Unplug the connector from the pneumatic connection board and measure the resistance between the leads at the unplugged flow valve connector. A multimeter should read approximately 1.75 ohms.

- If the resistance is approximately 1.75 ohms, the drive circuit is bad, replace the CPU board (see section 7) and test the flow valve again.
- If the flow valve test fails again, replace the flow valve (see section 7).

4a.3.9 Test Drive Pressure Limit Switch

The software tests the pressure limit switch to make sure that it trips at the correct manifold over pressure. The software opens the flow valve to a value where pressure continues to increase. It then waits for the DPL (Drive Pressure Limit) switch to trip. The pressure at which the DPL switch tripped is indicated. This value is the manifold pressure measured upstream of the drive gas check valve (the typical reading is 112 cm H_2O), not the actual pressure at the switch. If the DPL switch never trips (within 15 seconds) the test fails. If the DPL switch does not trip at a pressure within the correct tolerance, the test fails.

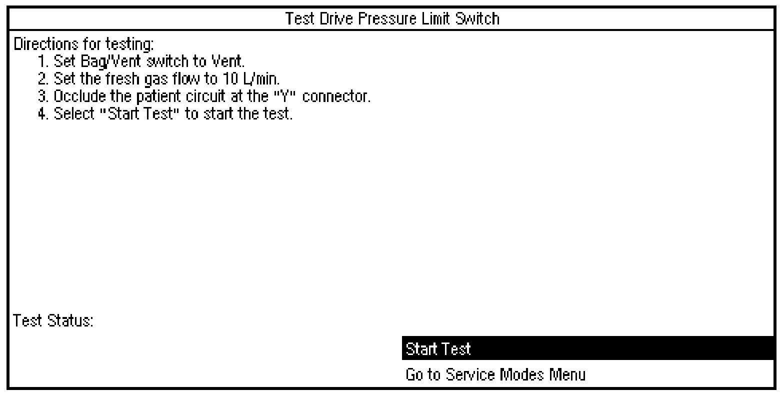


Figure 4-19 • Test Drive Pressure Limit Switch menu

Drive Pressure Limit Switch FAIL instructions

Go to the Discrete I/O signal menu and check the DPL (Drive Pressure Limit) switch status (Off).

Remove the rear subfloor. Connect a pressure test device to the black inline connector that is in the Exhalation Valve interface cuff tubing (SIB side).

Apply 104 +5/-4 cm H_2O (76.5 +3.8/-2.9 mm Hg) to activate the switch. Verify status change on the I/O signal screen (On).

If problem continues, replace SIB.

4a.3.10 Test 5V Fail Alarm

A 5-Volt supply (VDD) is used to power the digital circuits throughout the ventilator.

The 5-Volt supply (VDD) is derived in the power section of the control board. It is used to power the digital circuits throughout the ventilator. If the 5-Volt supply fails, the ventilator will sound a continuous alarm tone when the system switch is turned on.

To test the 5V Fail Alarm, follow the directions on the screen.

If the alarm tone does not sound, replace the CPU board (see section 7).

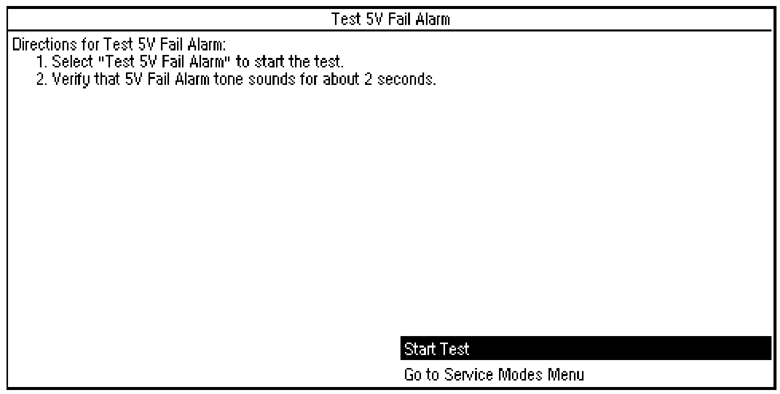


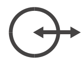
Figure 4-20 • Test 5V Fail Alarm menu

4a.3.11 Test Serial Ports

Two serial port tests may be done:

- **Public Port Test (Com 2)** - requires pins 6 and 13 of the serial connector to be jumpered.
- **Proprietary Port Test (Com 1)**- requires pins 2 and 3 of the serial connector to be jumpered.

Com 1 and Com 2 ports are located on the back of the ventilator and are identified with the following symbol:



Each test routine sets up the serial port circuits so transmitted data is echoed directly back to the receive circuits. The test fails if the data sent out is not equal to the data received.

If only the Proprietary Port Test fails, replace the CPU.

If both tests fail:

- check the harness connections between the control board and the Serial Adaptor Board (SAB).
- check the ribbon cable between the SAB and the external connector.
- replace the SAB.

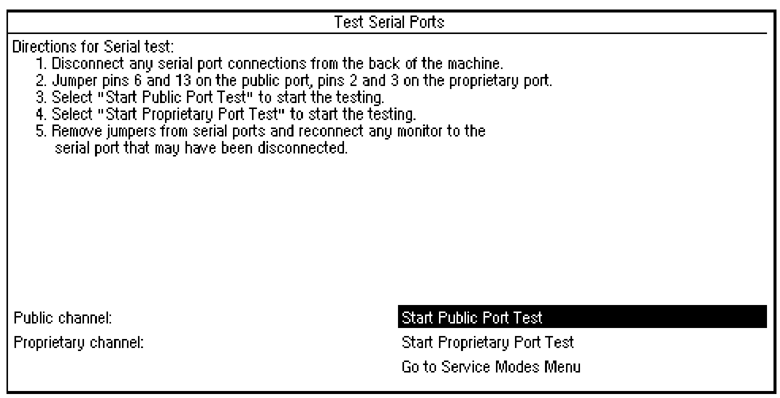


Figure 4-21 • Test Serial Ports menu

4a.3.12 Breathing System Leak Test

You can estimate how much of a leak there is in the ventilator portion of the breathing system by closing the patient circuit, inflating the bellows, and observing how quickly they fall on their own weight (part of the machine checkout procedure).

The Breathing System Leak Test allows you to more precisely test the ventilator portion of the breathing circuit for leaks.

By using the patient circuit to establish a closed loop, you can measure the leak rate.

- The leak rate is the fresh gas flow needed to maintain 30 cmH2O.
- The system should have a leak rate <200 mL/min.

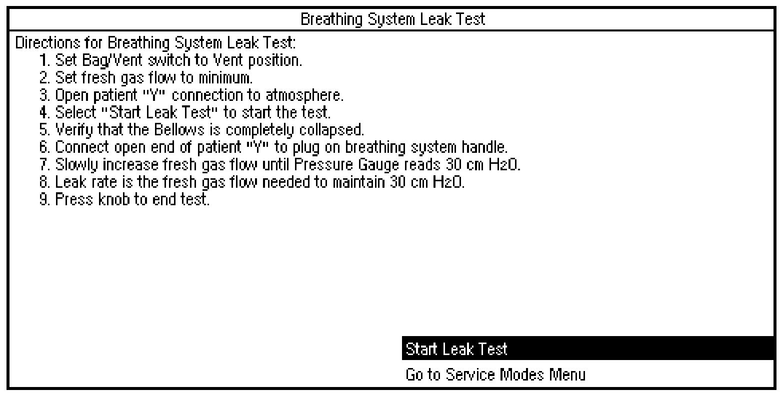


Figure 4-22 • Breathing System Leak Test menu

4a.3.13 Display A/D Channels

The software displays the A/D values for each of the A/D channels.

Display A/D Channels — Page 1 of 2

A/D Channel	Counts	Actual	Range
Inspiratory Flow	2034	0.000 L/min	-120 to 120 L/min
Expiratory Flow	2039	-0.025 L/min	-120 to 120 L/min
Airway Pressure	827	0.680 cm H_2O	-20 to 120 cm H_2O
Manifold Pressure	811	-0.040 cm H_2O	-20 to 120 cm H_2O
O_2	1644	100.000 %	0 to 100%
Flow Current Sense	2	0.000 Amps	0 to 1.024 Amps
Flow DAC Feedback	0	0.001 Volts	0 to 4.095 Volts
Battery Voltage	3312	13.300 Volts	7.0 to 16.0 Volts
Battery Current	980	-0.042 Amps	-0.6 to 6.0 Amps

Next A/D Menu
Go to Service Modes Menu

Figure 4-23 • Page 1 of Display A/D Channels menu

Display A/D Channels — Page 2 of 2

A/D Channel	Counts	Actual	Range
1.225 Volt Ref	1226	1.227 Volts	1.214 to 1.235 Volts
5.8 Voltage Test	2424	5.881 Volts	4.86 to 6.24 Volts
+15V Analog Supply	2083	14.986 Volts	13.77 to 16.27 Volts
-15V Analog Supply	906	-15.012 Volts	-12.62 to -17.46 Volts
+12V SIB Supply	2044	11.980 Volts	10.44 to 13.6 Volts
VEL Supply	2459	14.433 Volts	9.56 to 15.69 Volts
VSW Supply	2071	14.907 Volts	9.13 to 17.04 Volts
+12V Light Supply	2035	11.939 Volts	10.00 to 12.73 Volts
GIV Current Sense	6	0.363 mA	143.7 to 235.4 mA

Next A/D Menu
Go to Service Modes Menu

Figure 4-24 • Page 2 of Display A/D Channels menu

Remarks

This selection displays a listing of A/D Channels which are at various values depending upon the set parameters.

Refer to the following table for additional details for each of the displayed channels.

Table 4a-1 A/D Channels

A/D Channel	Counts[1]	Actual Range[1]	Displayed Range	Special Instructions
Inspiratory Flow[2]	1800-2300	Near Zero L/min	-120 to 120 L/min	Zero Offset Reading (nominal 2050 Counts)
Expiratory Flow[2]	1800-2300	Near Zero L/min	-120 to 120 L/min	Zero Offset Reading (nominal 2050 Counts)
Airway Pressure[2]	550-1050	Near Zero cm H_2O	-20 to 120 cm H_2O	Zero Offset Reading (nominal 800 Counts)
Manifold Pressure[2]	550-1050	Near Zero cm H_2O	-20 to 120 cm H_2O	Zero Offset Reading (nominal 800 Counts)
O2	0-4095	0 to 100%	0 to 100%	Count weight and limits are determined during O2 calibration
Flow Current Sense	0-4095	0 to 1.024 Amp	0 to 1.024 Amps	
Flow DAC Feedback	0-4095	0 to 4.095 Volts	0 to 4.095 Volts	
Battery Voltage	1740-3976	7 to 16 Volts	0 to 16.48 Volts	<7V = Low battery voltage failure. <11.65V = Low battery voltage warning. >16 Volts (10 Sec) = High battery voltage failure.
Battery Current	700-4000	-600 mA to 6 Amps	-2 to 6.19 Amps	-150 to -600 mA = Battery charging. -601 mA to -2 Amps = Charge current out of range. >300 mA = Operating on battery. >6 Amps = Battery discharge current out of range.
1.225 Voltage Reference	1214-1235	1.214 to 1.235 Volts	0 to 4.095 Volts	
5.8V Voltage Test	1997-2565	4.86 to 6.24 Volts	0 to 9.96 Volts	
+15V Analog Supply	1914-2262	13.77 to 16.27 Volts	0 to 29.46 Volts	
-15V Analog Supply	858-953	-12.62 to -17.46 Volts	-61 to 1.43 Volts	
+12V SIB Supply	1779-2322	10.44 to 13.62 Volts	0 to 24 Volts	
VEL Supply	1645-2675	9.56 to 15.69 Volts	0 to 24 Volts	
VSW Supply	1269-2368	9.13 to 17.04 Volts	0 to 29.46 Volts	
+12V Light Supply	1879-2217	11.02 to 13 Volts	0 to 24 Volts	In Rev 3.4 software, Range = 10.00 to 12.73 Volts
GIV Current Sense[3]	2371-3884	143.7 to 235.4 mA	0 to 248.2 mA	Off state reading is 0 to 259 counts

Notes:

1. **These columns show the acceptable range where possible.**
2. **The A/D count and displayed value shown for Airway Pressure, Manifold Pressure, Inspiratory Flow, and Expiratory Flow are the zero pressure values. These readings should be taken with the flow sensors disconnected by removing the circuit module.**
3. **The count range and displayed value shown for GIV Current Sense is with the GIV turned on. If the GIV is turned off, the off count range is 0 to 259 Counts.**

4a.3.14 Display Discrete I/O Signals

The *Discrete I/O Signals* menu displays discrete binary signals associated with machine switch positions.

There are several types of switches in the Aestiva machine:

- some switches are mechanically operated
- some switches are pneumatically operated
- some switches are electronic

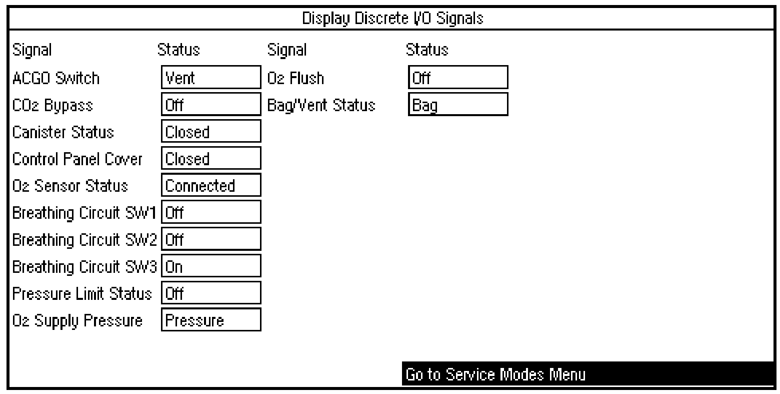


Figure 4-25 • Display Discrete I/O Signals menu

Mechanical switches

- ACGO Switch Status — Ventilation or Aux CGO (machines with ACGO)
- CO_2 Bypass — Off or On
- Canister Status — Closed or Open
- Control Panel Cover — Closed or Open
- Bag/Vent Status — Bag or Vent

Pneumatic switches

- Pressure Limit Status — Off or On
- O_2 Flush Status — Off or On
- O_2 Supply Pressure Status — Pressure or No Pressure

Electronic switches

- O_2 Sensor Status — Connected or Disconnected
- Circuit module ID:

Breathing Circuit Switch	Circle	Bain/Mapleson D	(no module)
One	**Off**	On	On
Two	**Off**	**Off**	On
Three	On	**Off**	On

Off = tab present to block light

On = no tab to block light

4a.3.15 Display Battery Status

The software displays the battery charge status. This checks the battery charge current.

Note: A negative current value means the battery is charging.

Battery Status	Values Displayed
On Battery	Battery Current > 0.300 Amps
Battery Charging	-0.600 ≤ Battery Current ≤ -0.150
Battery Charged	none of the above

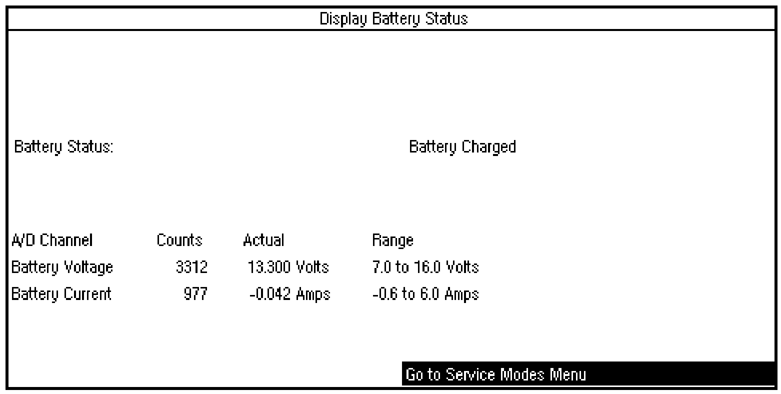


Figure 4-26 • Display Battery Status menu

If the battery has been on charge for several hours and you get a “battery is not charged” display:

- Check the battery in-line cable fuse.
- If the fuse is good, the battery is bad and you should replace it.

4a.3.16 Test Panel Switches

In the Test Panel Switches menu the software is set up to receive keyboard button presses and rotary encoder turns.

Press each button and turn the encoder one full turn in both directions.

When a button is pressed and held, the icon on the screen next to the button will contain an “x”.

After testing all the buttons and the control knob, select “Test Encoder Knob Turn”.

As you turn the encoder knob, verify that:

- each click of the encoder in the clockwise direction increments the clockwise total.
- each click of the encoder in the counterclockwise direction increments the counterclockwise total.

Remarks

If any of the select buttons test fails, replace the front panel keyboard assembly (see section 7). If the encoder knob test fails, replace the rotary encoder assembly (see section 7).

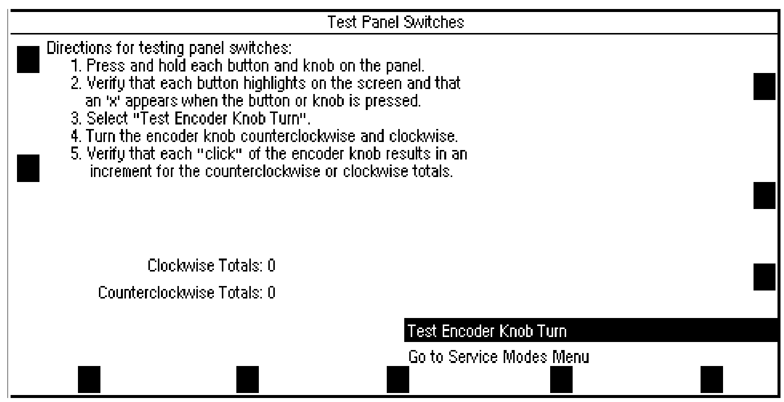


Figure 4-27 • Test Panel Switches menu

4a.3.17 Flow Valve Test Tool

The Flow Valve Test Tool is available for test and troubleshooting purposes only. It allows you to manually control the flow valve setting from 0 (closed) to 120 LPM, in 1 LPM increments, and observe key pressure and flow measurements on the same screen.

This is mainly used to test the drive gas circuit and MOPV valves as detailed in the MOPV test procedure (see section 5.4). However, it can also be used for other troubleshooting procedures whenever a set flow is required.

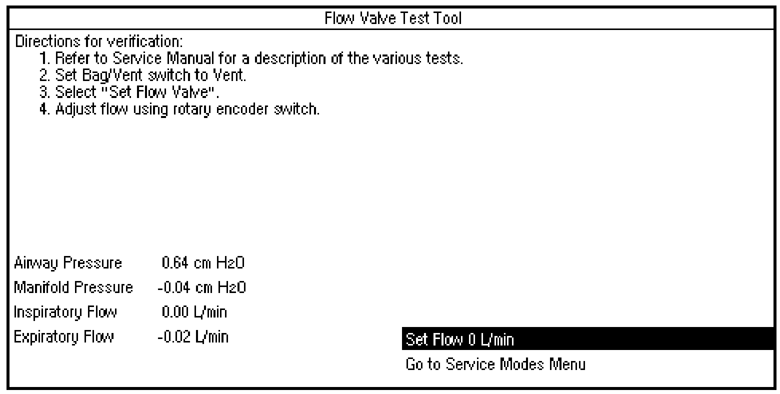


Figure 4-28 • Flow Valve Test Tool menu

Note: The flow does not turn off automatically. The flow must be set to zero to stop flow. Flow will originally be set to zero upon entering this screen.

4a.3.18 Adjust Drive Gas Regulator

The Adjust Drive Gas Regulator procedure establishes the required flow rate through the drive gas regulator for proper calibration.

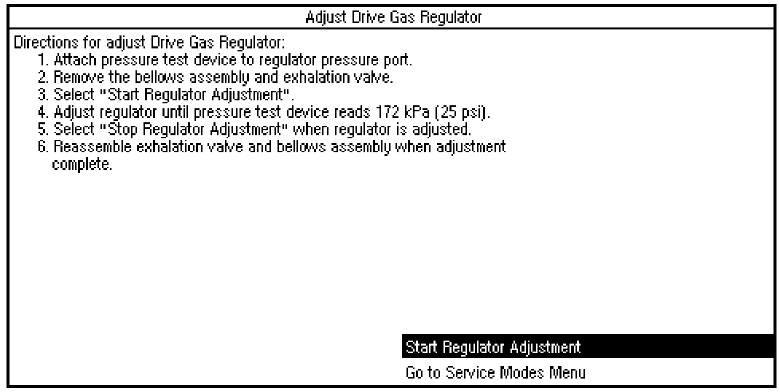


Figure 4-29 • Adjust Drive Gas Regulator menu

Remarks

The drive gas regulator should provide a constant gas input pressure of 172 kPa (25 psi).

You can verify this pressure by attaching a pressure test device to the regulator pressure port (shown below) and performing the above procedure.

If required, adjust the regulator to 172 ±1.72 kPa (25 ±0.25 psi).

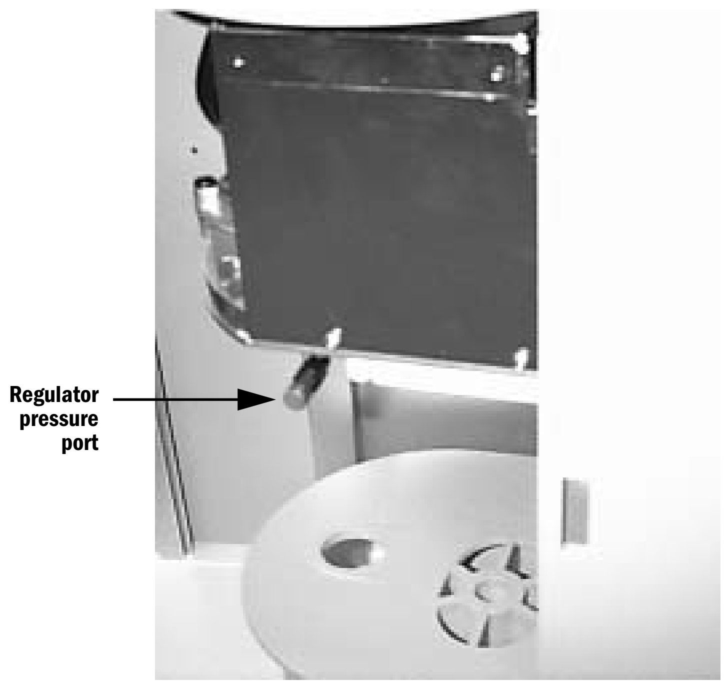


Figure 4-30 • Location of the regulator pressure port

4a.3.19 O2 Calibrations

The O2 Calibrations take into account the altitude setting. Before starting the calibrations, ensure that the altitude setting (in Calibrations/System Configuration) is set to the appropriate altitude for the machine location.

Note: a circle module is required for all calibrations.

For the 21% O2 calibration, software reads the A/D value for the O2 sensor when the O2 sensor is exposed to room air (21% O2).

- If this A/D value is not within the tolerance, the calibration fails.
- If the calibration passes, the A/D value is stored in the EEPROM.

The sensor must be calibrated at 21% O2 before calibration at 100% O2.

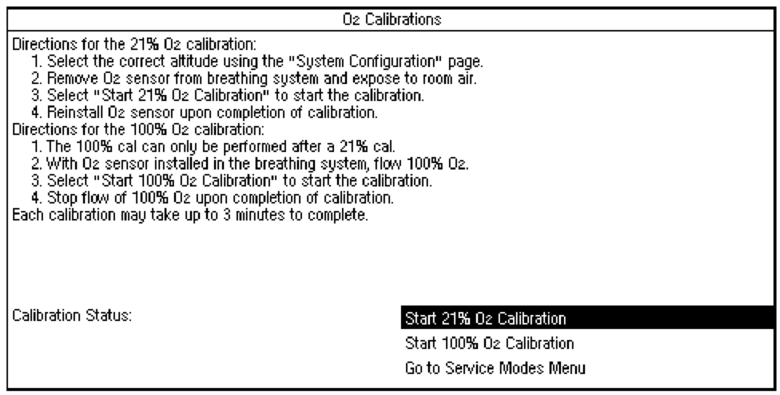


Figure 4-31 • O2 Calibrations menu

Remarks

Remove the O2 sensor from the breathing system and expose it to room air. The displayed reading should be 21% ±2% to pass the calibration requirements.

Reinstall the sensor that passed the 21% test in the breathing system and expose it to 100% O2. Select “Start 100% O2 Calibration” to begin test.

If it displays readings higher or lower than required to pass, replace the sensor.

4a.3.20 Calibrate Flow Sensors

The software calibrates the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers for zero flow/pressure offset voltage. It does so by reading the A/D values for inspiratory flow, expiratory flow, airway pressure and manifold pressure when the flow sensor module has been disconnected from the bulkhead connector. If the A/D values are not within the correct tolerance, the calibration fails. If the calibration passes, the offset A/D values at which the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers were calibrated at, are stored in the EEPROM.

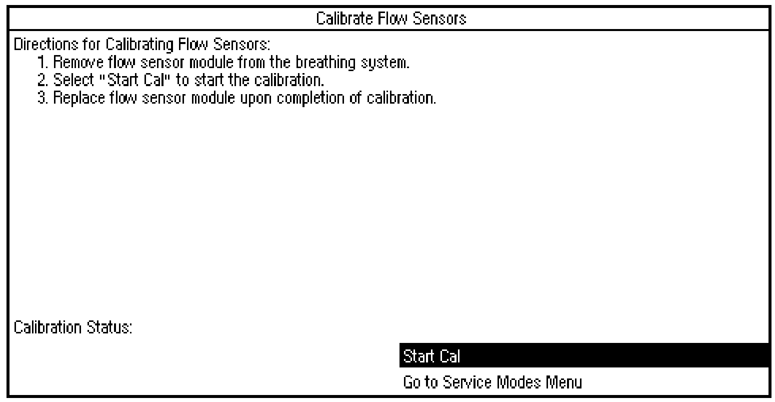


Figure 4-32 • Calibrate Flow Sensors menu

Remarks

Fail - indicates a problem with the SIB.

Inspect the Bulkhead Connector and SIB tubing for moisture or possible occlusion.

Check for bad differential pressure transducer.

- Ensure that the flow sensor module is disconnected from the bulkhead panel.
- Check the transducer outputs using the Display A/D menu.
- If the transducer is out of tolerance (Refer to Table 4a-1, on page 4-23), replace the SIB assembly.

4a.3.21 Pressure Sensitivity

The software prompts the user to perform the procedure to calibrate the pressure sensitivity. This calibration is not an automated calibration. It prompts the user to follow a set of procedural steps to perform the calibration. This calibration calculates the pressure sensitivity at four different pressures. It uses these four different pressure points along with the inspiratory flow and expiratory flow zero offsets to find the pressure sensitivity. If the calculations for the pressure sensitivity are not within the correct tolerance, the calibration fails. If the calibration passed, the four pressure sensitivity points are stored in the EEPROM.

Note This pressure transducer calibration must be performed if the SIB assembly or CPU board is replaced.

The Pressure Sensitivity Calibration can not be successfully performed using a Bain/Mapleson D breathing circuit module. Install a Circle module to perform the calibration.

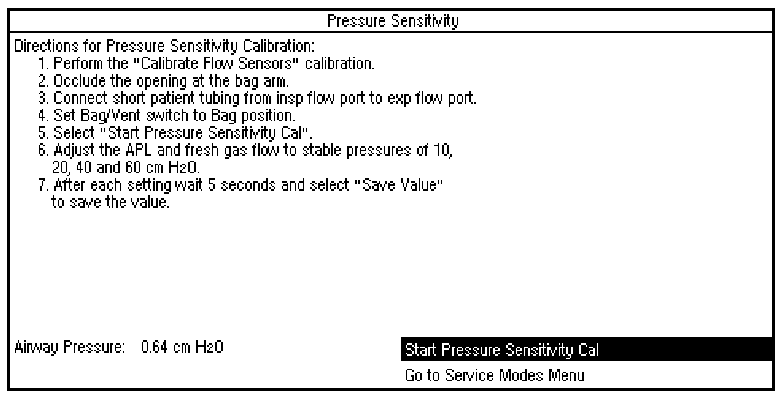


Figure 4-33 • Pressure Sensitivity menu

Pressure sensitivity FAIL instructions

Flow Sensor Leak Test:

1. Select “Display A/D Channels” from the Diagnostic Tests/Tools menu.
   Set Fresh gas flow to 2 LPM.
   Open the APL valve (0 cm H_2O).
   Place Bag to Vent switch in the Bag/APL position.
   Connect a short tube between the inspiratory and expiratory flow sensors.

The airway pressure, inspiratory flow and expiratory flow on the ventilator display should read near zero (between +0.5 and -0.5 LPM flows).

2. Occlude the bag port. Adjust the APL to read 10 cm H_2O on the gauge. The flow may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM. Very gently push the tubes coming from the flow sensors slightly in all directions. Observe to see if the flow measurements jump.

⚠ **Caution** If either sensor reads more than 2 LPM, STOP. This indicates a possible leak in the flow sensor pneumatic circuit. Skip steps 3 and 4, go directly to step 5. If the pressure is increased further, the SIB may be damaged.

3. Adjust the APL to read 20 cm H_2O on the gauge. The flows may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM.
4. Adjust the APL to read 40 cm H_2O on the gauge. The flows may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM.
5. If the flow measurements on the ADC page stay near zero, the flow sensors are good. If either sensor indicates a flow where there is none, there may be a leak. To troubleshoot, reduce the circuit pressure back to zero. Reverse the flow sensor connections at the SIB interface panel and repeat the above tests.
6. If the problem follows the sensor, discard the sensor. It has a leak.
7. If the problem stays with the same side of the circuit, it is likely the leak is in the tubing, not with the sensor.

4a.3.22 Calibrate Flow Valve

The software prompts the user to perform the procedural steps to calibrate the flow valve. This is an automated calibration. It gradually opens the flow valve and monitors the manifold pressure. When the manifold pressure reaches 1.9 to 2.0 cm H_2O the value at which the flow valve has been opened is saved. The flow valve is then closed. The value at which the flow valve was opened to is then checked to make sure it is within the correct tolerance. If it is not, the calibration fails. If the calibration passes, the flow valve calibration point is stored in the EEPROM.

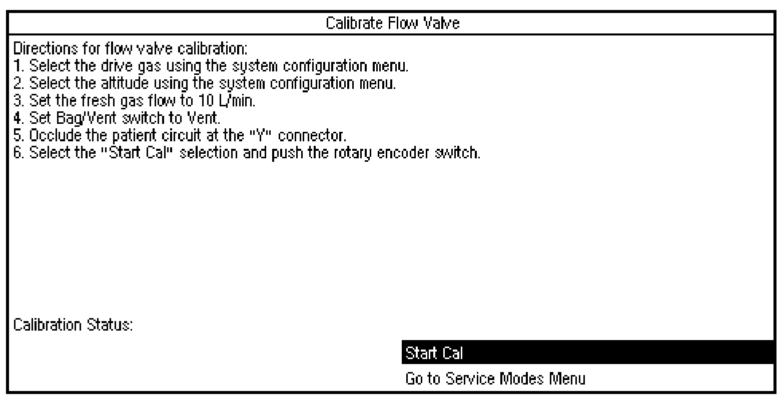


Figure 4-34 • Calibrate Flow Valve menu

Remarks

Check that the Bag/Vent selection switch is in the vent position. If the flow valve calibration test fails immediately, the most likely fault is a failed manifold transducer. It can also be a failed regulator or the regulator could need calibration. Another cause could be a failed flow valve.

4a.3.23 Bleed Resistor Calibration

The software calibrates the bleed resistor as described below. Other than the setup procedure, this calibration is completely automated.

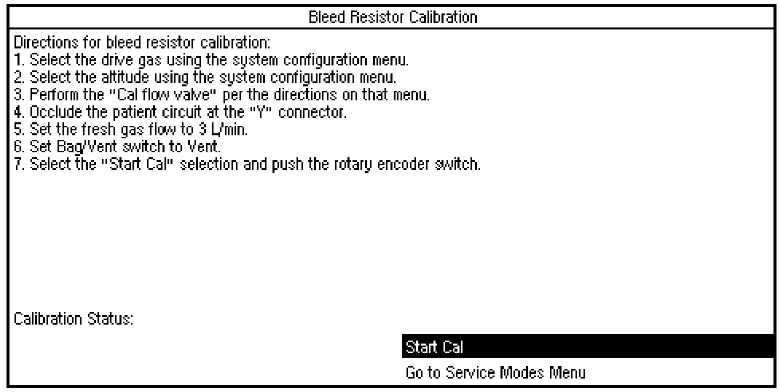


Figure 4-35 • Bleed Resistor Calibration menu

Software procedure

The software performs the calibration as follows:

1. Opens the flow valve to the starting point that was found (where manifold pressure is 91-92 cm H_2O).
2. Waits for the flow to stabilize.
3. Once the flow stabilized, sets the flow to 12 L/min.
4. Wait for the flow to stabilize.
5. Repeat steps 1-4, replacing step 3 with progressively smaller flows.

There are 12 points that are calculated for the bleed resistor calibration. If the calibration passes, the calculated bleed resistor calibration points are stored in EEPROM.

Remarks

If the bleed resistor calibration test fails, check altitude and drive gas settings. Ensure that the breathing circuit gas is exhausting out the scavenging port during the test. A negative finding indicates a massive circuit leak. Check for proper regulator pressure calibration. Ensure that the Flow Valve Cal test was conducted properly. Otherwise, failure indicates a calibration problem with the flow valve.

4a.3.24 Service Calibrations Required

The *Schedule Service Calibrations* menu lists which setting or calibration must be performed when the “Service Calibration ⚠” alarm appears in normal operation. After the setting or calibration is properly completed, the text for that setting or calibration is removed from the list.

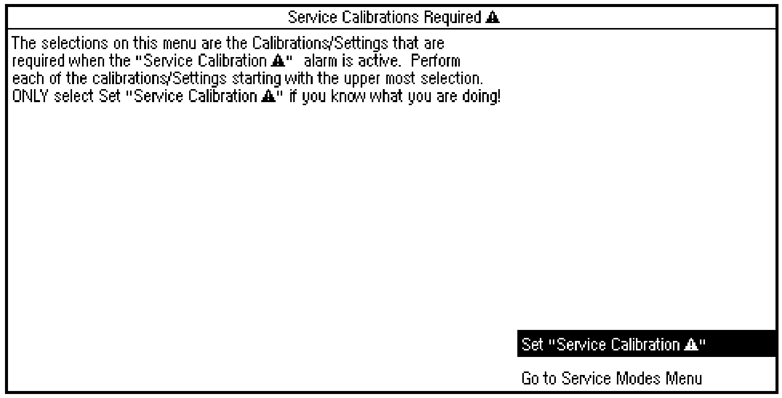


Figure 4-36 • Service Calibrations Required menu

The normal operation “Service Calibration ⚠” alarm message is only removed when all the required settings or calibrations are completed.

Remarks

The **Set Service Calibration** menu item is used by the **factory** to activate the Service Calibration alarm and require that all settings and calibrations be performed when the Aestiva machine is set up for operation at its permanent location.

There is no need to set the “Service Calibration ⚠” alarm in the field.

Select “No” when the following warning appears if you selected the “Set Service Cal” menu item.

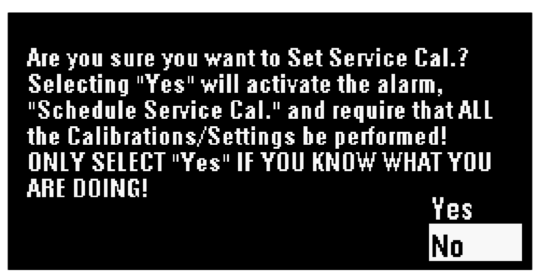


Figure 4-37 • Set Service Calibration menu

If you select “Yes” you will see the screen displayed in Figure 4-38. Follow the directions on the screen to complete the calibrations.

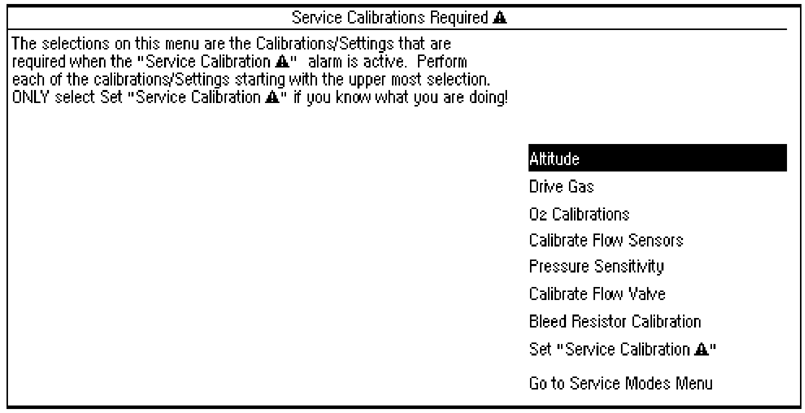


Figure 4-38 ▪ Service Calibration full menu

Notes

4b Tests and Calibration — Software Revisions 1.X and 3.X

⚠ WARNING Post-Service Checkout is required after you complete this section. You must perform *Section 3.1 Post-service checkout* after performing any maintenance, service or repair. Failure to do so may result in patient injury.

⚠ CAUTION Section 4b should only be used with versions 1.X and 3.X software. Tests and Calibrations for version 4.X software are located in section 4a.

In this section To ensure proper operation, the Aestiva 7900 Ventilator includes several tests that run automatically (self tests) and a series of menu pages that a qualified service person can use to test, calibrate, or troubleshoot ventilator related components in the Aestiva machine (Service Mode).

4b.1 Self tests

The Aestiva 7900 Ventilator software includes self tests that determine whether or not the operating software is functioning properly and whether or not the electronic circuits on the circuit boards are functional.

The self tests include:

- Powerup tests
- Continuous tests
- Periodic tests

Powerup tests

The following is a list of the tests run at powerup:

- Sequential watchdog
- Logical watchdog
- Data RAM walking pattern test
- FLASH ROM CRC verification
- Gas inlet valve test (electrical and pneumatic)
- Calibration of the manifold sensor

If one or more of these tests fail, the display provides a readout of the problem.

The On and Off states of the Gas Inlet Valve (GIV) are tested at power up. The electronic feedback signal as well as the manifold pressure will be tested to determine pass/failure. If the GIV causes the self test to fail on power up, an alarm sound and the message “Gas Inlet Valve Failure” is displayed. An error code (1002C) will register on the error code service mode menu.

If the calibration of the manifold sensor fails on power up, an alarm sounds and the message “Manifold Pressure Sensor Failure” is shown. An error code (1003E) will also show on the error code service menu.

Continuous tests

These tests are run continuously during normal operation and alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area.

- Flow valve electrical feedback
- Gas inlet valve electrical feedback
- Supply voltage checks
- Battery voltage checks

The flow valve feedback signal is tested in non-mechanical and mechanical ventilation states. The flow valve is closed in non-mechanical ventilation.

The Gas Inlet Valve ON state is tested (via electronic feedback) every 3 seconds once normal operation is entered.

Periodic tests

These tests are run every 30 seconds during normal operation. Alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area.

- CPU Test
- Display RAM walking pattern test
- Data RAM walking pattern test
- FLASH ROM CRC verification

4b.2 Service Mode Confirmation menu

The service calibration mode tests and/or calibrates hardware necessary to prepare a ventilator in manufacture for factory shipment and to service a ventilator in the field.

There are two ways to enter the service mode:

- If the machine is turned off, push and hold in the adjustment knob while setting the system switch to On. Hold the adjustment knob pushed in until the “Service Mode Confirmation” menu appears. Use the adjustment knob to highlight “Service Mode”, then push the adjustment knob to confirm the selection.
- If the machine is already in normal operation, set the Bag/Vent switch to Bag. Then, press the V_T/Pinsp, the PEEP, and the menu switches at the same time to reset the software (powerup). Push and hold the adjustment knob until the “Service Mode Confirmation” menu appears.

All data displayed by the ventilator during and after a service mode test or measurement is also output to the serial port.

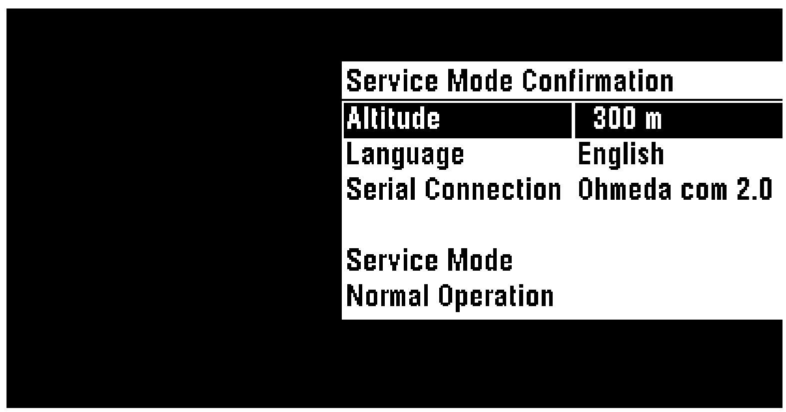


Figure 4b-1 • Service confirmation menu

From this menu you can:

- Set Altitude
- Set Language
- Set Serial Connection
- Go to the Service Mode or Normal Operation

4b.2.1 Set the altitude

The accuracy of some of the ventilator measurements is altitude sensitive. To ensure the specified accuracy, the altitude setting should be set to the specific altitude where each machine is located.

Altitude setting ranges from -400 to 3600 meters in increments of 100 meters. The setting is saved in EEPROM and the default value is 300 meters.

4b.2.2 Set the language

Text shown in the normal mode of operation is language sensitive, but the service confirmation and calibration modes are shown in English. The other language choices are shown in language specific text. For example, Swedish would be shown as “Svenska”.

The language choices are:

- English
- French
- German
- Italian
- Spanish
- Japanese
- Dutch
- Swedish

The language setting is stored in EEPROM with the default setting as English.

4b.2.3 Set the serial connection

There are two serial ports on the Aestiva 7900 Ventilator, the Datex-Ohmeda proprietary channel and the public channel. The proprietary channel is used for software development testing and manufacturing test.

The public channel serial connection alternatives are:

- Ohmeda RGM
- 7800 Emulation
- Ohmeda Com 1.0
- Ohmeda Com 2.0

The serial connection used is stored in EEPROM. The default selection is Ohmeda RGM.

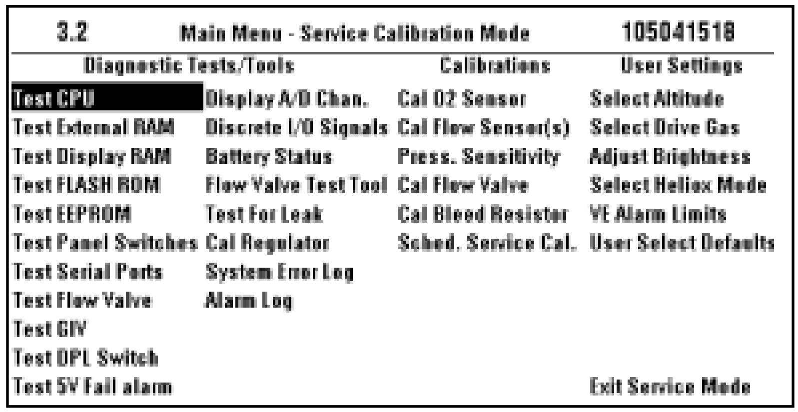
When you are in the serial connection menu, all display graphics except for the menu box are removed from the screen. All switches other than the adjustment knob are inactive, therefore accidently pushing a key will not cause any action.

4b.3 Main Menu - Service Calibration Mode

The service mode is set from the service confirmation menu. Select "Service Mode" and push the adjustment knob. The service mode Main Menu displays all selectable service tests.

Software revision 3.X adds several menu items to the service mode. Most of the service screens are identical in 3.X or 1.X software. Screens that differ significantly are shown separately. Minor differences are noted in the text.

Software 3.X



Software 1.X

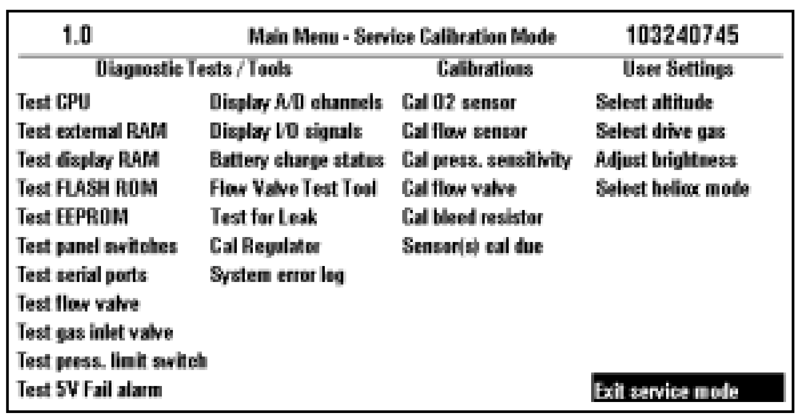


Figure 4b-2 • Service mode main menu

The service mode has a top level main menu screen which displays all the selectable service tests in categorical order; Diagnostic Tests/ Tools, Calibrations and User settings. Any service test can be selected from this menu with the adjustment knob cursor. The software version is shown at the top-left of the screen and the date code is shown at the top-right of the screen.

Exit Service Mode

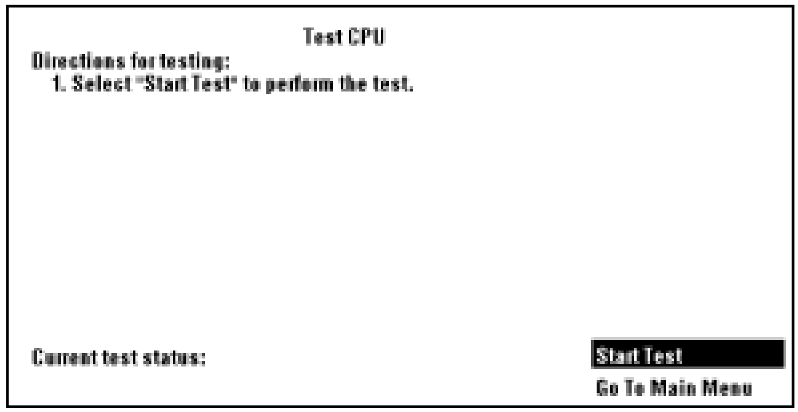
Provides the means to exit the service mode via a hardware reset.

Allows the service person to return to the main operating waveform display and operating menu.

4b.4 Diagnostic Tests

4b.4.1 Test CPU

The software tests the CPU integer instructions as well as the CPU register(s). If this test fails, the CPU did not perform an integer instruction correctly, or the CPU register(s) have failed.

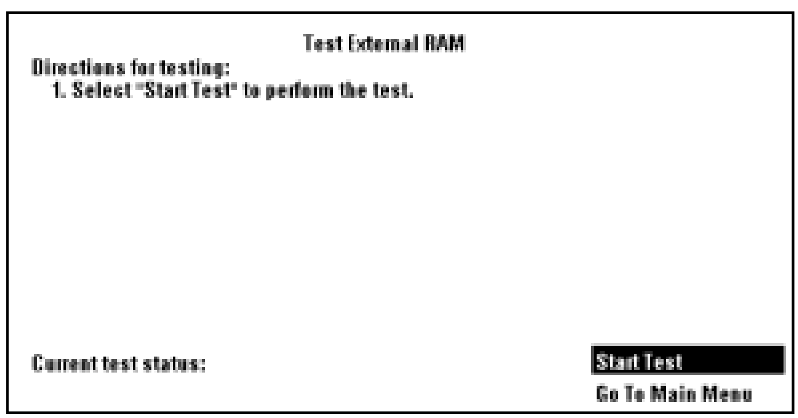


CPU test FAIL instructions

Upon FAIL, replace the CPU board (see Section 7.5).

4b.4.2 Test External RAM

The software tests all of the external RAM memory with a walking bit pattern test. It writes a certain bit pattern to a block of memory and then reads that block of memory. If the bit pattern that it wrote is not the same bit pattern that it reads back the test fails.

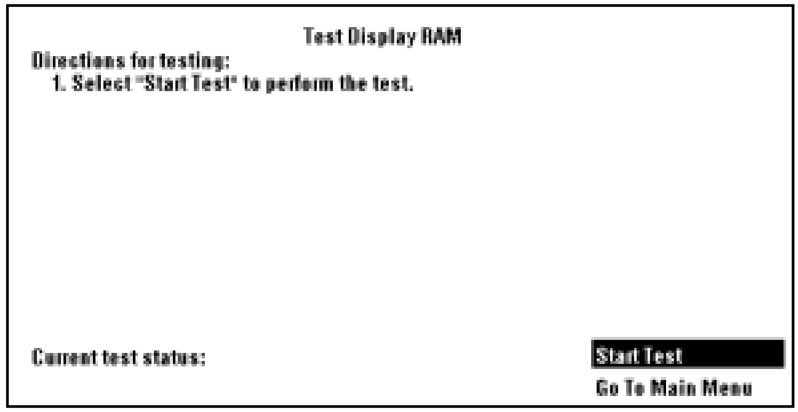


External RAM test FAIL instructions

Upon FAIL, replace the CPU board (see Section 7.5).

4b.4.3 Test Display RAM

The software tests all of the display RAM memory via a walking bit pattern test. It writes a certain bit pattern to a block of memory and then reads that block of memory. If the bit pattern that was written is not the same bit pattern that it reads back the test fails.

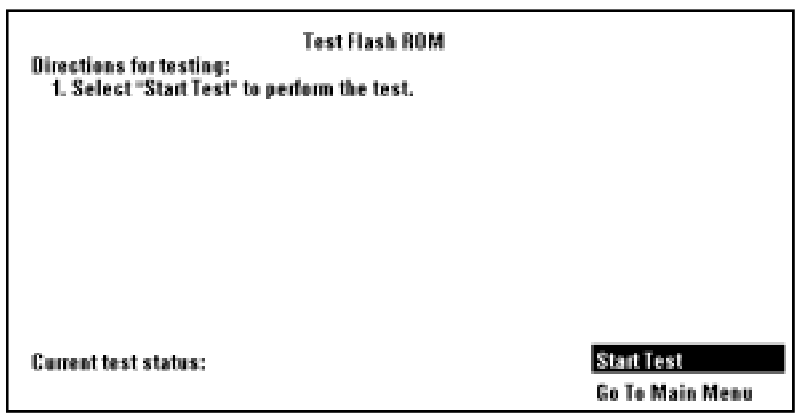


Display RAM test FAIL instructions

Upon FAIL, replace the CPU board (see Section 7.5).

4b.4.4 Test Flash ROM

The software tests the Flash ROM via a CRC check (Cyclic Redundancy Check). A CRC value has been calculated for the Flash ROM memory and this value is stored in the Flash ROM. This test recalculates the CRC for the Flash ROM and compares it to the value stored in Flash ROM. If the value that was calculated does not equal the value that was stored in Flash ROM, the test will fail.

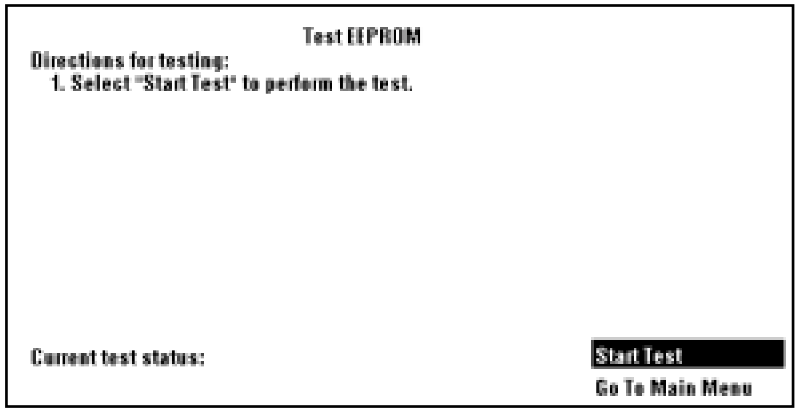


Flash ROM test FAIL instructions

Upon FAIL, replace the CPU board (see Section 7.5).

4b.4.5 Test EEPROM

The software tests all of the EEPROM memory via a bit pattern test. It writes a certain pattern to a block of memory and then reads that block of memory. If the bit pattern that was written is not the same as the bit pattern read back, the test fails.

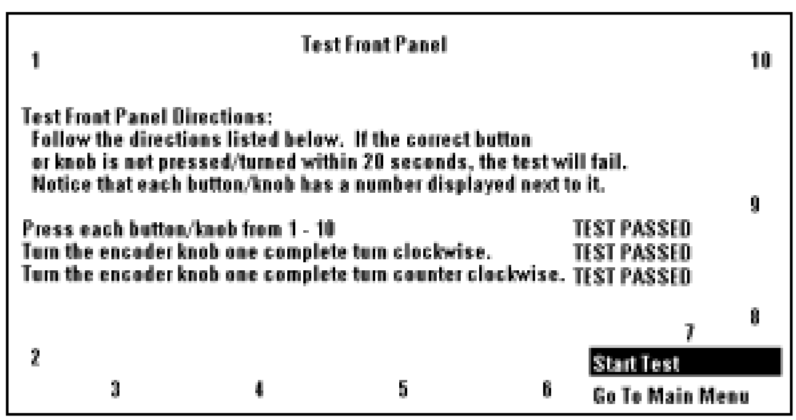


EEPROM test FAIL instructions

Upon FAIL, replace the CPU board (see section 7.5).

4b.4.6 Test Panel Switches

The software sets up the ventilator to receive all button presses and control wheel turns. The test asks the user to press each of the buttons and turn the control wheel one full turn in both directions. Each time a button is pressed the number next to the button is reverse-highlighted. If the button is pressed and the number next to the button does not reverse highlight the test for that button failed. If all of the buttons are pressed and all of the numbers next to the buttons are reverse-highlighted the button press test passes. The control wheel turn test works the same way. The user is prompted to turn the control wheel clockwise and counter-clockwise one full turn (16 clicks). When the control wheel is turned (one full turn in either direction) and the control wheel is working, the test passes. If the control wheel is not working, the test times-out in about 10 seconds and the test fails.

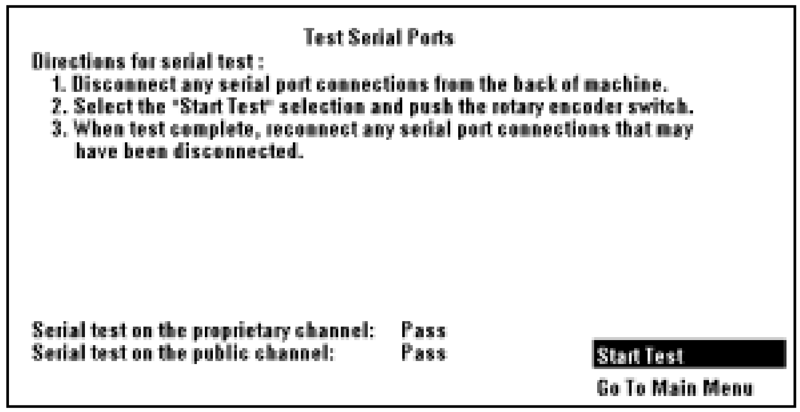


Panel switch test FAIL instructions

If any of the select buttons or the adjustment knob turn test fails, replace the front panel keyboard (see Section 7.2) or the rotary encoder (see Section 7.3).

4b.4.7 Test Serial Ports

The software performs an internal test on both of the serial ports. The software sets up the serial ports so data sent out the serial ports is echoed directly back to that serial port. The test fails if the data sent out is not equal to the data received. The status of the test is displayed on the ventilator's front screen. The software checks the serial ports to ensure any data sent out is looped back as a direct echo. If the returned data is not the same as that sent, the ports test fails.



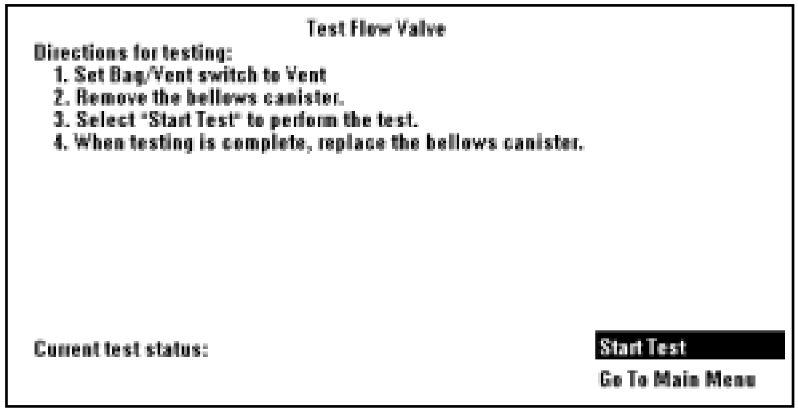
Serial port test FAIL instructions

Upon FAIL, replace the CPU board (see Section 7.5).

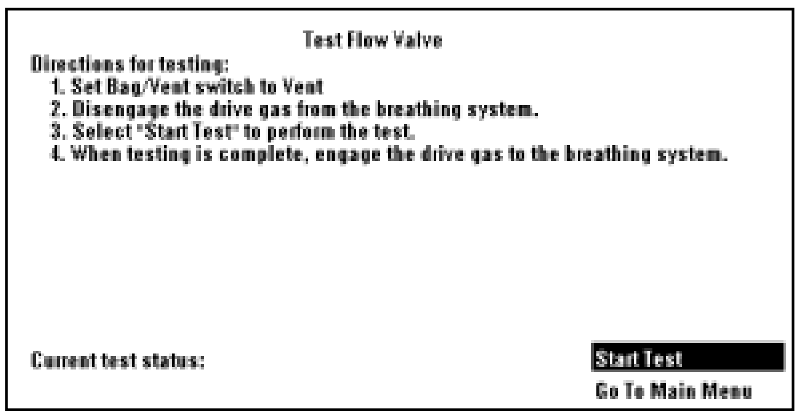
4b.4.8 Test Flow Valve

To test the flow valve the software starts by closing the flow valve. It then opens the flow valve in increments until the flow valve is completely open. At each of the settings of the flow valve the A/D (Analog/Digital) channel for Flow DAC (Digital to Analog Converter) Feedback and Flow Current Sense will be read. If the A/D for the Flow DAC Feedback and Flow Current Sense are not within the correct tolerance the test fails.

Software 3.X



Software 1.X



After setting the Bag/Vent switch to Vent, disengage the drive gas from the breathing system by removing the bellows housing.

Flow valve test FAIL instructions

A failure can be caused either by the drive circuit or a flow valve malfunction.

Go to the "Flow Valve Test Tool" menu (see section 4b.6) to check the drive circuit for proper voltage output.

Set the flow control to output 120 liters per minute. Unplug the connector from the pneumatic connection board and measure the resistance between the leads at the unplugged flow valve connector. A multimeter should read approximately 1.75 ohms.

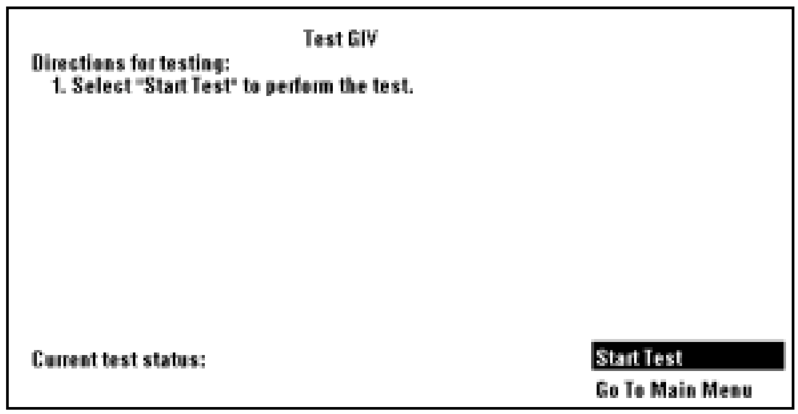
- If the resistance is approximately 1.75 ohms, the drive circuit is bad, replace the CPU board (see Section 7.5) and test the flow valve again.
- If the flow valve test fails again, replace the flow valve (see Section 7.8).

4b.4.9 Test GIV (Gas Inlet Valve)

To test the gas inlet valve the software first closes the GIV. It reads the A/D channel for the GIV. If the A/D channel for the GIV does not read closed, the test fails; otherwise, the test continues.

The software then opens the flow valve to the calibrated flow of the bleed resistor and waits for the flow to stabilize (about 2 seconds). Once the flow is stabilized the software checks to see if manifold pressure has dropped to less than 0.5 cm H_2O. If manifold pressure does not drop below 0.5 cm H_2O, the test fails; otherwise, the test continues.

The software then closes the flow valve and opens the GIV. It reads the A/D channel for the GIV. If the A/D channel for the GIV does not read open, the test fails.



GIV test FAIL instructions

Failure can be caused by the valve malfunctioning or the CPU board.

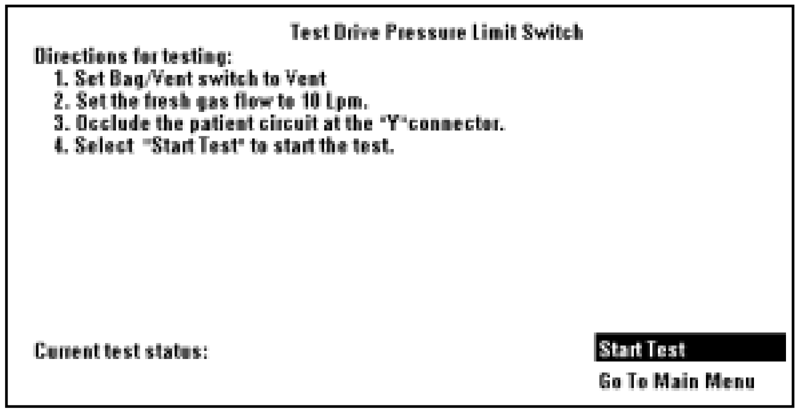
Use a multimeter to measure the resistance of the GIV solenoid. It should be approximately 25 ohms. If necessary, replace the GIV solenoid (see Section 7.9).

Use a multimeter to measure the voltage at the inlet valve connector on the pneumatic connection board. The voltage should be 4.5 volts when the GIV is open.

- If the voltage is 4.5 volts or greater, service the GIV (see Section 7.9).
- If the voltage is less than 4.5 volts replace the CPU board (see Section 7.5).

4b.4.10 Test DPL (Drive Pressure Limit) switch

The software tests the pressure limit switch to make sure that it trips at the correct manifold over pressure. The software opens the flow valve to a value where pressure continues to increase. It then waits for the DPL (Drive Pressure Limit) switch to trip. The pressure at which the DPL switch tripped is indicated. This value is the manifold pressure measured upstream of the drive gas check valve (the typical reading is 112 cm H_2O), not the actual pressure at the switch. If the DPL switch never trips (within 15 seconds) the test fails. If the DPL switch does not trip at a pressure within the correct tolerance, the test fails.



Pressure limit switch FAIL instructions

Go to the Discrete I/O signal menu and check the DPL (Drive Pressure Limit) switch status (Off).

Remove the rear subfloor. Connect a pressure test device to the black inline connector that is in the Exhalation Valve interface cuff tubing (SIB side).

Apply 104 +5/-4 cm H_2O (76.5 +3.8/-2.9 mm Hg) to activate the switch. Verify status change on the I/O signal screen (On).

If problem continues, replace SIB.

4b.4.11 Test 5V Fail Alarm

This test is only available in 3.x software.

A 5-Volt supply (VDD) is used to power the digital circuits throughout the ventilator.

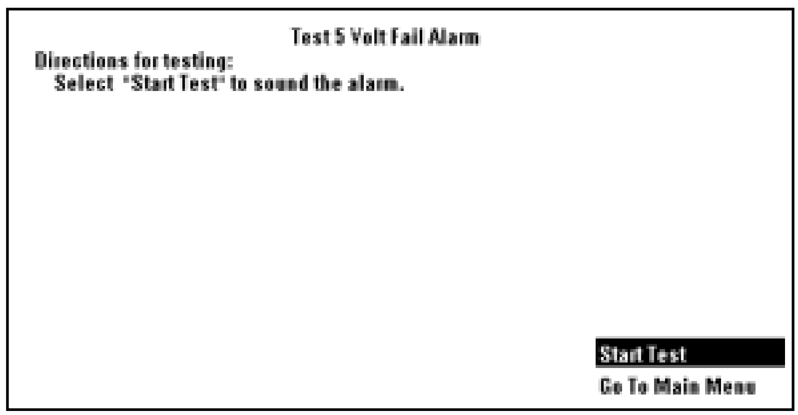
Where the 5-Volt supply (VDD) is derived depends on the type of CPU board that is used:

- In machines with the original CPU board (non-integrated), the VDD voltage is derived on the power supply board.
- In machines with an integrated CPU board, the VDD voltage is derived in the power section of the CPU board.

If the VDD supply fails, the ventilator will sound a continuous alarm tone when the system switch is turned on. The alarm is generated on the CPU board through a dedicated "sound source" that is part of the CPU board.

To test the 5V Fail Alarm, follow the directions on the screen.

Software 3.X



Remarks

If the alarm tone does not sound, replace the CPU board (see Section 7.5).

4b.5 Diagnostic Tools

4b.5.1 Display A/D channels

The software displays the A/D values for each of the A/D channels.

Display A/D channels — Page 1 of 2

A/D Channel	Counts	Actual	Range
Airway Pressure	873	1.240 cmH_2O	-20.0 to 120.0 cmH_2O
Manifold Pressure	807	0.080 cmH_2O	-20.0 to 120.0 cmH_2O
Inspiratory Flow	2046	-0.1 L/min	-120.0 to 120.0 L/min
Expiratory Flow	2037	0.1 L/min	-120.0 to 120.0 L/min
Flow Current Sense	0	0.000 Amps	0.0 to 1.024 Amps
Flow DAC Feedback	1	0.001 Volts	0.0 to 4.095 Volts
GIV Current Sense	2957	179.218 mA	0.0 to 200.0 mA
O2 Concentration	1834	101.739 %	0.0 to 100.0 %

More A/D Channels
Go To Main Menu

Display A/D channels — Page 2 of 2

A/D Channel	Counts	Actual	Range
1.225 Voltage Ref	1226	1226 mV	1220 to 1229 mV
5.0 Voltage Test	2377	5.767 Volts	4.90 to 6.09 Volts
+15V Analog Supply	2082	14.963 Volts	14.25 to 15.75 Volts
- 15V Analog Supply	909	- 14.910 Volts	-14.25 to -15.75 Volts
+12 SIB Supply	2052	12.018 Volts	10.8 to 13.2 Volts
VEL Supply	2443	14.326 Volts	10.0 to 15.225 Volts
VSW Supply	2088	15.006 Volts	9.5 to 16.5 Volts
+12V Light Supply	2029	11.883 Volts	11.4 to 12.6 Volts
Battery Voltage	3305	13.267 Volts	0.0 to 16.0 Volts
Battery Current	985	- 0.024 Amps	-0.6 to 6.0 Amps

More A/D Channels
Go To Main Menu

Remarks

This selection displays a listing of A/D Channels which are at various values depending upon the set parameters.

Refer to the following table for additional details for each of the displayed channels.

Table 4b-1 A/D Channels

A/D Channel	Counts[1]	Actual Range[1]	Displayed Range	Special Instructions
Airway Pressure[2]	550-1050	Near Zero cm H_2O	-20 to 120 cm H_2O	Zero Offset Reading (nominal 800 Counts)
Manifold Pressure[2]	550-1050	Near Zero cm H_2O	-20 to 120 cm H_2O	Zero Offset Reading (nominal 800 Counts)
Inspiratory Flow[2]	1800-2300	Near Zero L/min	-120 to 120 L/min	Zero Offset Reading (nominal 2050 Counts)
Expiratory Flow[2]	1800-2300	Near Zero L/min	-120 to 120 L/min	Zero Offset Reading (nominal 2050 Counts)
Flow Current Sense	0-4095	0 to 1.024 Amp	0 to 1.024 Amps	
Flow DAC Feedback	0-4095	0 to 4.095 Volts	0 to 4.095 Volts	
GIV Current Sense[3]	2371-3884	143.7 to 235.4 mA	0 to 248.2 mA	Off state reading is 0 to 259 counts
O2 Concentration	0-4095	0 to 100%	0 to 100%	Count weight and limits are determined during O2 calibration
1.225 Voltage Reference	1214-1235	1.214 to 1.235 Volts	0 to 4.095 Volts	
5.8V Voltage Test	1997-2565	4.86 to 6.24 Volts	0 to 9.96 Volts	
+15V Analog Supply	1914-2262	13.77 to 16.27 Volts	0 to 29.46 Volts	
-15V Analog Supply	858-953	-12.62 to -17.46 Volts	-61 to 1.43 Volts	
+12V SIB Supply	1779-2322	10.44 to 13.62 Volts	0 to 24 Volts	
VEL Supply	1645-2675	9.56 to 15.69 Volts	0 to 24 Volts	
VSW Supply	1269-2368	9.13 to 17.04 Volts	0 to 29.46 Volts	
+12V Light Supply	1879-2217	11.02 to 13 Volts	0 to 24 Volts	In Rev 3.4 software, Range = 10.00 to 12.73 Volts
Battery Voltage	1740-3976	7 to 16 Volts	0 to 16.48 Volts	<7V = Low battery voltage failure. <11.65V = Low battery voltage warning. >16 Volts (10 Sec) = High battery voltage failure.
Battery Current	700-4000	-600 mA to 6 Amps	-2 to 6.19 Amps	-150 to -600 mA = Battery charging. -601 mA to -2 Amps = Charge current out of range. >300 mA = Operating on battery. >6 Amps = Battery discharge current out of range.

Notes:

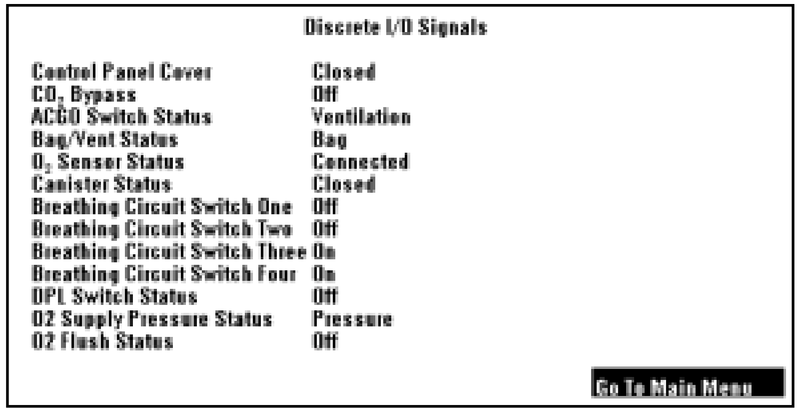
1. **These columns show the acceptable range where possible.**
2. **The A/D count and displayed value shown for Airway Pressure, Manifold Pressure, Inspiratory Flow, and Expiratory Flow are the zero pressure values. These readings should be taken with the flow sensors disconnected by removing the circuit module.**
3. **The count range and displayed value shown for GIV Current Sense is with the GIV turned on. If the GIV is turned off, the off count range is 0 to 259 Counts.**

4b.5.2 Display I/O signals

The *Discrete I/O Signals* menu displays discrete binary signals associated with machine switch positions.

There are several types of switches in the Aestiva machine:

- some switches are mechanically operated,
- some switches are pneumatically operated,
- some switches are electronic,



Mechanical switches

- Control Panel Cover — Closed or Open
- CO_2 Bypass — Off or On
- ACGO Switch Status — Ventilation or Aux CGO (machines with ACGO)
- Bag/Vent Status — Bag or Vent
- Canister Status — Closed or Open

Pneumatic switches

- O_2 Supply Pressure Status — Pressure or No Pressure
- O_2 Flush Status — Off or On
- DPL Switch Status — Off or On

Electronic switches

- O_2 Sensor Status — Connected or Disconnected
- Circuit module ID

Breathing Circuit Switch	Circle	Bain/Mapleson D	(no module)
One	**Off**	On	On
Two	**Off**	**Off**	On
Three	On	**Off**	On
Four	On	On	On

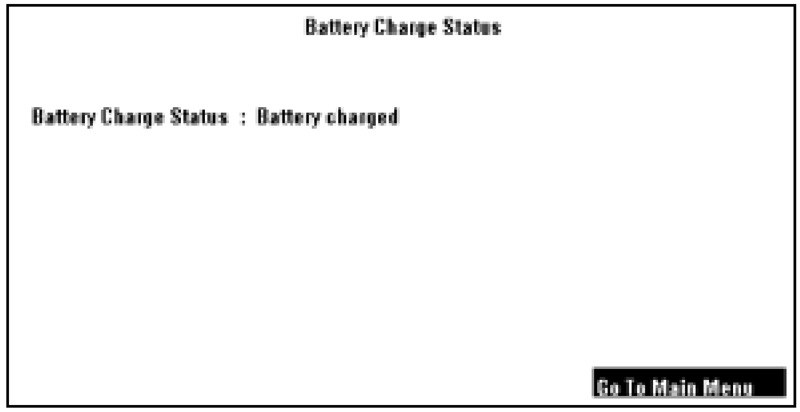
Off = tab present to block light

On = no tab to block light

4b.5.3 Battery Charge Status

The software displays the battery charge status. This checks to see if the battery charge is greater than or equal to 12.5 volts. If it is less than 12.5 volts, the battery charge status displays that the battery is not charged. If it is greater than or equal to 12.5 volts, the battery charge status displays that the battery is charged.

Battery Charge Status: Battery Charged (greater than 12.5 volts)



Remarks

If the battery has been on charge for several hours and you get a “battery is not charged” display:

- Check the battery in-line cable fuse.
- If the fuse is good, the battery is bad and you should replace it.

4b.5.4 System Error Log

The *System Error Log* displays the 10 most current errors that have been logged. The **Error code**, the **Address**, and the **software revision** are important pieces of information if technical support is required. Note that the system time is listed in ticks. One tick equals 10 ms.

Software note

The *Bootup Count When Log Last Cleared* entry is not supported in revision 1.X software.

System Error Log

Bootup Count	System Time	Error Code	Address
1018	3929 ticks	35 hex	3A97A hex
1017	8070 ticks	35 hex	3A97A hex
1012	4070 ticks	35 hex	3A97A hex
1011	431 ticks	1002C hex	5B966 hex
1009	8066 ticks	35 hex	3A97A hex
1007	6922 ticks	35 hex	3A97A hex
1006	2472 ticks	35 hex	3A97A hex
1001	8069 ticks	35 hex	3A97A hex
992	8069 ticks	35 hex	3A97A hex
990	8069 ticks	35 hex	3A97A hex

Current Bootup Count: 1027
Bootup Count When Log Last Cleared: 494
Total System On Time: 953 Hrs 0 Mins

Clear Error Log
Go To Main Menu

Remarks

The software clears the errors that have been logged when "Clear Error Log" is set so a new listing may be compiled.

4b.5.5 Alarm log

The software displays the 10 most current errors that have been logged. All alarms are listed in section5, Troubleshooting.

Note that the system time is listed in ticks. One tick equals 10 ms.

Software 3.X only

Alarm Log

Alarm Message	Bootup Count	System Time	# Times
Sustained Paw	229	42164 ticks	1
Pres Control Not Avail.	229	40564 ticks	1
Unable to Drive Bellows	229	17863 ticks	2
Unable to Drive Bellows	228	1813 ticks	1
Unable to Drive Bellows	226	2313 ticks	2
Unable to Drive Bellows	225	1713 ticks	1
Unable to Drive Bellows	224	1413 ticks	1
Check Flow Sensors ▲	219	29364 ticks	1
Low Paw	219	28164 ticks	2
Low Paw	209	6214 ticks	1

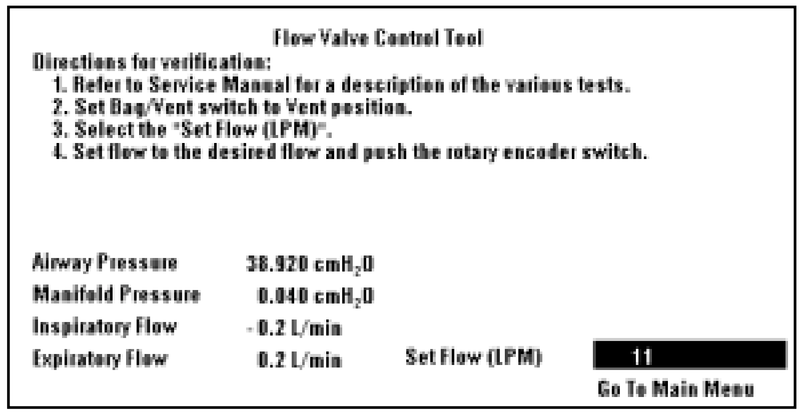
Current Bootup Count: 236
Bootup Count When Log Last Cleared: 404

Clear Alarm Log
Go To Main Menu

4b.6 Flow Valve Test Tool

The *Flow Valve Control Tool* menu is available for test and troubleshooting purposes only. It allows you to manually control the flow valve setting from 0 (closed) to 120 LPM, in 1 LPM increments, and observe key pressure and flow measurements on the same screen.

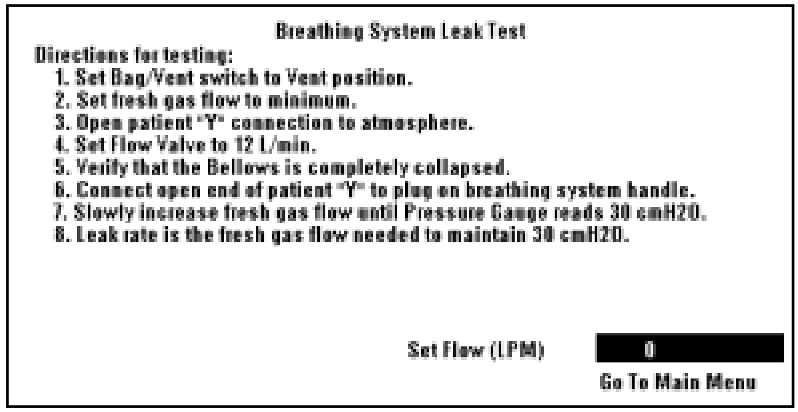
This is mainly used to test the drive gas circuit and MOPV valves as detailed in the MOPV test procedure (see Section 6.4). However, it can also be used for other troubleshooting procedures whenever a set flow is required.



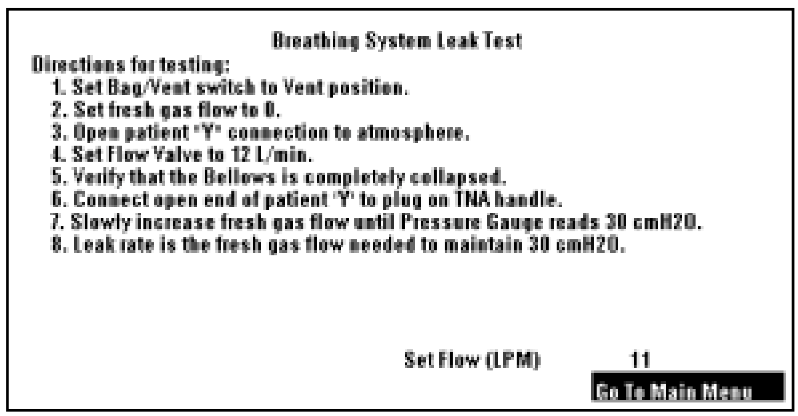
4b.7 Test Breathing System For Leak

The software allows you to test the breathing system for leaks. By using the patient circuit to establish a closed loop, you can measure the leak rate. The leak rate is equal to the fresh gas flow needed to maintain 30 cm H_2O. The system should have a leak rate ≤ 200 mL.

Software 3.X



Software 1.X



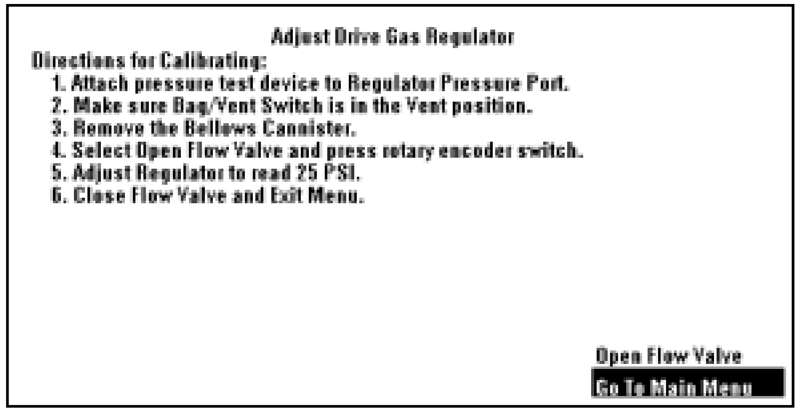
Remark Refer to the 3.X software menu to clarify two items on the 1.X software menu:

- In step 2, set the fresh gas flow to minimum.
- In step 6, you can occlude the patient circuit by connecting the open end of the patient "Y" to the plug that is part of the handle at the front of the breathing system.

4b.8 Adjust Drive Gas Regulator

The drive gas regulator must be calibrated under flow conditions.

The *Adjust Drive Gas Regulator* procedure establishes the required flow rate through the drive gas regulator for proper calibration.

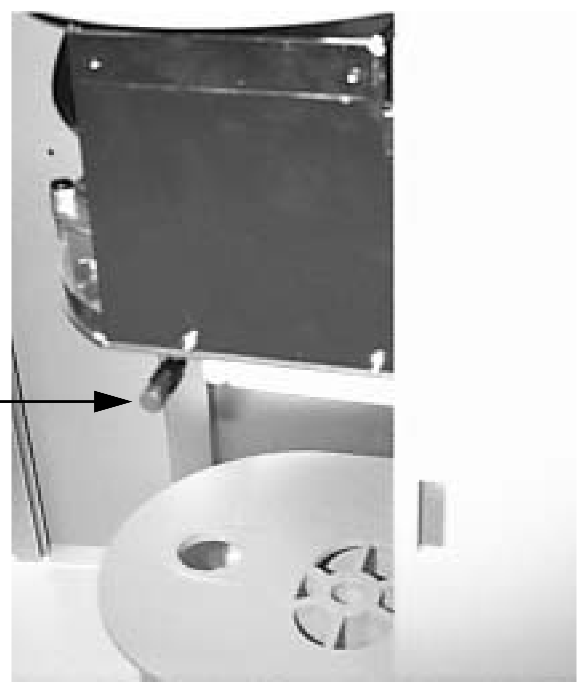


Remarks

The drive gas regulator should provide a constant gas input pressure of 172 kPa (25 psi).

You can verify this pressure by attaching a pressure test device to the regulator pressure port (shown below) and performing the above procedure.

If required, adjust the regulator to 172 ±1.72 kPa (25 ±0.25 psi).



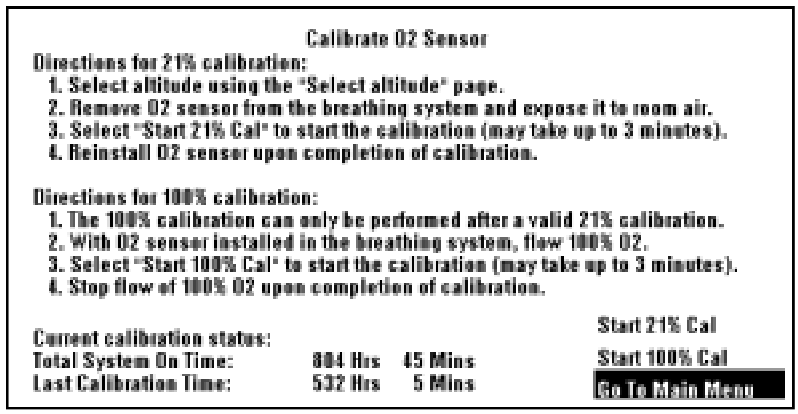
4b.9 Calibrations

4b.9.1 Calibrate O_2 Sensor

The software calibrates the O_2 sensor at a selected altitude, see “Select Altitude” menu. Set the appropriate altitude for the machine location. The software in the ventilator calibrates the O_2 sensor by reading the A/D for the O_2 sensor when the v sensor is exposed to room air (21% O_2). If this A/D value is not within the tolerance the calibration fails. If the calibration passes, the A/D value at which the O_2 sensor was calibrated is stored in the EEPROM.

Note: a circle module is required for all calibrations.

The sensor must be calibrated at 21% O_2 before calibration at 100% O_2.



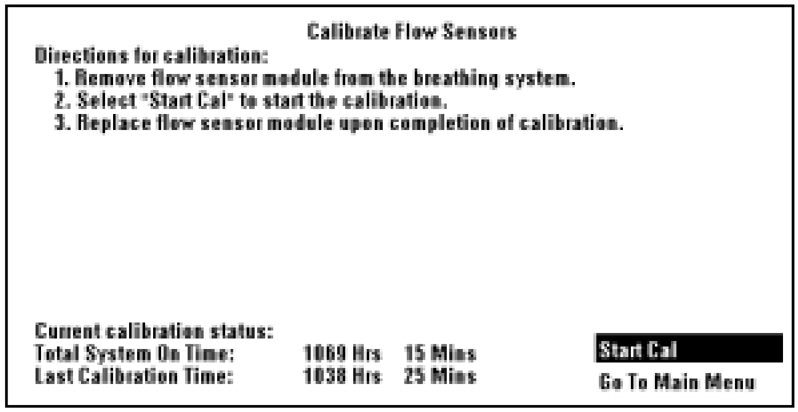
Remarks

Remove the O_2 sensor from the breathing circuit module and expose it to room air for approximately 3 minutes. The displayed reading should be 21% ± 2% to pass the calibration requirements. Place the sensor that passed the 21% test in the breathing system and expose it to 100% O_2 for 3 minutes.

If the sensor passes, the A/D value at which it passed is stored in the EEPROM. If it displays readings higher or lower than required to pass, replace the sensor.

4b.9.2 Calibrate Flow Sensors

The software calibrates the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers for zero flow/pressure offset voltage. It does so by reading the A/D values for inspiratory flow, expiratory flow, airway pressure and manifold pressure when the flow sensor module has been disconnected from the bulkhead connector. If the A/D values are not within the correct tolerance, the calibration fails. If the calibration passes, the offset A/D values at which the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers were calibrated at are stored in the EEPROM.



Remarks

Fail - indicates a problem with the SIB.

Inspect the Bulkhead Connector and SIB tubing for moisture or possible occlusion.

Check for bad differential pressure transducer.

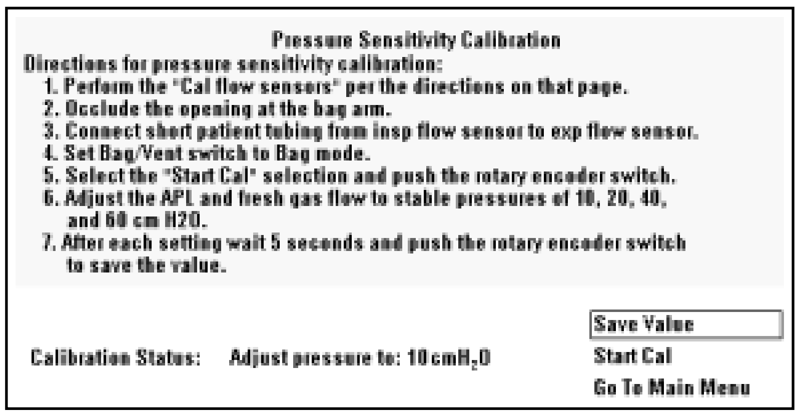
- Ensure that the flow sensor module is disconnected from the bulkhead panel.
- Check the transducer outputs using the Display A/D menu.
- If the transducer is out of tolerance (Refer to Table 4b-1, on page 4-16), replace the SIB assembly.

4b.9.3 Pressure Sensitivity Calibration

The software prompts the user to perform the procedure to calibrate the pressure sensitivity. This calibration is not an automated calibration. It prompts the user to follow a set of procedural steps to perform the calibration. This calibration calculates the pressure sensitivity at four different pressures. It uses these four different pressure points along with the inspiratory flow and expiratory flow zero offsets to find the pressure sensitivity. If the calculations for the pressure sensitivity are not within the correct tolerance, the calibration fails. If the calibration passed, the four pressure sensitivity points are stored in the EEPROM.

Note This pressure transducer calibration must be performed if the SIB assembly or CPU board is replaced.

The Pressure Sensitivity Calibration can not be successfully performed using a Bain/Mapleson D breathing circuit module. Install a Circle module to perform the calibration.



Pressure sensitivity FAIL instructions

Flow Sensor Leak Test:

1. Select "Display A/D Channels" from the main service menu.
   Set Fresh gas flow to 2 LPM.
   Open the APL valve (0 cm H_2O).
   Place Bag to Vent switch in the Bag/APL position.
   Connect a short tube between the inspiratory and expiratory flow sensors.

The airway pressure, inspiratory flow and expiratory flow on the ventilator display should read near zero (between +0.5 and -0.5 LPM flows).

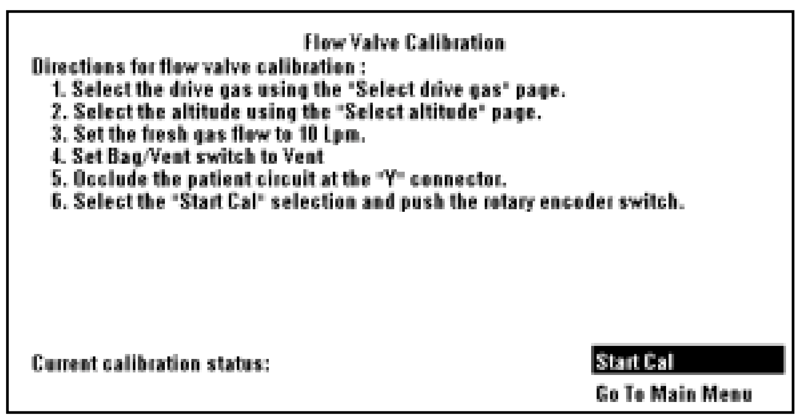
2. Occlude the bag port. Adjust the APL to read 10 cm H_2O on the gauge. The flow may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM. Very gently push the tubes coming from the flow sensors slightly in all directions. Observe to see if the flow measurements jump.

⚠ **Caution** If either sensor reads more than 2 LPM, STOP. This indicates a possible leak in the flow sensor pneumatic circuit. Skip steps 3 and 4, go directly to step 5. If the pressure is increased further, the SIB may be damaged.

3. Adjust the APL to read 20 cm H_2O on the gauge. The flows may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM.
4. Adjust the APL to read 40 cm H_2O on the gauge. The flows may jump briefly, but should stabilize to read between +0.5 and -0.5 LPM.
5. If the flow measurements on the ADC page stay near zero, the flow sensors are good. If either sensor indicates a flow where there is none, there may be a leak. To troubleshoot, reduce the circuit pressure back to zero. Reverse the flow sensor connections at the SIB interface panel and repeat the above tests.
6. If the problem follows the sensor, discard the sensor. It has a leak.
7. If the problem stays with the same side of the circuit, it is likely the leak is in the tubing, not with the sensor.

4b.9.4 Calibrate Flow Valve

The software prompts the user to perform the procedural steps to calibrate the flow valve. This is an automated calibration. It gradually opens the flow valve and monitors the manifold pressure. When the manifold pressure reaches 1.9 to 2.0 cm H_2O the value at which the flow valve has been opened is saved. The flow valve is then closed. The value at which the flow valve was opened to is then checked to make sure it is within the correct tolerance. If it is not, the calibration fails. If the calibration passes, the flow valve calibration point is stored in the EEPROM.



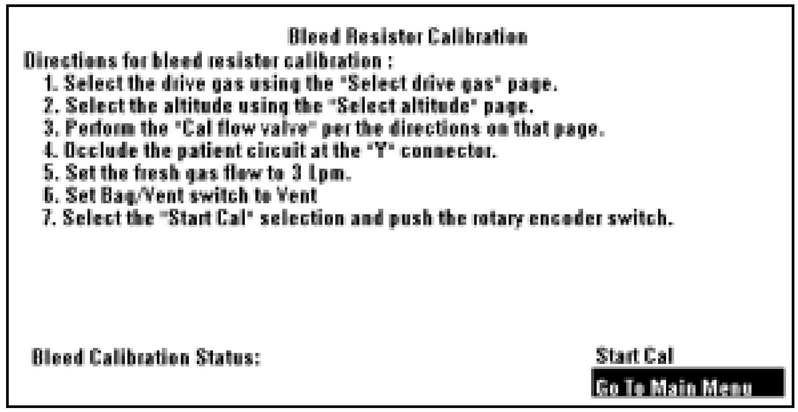
Remarks

Check that the Bag/Vent selection switch is in the vent position. If the flow valve calibration test fails immediately, the most likely fault is a failed manifold transducer. It can also be a failed regulator or the regulator could need calibration. Another cause could be a failed flow valve.

4b.9.5 Calibrate Bleed Resistor

The software calibrates the bleed resistor as described below. Other than the setup procedure, this calibration is completely automated.

Note: Step 5 in software revision 1.0 indicates that you should set the fresh gas flow to “10 Lpm”. The correct setting is “3 Lpm”.



Software procedure

Then software performs the calibration as follows:

1. Opens the flow valve to the starting point that was found (where manifold pressure is 91-92 cm H_2O).
2. Waits for the flow to stabilize.
3. Once the flow stabilized, sets the flow to 12 L/min.
4. Wait for the flow to stabilize.
5. Repeat steps 1-4, replacing step 3 with 11 L/min, 10 L/min, 9 L/min and so on to 1 L/min.

Therefore, there are 12 points that are calculated for the bleed resistor calibration. Calibration points may be greater than the listed cm H_2O, but if any one of these points is less than the cm H_2O listed below, calibration fails. If the calibration passes, the calculated bleed resistor calibration points are stored in EEPROM.

(12) ≥ 46 cm H_20	(8) ≥ 23.3 cm H_20	(4) ≥ 6.9 cm H_20
(11) ≥ 36.7 cm H_20	(7) ≥ 18.2 cm H_20	(3) ≥ 3.7 cm H_20
(10) ≥ 32.2 cm H_20	(6) ≥ 14.4 cm H_20	(2) ≥ -5 cm H_20
(9) ≥ 27.8 cm H_20	(5) ≥ 10.6 cm H_20	(1) ≥ -5 cm H_20

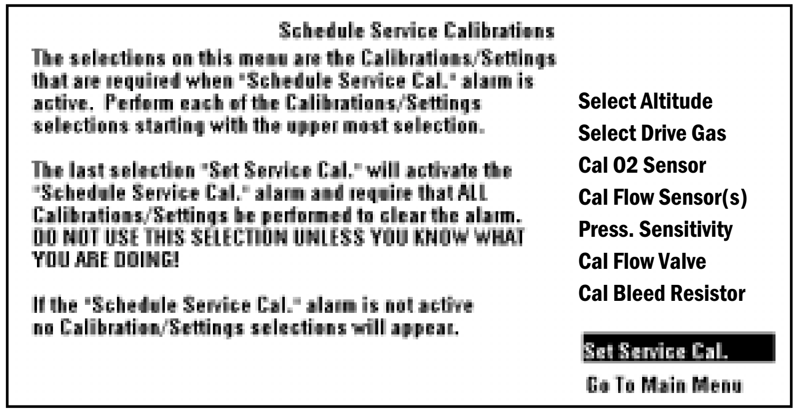
Remarks

If the bleed resistor calibration test fails, check altitude and drive gas settings. Ensure that the breathing circuit gas is exhausting out the scavenging port during the test. A negative finding indicates a massive circuit leak. Check for proper regulator pressure calibration. Ensure that the Flow Valve Cal test was conducted properly. Otherwise, failure indicates a calibration problem with the flow valve.

4b.10 Schedule Service Calibration — Software 3.X

The *Schedule Service Calibrations* menu lists which setting or calibration must be performed when the “Schedule Cal Due” alarm appears in normal operation. After the setting or calibration is properly completed, the text for that setting or calibration is removed from the list.

Software 3.X



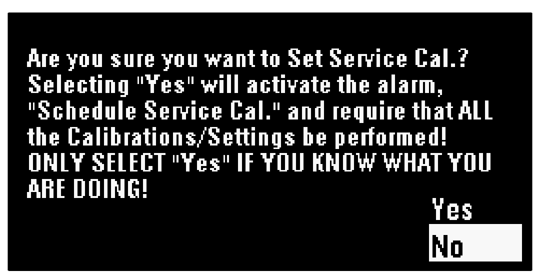
The normal operation “Schedule Service Calibrations” alarm message is only removed when all the required settings or calibrations are completed.

Remarks

The **Set Service Cal.** menu item is used by the **factory** to activate the “Schedule Cal Due” alarm and require that all settings and calibrations be performed when the Aestiva machine is set up for operation at its permanent location.

There is no need to set the “Schedule Cal Due” alarm in the field.

Select “No” when the following warning appears if you selected the “Set Service Cal” menu item.



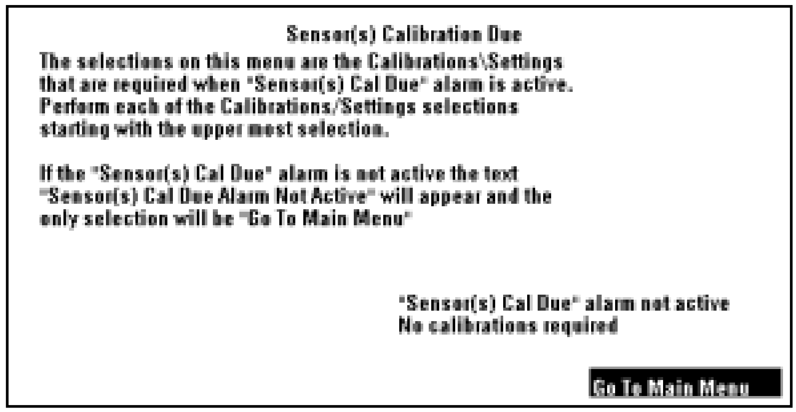
4b.11 Sensor(s) cal due — Software 1.X

This menu displays which sensors or setting must be performed when the "Sensors Cal Due" alarm appears in normal operation. After the cal/setting is properly completed, the text for that cal/setting will be removed.

If the "Sensor(s) Cal Due" alarm is not active, the menu displays the text:

"Sensor(s) Cal Due" alarm not active
No calibrations required

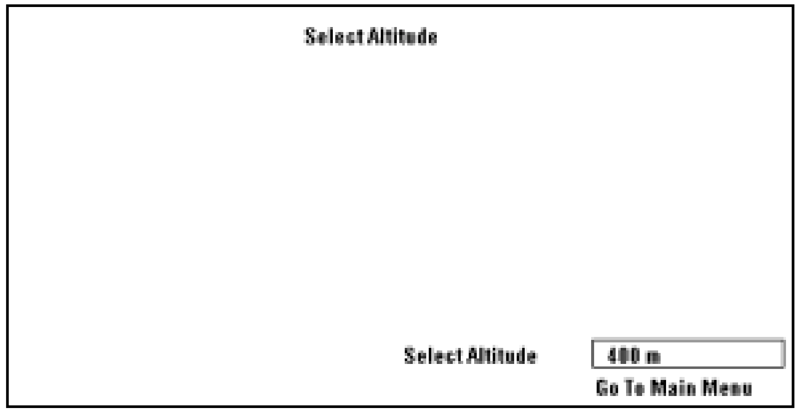
Software 1.X



4b.12 User Settings

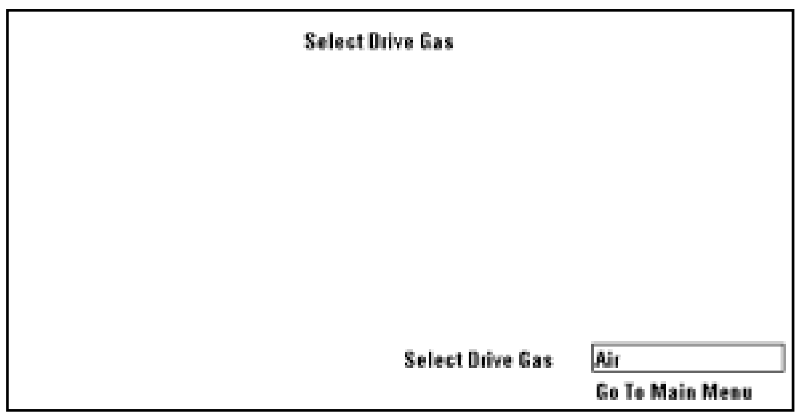
4b.12.1 Select Altitude

This provides the user with the means to select the altitude setting.



4b.12.2 Select Drive Gas

This provides the user with the means to tell the ventilator which drive gas is being used.

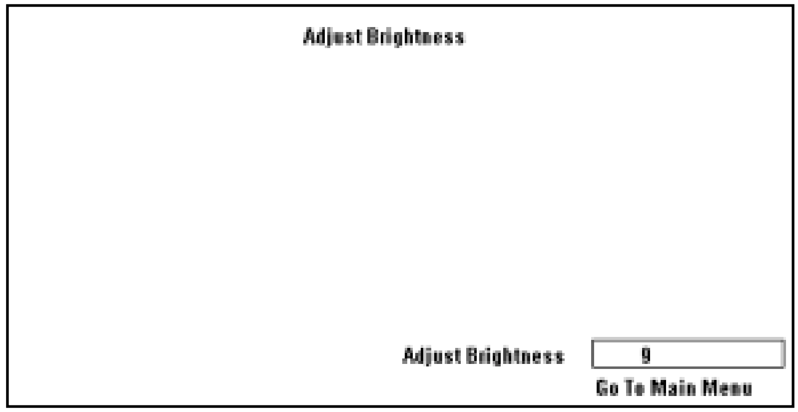


⚠ **Caution** If you change the drive gas, you must also change the drive gas selection on the service setup screen. If the drive gas selection and the actual drive gas do not agree, volumes will not be correct.

To change the actual drive gas, refer to Section 4, “Repair Procedures,” of the Aestiva Anesthesia Machine Service Manual.

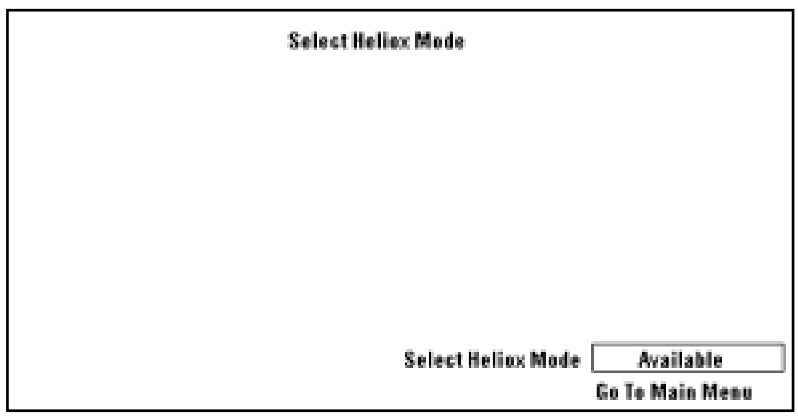
4b.12.3 Adjust Brightness

This provides the user with the means to select the display brightness.



4b.12.4 Select Heliox Mode

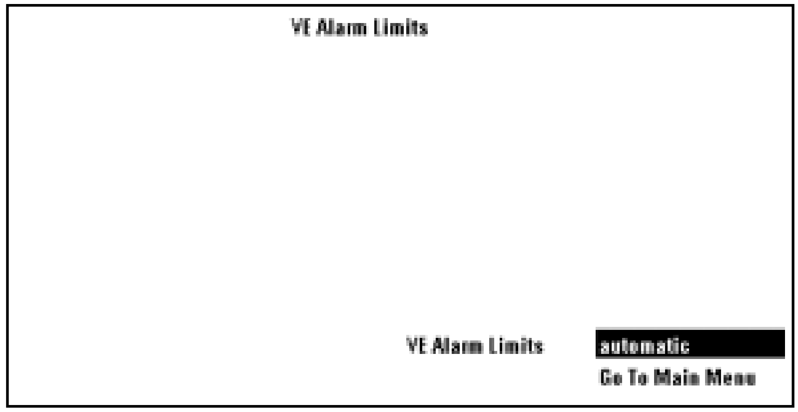
This provides the user with the means to select the Heliox mode with systems having ANSI gas systems with Heliox flow tubes installed. Set “Select Heliox Mode” to **Available** to allow the user to turn Heliox mode on or off during the normal operations mode. Set “Select Heliox Mode” to **Not Available** to prevent the user from turning Heliox mode on during normal operation.



4b.12.5 V_E Alarm Limits

The setting on the *V_E Alarm Limits* menu determines how the V_E alarm limits are set:

- If *V_E Alarm Limits* is set to **Automatic**, the ventilator software calculates the high and low V_E alarm limits and sets them to ±20% of the set V_E. The user is still able to change the limits through the Alarm Settings selection in the Main Menu.
- If *V_E Alarm Limits* is set to **User Adjustable**, the user sets the limits on the *Alarm Settings* menu.



4b.12.6 User Select Defaults

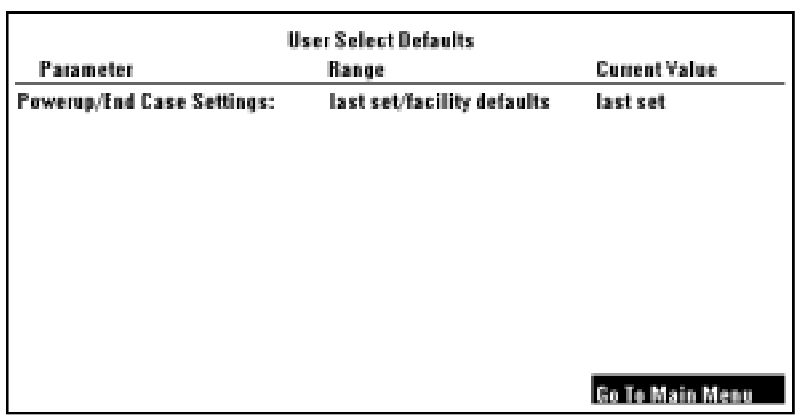
This menu (feature) is only available in 3.X software.

The *User Select Defaults* menu determines the control settings used by the system at power up:

- If **last set** is selected, the system saves its settings when you turn it off and powers up with the same settings.
- If **facility defaults** is selected, the system powers up with default facility settings and returns to default settings when the user selects “End Case”.

Use this page to set the defaults as shown.

Screen with “last set” selected:



When **facility defaults** is selected, the screen expands to two pages:

- Page 1 of 2 – control settings
- Page 2 of 2 – alarm limits.

⚠ CAUTION Ask the customer BEFORE you change any default settings. Make sure that they understand these options can only be set in Service Mode.

Screen with "facility defaults" selected:

Parameter	User Select Defaults Range	Page 1 of 2 Current Value
Powerup/End Case Settings:	last set/facility defaults	facility defaults
Ventilation Mode:	pressure/volume control	volume control
V_T:	20 - 1500 mL	250 mL
Pinspired:	5 - 60 cmH_2O	9 cmH_2O
Rate:	4 - 100 /min	18 /min
I:E:	2:1 - 1:8	1:8
Plimit:	12 - 40 cmH_2O	40 cmH_2O
Inspiratory Pause:	Off, 5 - 60%	Off
		More Defaults
		Go To Main Menu

Parameter	User Select Defaults Range	Page 2 of 2 Current Value
Low O2 alarm limit:	18 - 100%	18%
High O2 alarm limit:	21 - 100%, Off	Off
Low VE alarm limit:	Off, 0.1 - 10 L/min	Off
High VE alarm limit:	0.1 - 30 L/min, Off	Off
Low VTE alarm limit:	Off, 5 - 1500 mL	Off
High VTE alarm limit:	20 - 1600 mL, Off	Off
		More Defaults
		Go To Main Menu

Notes

5 Troubleshooting

⚠ WARNING Post-Service Checkout is required after you complete this section. You must perform section 3 “Post-Service Checkout” after performing any maintenance, service or repair. Failure to do so may result in patient injury.

In this section

5.1 Troubleshooting instructions

For ventilator problems that do not generate any error or alarm messages, even though the ventilator may not be functioning correctly:

- Refer to section 5.4, Mechanical/electrical troubleshooting guide.

For ventilator problems that result in an Alarm or Error message:

- Refer to section 5.2, System Error Log.
- Refer to section 5.3, Alarm messages.

To help isolate a problem:

- Refer to section 5.5, Troubleshooting Flowcharts.

To locate specific test points:

- Refer to section 5.6, Power supply test points.

Important If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two (2) seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous beeping audio alarm can be silenced only by turning the ventilator or anesthesia machine, as applicable, power switch OFF and after five seconds back ON.

⚠ **WARNING** This system operates correctly at the electrical interference levels of IEC 601-1-2. Higher levels can cause nuisance alarms that may stop mechanical ventilation.

⚠ **WARNING** Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternate ventilator/anesthesia system can be used.

5.2 System Error Log

5.2.1 Error messages for Software Revision 4.X

For Revision 4.X software, the Error Log displays up to 10 of the most current error messages that have been logged.

Error messages include:

- Minimum Monitoring alarms that stop mechanical ventilation;
- Minimum System Shutdown alarms that stop mechanical ventilation and monitoring.

To troubleshoot Error Log messages for Revision 4.X software, refer to Section 5.3, "*Alarm Messages.*"

5.2.2 Error codes for Software Revisions 1.X and 3.X

The following table of error codes is numerical in order and may be referenced from the "System Error Log" menu displayed. Check the number on the menu and reference this table for the description and service action. Actions are numbered in a logical action sequence. If action 1 fixes the error, no further action is required. Otherwise, action 2 and/or 3 need(s) to be taken.

Note: The following Error Log table lists codes for those errors that pertain to service. Other codes will display from time to time; however, these are software informational codes only and should not be of concern to a service person.

Error code (hex)	Description of error logged	Service action
≤10020	Software error	Clear error log and reboot the system.
10021	Defaults loaded to non-volatile memory EEPROM. (This is NORMAL if you have just loaded new software.)	1. If EEPROM or CPU board were replaced, clear error log and reboot. 2. EEPROM failure, replace EEPROMs. 3. Replace CPU board.
10022	Software error	Clear error log and reboot the system.
10023	Defaults loaded to non-volatile memory EEPROM. (This is NORMAL if you have just loaded new software.)	1. If EEPROM or CPU board were replaced, clear error log and reboot. 2. EEPROM failure, replace EEPROMs. 3. Replace CPU board.
10024 - 10026	Software error	Clear error log and reboot the system.
10029	Minimum system monitoring caused by DPL switch tripping.	Reboot the system. If problem continues, refer to Section 4b.4.10, "*Test DPL Switch.*"
1002B	Minimum system monitoring caused by incorrect flow valve feedback.	Reboot the system. If problem continues, refer to Section 4b.4.8, "*Test Flow Valve*."
1002C	Minimum system monitoring caused by incorrect GIV feedback.	Reboot the system. If problem continues, refer to Section 4b.4.9, "*Test GIV*."
10030	Minimum system monitoring caused by control setting change fail.	Reboot system. If problem continues, replace CPU board.
10034	Minimum system monitoring cause by a state error.	Reboot system. If problem continues, replace CPU board.

Error code (hex)	Description of error logged	Service action
10035	Non-volatile memory EEPROM data out of range. (This is NORMAL if you have just loaded new software.)	Reboot system. If problem continues, replace CPU board.
10036	Non-volatile memory EEPROM region protected value error. (This is NORMAL if you have just loaded new software.)	Reboot system. If problem continues, replace CPU board.
10037	Software error storing parameter in non-volatile memory.	Reboot system. If problem continues, replace CPU board.
10038	One of three safety relevant parameter areas has difference in SRC triplicate storage (external RAM problem).	Reboot system. If problem continues, replace CPU board.
10039	All three safety relevant parameter areas are different in SRC storage (external RAM problem).	Reboot system. If problem continues, replace CPU board.
1003A	There are no more EEPROM areas to switch to (EEPROM problem).	Reboot system. If problem continues, replace CPU board.
1003B - 1003D	Minimum system monitoring caused by memory failure (external RAM problem).	Reboot system. If problem continues, replace CPU board.
1003E	Minimum system monitoring caused by manifold pressure sensor failure.	Reboot system. If problem continues, replace SIB board.
1003F - 10041	Software upset. Sample causes includes too many key pushes too fast.	Reboot system. If problem continues, replace CPU board.
10042	The system clock has been reprogrammed (CPU timer problem).	Reboot system. If problem continues, replace CPU board.
10043	Software time-out	Reboot system. If problem continues, replace CPU board.
10044	Memory error (external RAM)	Reboot system. If problem continues, replace CPU board.
10045	Sustained airway pressure holding for more than 15 seconds.	No Service Action Required. Error only indicates occurrence.
10047	Minimum system shutdown: SIB 12V test failed	Reboot system. If problem continues, **For machines with original CPU:** 1. Measure the voltage at TP9 of the CPU (Section 6.6.2) Verify SIB_12V = +12V ±5%. If out of spec, disconnect CPU and measure again. If still out of spec, replace the CPU; otherwise continue. 2. Replace SIB. **For machines with Integrated CPU:** 1. Replace CPU. 2. Replace SIB.
10048	Minimum system shutdown: 15V Local 10 VA test failed	Replace PSB (power supply board). Replace CPU board

<table>
<tr><th>Error code (hex)</th><th>Description of error logged</th><th>Service action</th></tr>
<tr><td>10049</td><td>Minimum system shutdown:
display voltage test failed</td><td>Reboot system. If problem continues,
For machines with original CPU:
1. Measure voltage at TP 22 of the PSB (Section 6.6.1).
Verify VH_EL = +14.5V (10-15V).
If in spec, replace PSB to CPU cable; otherwise continue.
2. Disconnect the Display cable. Measure again.
If in spec, replace EL Display; otherwise continue.
3. Disconnect CPU board. Measure again.
If in spec, replace CPU board; otherwise replace PSB.
For machines with Integrated CPU:
1. Measure voltage at TP 213 of the CPU (Section 6.6.3).
Verify VH_EL = +14.5V (10-15V).
If in spec, replace CPU; otherwise continue.
2. Disconnect the Display cable. Measure again.
If in spec, replace EL Display; otherwise replace CPU.</td></tr>
<tr><td>1004A</td><td>Minimum system shutdown:
A/D converter failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1004B</td><td>Minimum system shutdown:
CPU test failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1004C</td><td>Minimum system shutdown:
flash EPROM failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1004D</td><td>Minimum system shutdown:
external RAM failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1004E</td><td>Minimum system shutdown:
display RAM failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1004F</td><td>Minimum system shutdown:
software watchdog failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>10050</td><td>Minimum system shutdown:
sequential watchdog failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>10051</td><td>Minimum system shutdown:
CPU clock too fast</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>10052</td><td>Minimum system shutdown:
CPU clock too slow</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>10053 through
10057</td><td>Minimum system shutdown:
CPU internal error</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>10058</td><td>Minimum system shutdown:
V_AUX test failed</td><td>Reboot system. If problem continues,
For machines with original CPU:
1. Measure voltage at TP 19 of the PSB (Section6.6.1).
Verify V_AUX = +4.988 to +6.09V.
If in spec, replace PSB to CPU cable; otherwise continue.
2. Disconnect CPU board. Measure again.
If in spec, replace CPU board; otherwise replace PSB.
For machines with Integrated CPU:
1. Replace CPU board</td></tr>
<tr><td>10059</td><td>Minimum system shutdown:
external reference voltage failed</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
<tr><td>1005A</td><td>Minimum system shutdown:
bootup memory failure</td><td>Reboot system. If problem continues, replace CPU board.</td></tr>
</table>

Error code (hex)	Description of error logged	Service action
1005B	Minimum system shutdown: +15V analog out-of-range	Refer to section 5.3, Alarm messages.
1005C	Minimum system shutdown: -15V analog out-of-range	Refer to section 5.3, Alarm messages.
1005D, 1005E	External communications error.	Reboot system. If problem continues: 1. Make sure any external device is correctly connected. 2. Make sure the correct communications protocol is selected. 3. Replace CPU board.
1005F	Unexpected reset in boot code. This can occur if the system switch is cycled (On-Off-On) too fast.	Reboot system. If problem continues, replace CPU board.
10060	Stuck in boot code	Reboot system. If problem continues, replace CPU board.
10061	Minimum system monitoring caused by incorrect feed back on flow valve current.	Reboot system. If problem continues: 1. Check power supply voltages. 2. Replace CPU board.
20001	Possible CPU board A/D converter problem.	Reboot system. If problem continues, replace CPU board.
20002-2000C	Software upset	Reboot system. If problem continues, replace CPU board.
2000D	A switch for EEPROM region was requested but there are no more areas to switch to (EEPROM problem).	Reboot system. If problem continues, replace CPU board.
2000E-2000F	Software upset	Reboot system. If problem continues, replace CPU board.
20010	Software upset	Reboot system. If problem continues: 1. Check **Total System On Time** on the System Error Log Screen. If unusually large, upgrade software to Rev 3.5 or greater. 2. Replace CPU board.
9999900	Bootup RAM failure	Reboot system. If problem continues, replace CPU board.
9999901-9999918	CPU upset	Reboot system. If problem continues, replace CPU board.
9999919-999991F	Software upset	Reboot system. If problem continues, replace CPU board.
9999920	Flash CRC test failed	Reboot system. If problem continues, replace CPU board.
9999921	Software download failed	Try to load the software again. Reboot system. If problem continues, replace CPU board.
9999922	Stuck in boot code.	Reboot system. If problem continues, replace CPU board.
9999923	Unexpected interrupt or jumped into boot code unexpectedly. Cycling power too fast can cause this.	Reboot system. If problem continues, replace CPU board.
10010100-10010211	Serial port error: 100 = parity 203 = baud rate 204 = not initialized 207 = out of sync	Reboot system, if problem continues: 1. Make sure any external device is correctly connected. 2. Make sure the correct communications protocol is selected. 3. Do the serial ports test (Section 4b.4.7). 4. Replace CPU board.

5.3 Alarm messages

The Service Mode (refer to section 4) includes a log of the most recent Alarm messages experienced by the ventilator system.

If a User Alarm persists after the recommended action has been performed, the Service Repair column indicates the probable component and related circuit that needs repair. Use the Service Mode tests to isolate the fault.

For messages that begin with “Ventilate Manually:” and are followed by a specific message, refer to the specific alarm message.

For numbers in parentheses, see the applicable footnote at the end of the table.

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
+15V Analog Out-of-Range	Minimum Shutdown (6)		Voltage out-of-range	Check the +15 V supply from service mode under Display A/D channels. Verify that the Counts value is between 1914 and 2262. **For machines with original CPU:** If not in range, measure the +15 V supply on CPU board at TP7 referenced to ground at TP1 (14.25 to 15.75 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel. If not in range, remove the SIB to CPU cable and re-test. If in range, the SIB to CPU cable or SIB may be shorting the +12 V SIB supply and loading the +15 V supply. If not in range, measure the +15 V supply on Power Supply board at TP21 referenced to ground at TP4 (14.25 to 15.75 volts). If not in range then remove power supply to CPU cable, and re-test using PJ1 pin 2 (the round pad) as the ground reference. If still not in range, replace the power supply board. If voltage is in range on the power supply board, replace the CPU board. **For machines with Integrated CPU:** If not in range, (Refer to section 5.6.3) measure the +15 V supply on CPU board at TP1 referenced to ground at TP207 (14.25 to 15.75 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel. If not in range, remove the SIB to CPU cable and re-test. If in range, the SIB to CPU cable or SIB may be shorting the +12 V SIB supply and loading the +15 V supply. If still not in range, replace the CPU.

Message	Alarm type/ Priority	Enabling Criteria / Removal Criteria	Alarm Condition	Service Repair
-15V Analog Out-of-Range	Minimum Shutdown (6)		Voltage out-of-range	**For machines with original CPU:** Check the -15 V supply from service mode under Display A/D channels. Verify that the Counts value is between 858 and 953. If not in range, measure the -15 V supply on CPU board at TP6 referenced to ground at TP1 (-14.25 to -15.75 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel. If not in range, measure the -15 V supply on Power Supply board at TP20 referenced to ground at TP4 (-14.25 to -15.75 volts). If not in range then remove power supply to CPU cable, and re-test using PJ1 pin 2 (the round pad) as the ground reference. If still not in range, replace the power supply board. If voltage is in range on the power supply board, replace the CPU board. **For machines with Integrated CPU:** Replace the CPU board.
12 Hour Test	User Alarm	System in use for more than 12 hours without a power-up self test. Removal: To do the test, move the system switch from Standby to On.		
Absorber panel open	User Alarm	The top panel is not completely closed. Removal: Close the panel.		If persists, check: • panel switch • harness to SIB • SIB • cable from SIB to CPU board
A/D Converter Failure	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace: • CPU board
Adjust Low Ve Limit	User Alarm	The audible circuit leak alarm is Off (Alarm menu) but the low VE alarm limit is not set within 50% of measured Ve. Ve alarm limit is Off in SIMV or PSVPro modes. Removal: Set the low Ve alarm.		

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
All Vent modes Available (1.X and 3.X)	low		VT Compensation Off is active without the patient or delivered volume mismatch alarms	This alarm means that a previous volume compensation problem has cleared.
		Alarm condition becomes false.		
Apnea Alarm Standby	User Alarm	Normal condition after End Case, power-up, or ACGO change from On to Off.	Monitoring resumes after first breath (mechanical) or 2 breaths within 30 sec (non-mechanical).	
Apnea Alarm Off	User Alarm	The cardiac bypass option is selected (alarm limit menu).	Apnea alarms are normally turned off when this option is selected.	
Aux Gas Outlet On	User Alarm	The outlet selection switch is set to the auxiliary common gas outlet.		If persists, check: • ACGO switch • SIB • cable from SIB to CPU board
		Connect the patient circuit to the auxiliary outlet. For mechanical ventilation or manual ventilation with monitoring, select the common gas outlet.		
Backup Mode Active	User Alarm	SIMV-PC + PSV mode entered.	No spontaneous breath within set delay time.	
Battery Charger Fail	User Alarm	The current in the battery charging circuit is too high.	The system is operational, but may fail later depending on what caused this alarm.	Replace: • battery **For machines with original CPU:** • PSB **For machines with Integrated CPU:** • CPU board
Battery Charging	User Alarm	The battery is not fully charged. If power fails, the total backup time will be less than 30 minutes.		If persists, replace: • battery **For machines with original CPU:** • PSB **For machines with Integrated CPU:** • CPU board
		Leave the system plugged in to charge the battery.		
Battery Current High	User Alarm	Battery current > 6 amps for 10 seconds.	The system continues to operate but may fail.	If persists, replace: • battery **For machines with original CPU:** • PSB **For machines with Integrated CPU:** • CPU board

Message	Alarm type/ Priority	Enabling Criteria **Removal Criteria**	Alarm Condition	Service Repair
Battery Failure High	User Alarm	Battery voltage > 16 V for 10 seconds.	The system continues to operate, but may fail.	If persists, replace: • battery **For machines with original CPU:** • PSB **For machines with Integrated CPU:** • CPU board
Battery Failure Low	User Alarm	The battery voltage is too low (<7 V) to supply the system if power fails. **Removal:** Leave the system plugged in to charge the battery.	The battery does not have enough charge to power the equipment if power fails.	If persists, replace: • battery **For machines with original CPU:** • PSB **For machines with Integrated CPU:** • CPU board
Cal Flow Sensors	User Alarm	The last flow sensor calibration failed. **Removal:** Calibrate the flow sensors. Look for water in the flow sensor tubes. Dry if necessary.		This alarm message indicates that the last flow sensor's differential pressure transducer calibration failed. With the BTV switch in Bag, ensure sensors are removed until the "No Insp/No Exp flow sensor" message appears. If persists, replace: • Check for moisture • Refer to Troubleshooting Flowcharts (Section 5.5)
Calibrate O2 Sensor	low	Sensor connected **Removal:** Successful calibration of sensor.	Offset, slope, or cell voltage not in range or O_2 > 110%	Calibrate the O_2 sensor. If calibration fails, replace the O_2 sensor. If calibration still fails, replace the SIB board.
Canister open	User Alarm	The canister release is open (large leak) without a bypass mechanism. **Removal:** Close the canister release.		If persists, check: • canister switch • harness to SIB • SIB • cable from SIB to CPU board
Cannot Drive Bellows (4.X)	User Alarm	The internal manifold pressure is higher than Paw + tolerance. **Removal:** Fill the bellows, if empty.		Check the breathing circuit for leaks or hose occlusions. Perform flow sensor calibration. Check the drive gas check valve. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
Cardiac Bypass	User Alarm	The cardiac bypass option is selected (Alarm limit menu). **Removal:** Use the alarm limits menu to change this setting.		

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
Check Flow Sensors	medium (1)	In-range flow data available in mechanical ventilation	No or negative flow on insp sensor during inspiration in a circle system or negative flow on exp sensor in expiration	Check flow sensor connections for “No Flow Sensor” alarm. Check the breathing circuit Perform flow sensor calibration. Check insp/exp check valves. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Inspiratory and/or expiratory flow sensor(s) are connected Two consecutive breaths measured with “correct” flow seen by flow sensors		
Circuit Leak Audio Off	User Alarm	Control setting on the Alarm limit menu.	This message tells you that the audio alarm for circuit leaks was turned off.	
Connect O2 Sensor	low		Digital I/O signal indicates a disconnect	Is O_2 sensor connected. If it is, replace the O_2 cable. If problem persists, check or replace the SIB to CPU cable. If problem persists, replace the SIB board. If problem persists, replace the CPU board.
		Alarm condition becomes false.		
Control Settings Input Has Failed	Minimum Monitoring (8) (9)	Change initiated by user	Internal software error	Replace the CPU board.
CPU Failure	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace the CPU board.
CPU Internal Error (7)	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace the CPU board.

<table>
<tr><th rowspan="2">Message</th><th rowspan="2">Alarm type/ Priority</th><th>Enabling Criteria</th><th>Alarm Condition</th><th rowspan="2">Service Repair</th></tr>
<tr><th colspan="2">Removal Criteria</th></tr>
<tr><td>Display Voltage Out-of-Range</td><td>Minimum Shutdown
(6)</td><td></td><td>Display voltage out-of-range</td><td>Check the VEL supply from service mode under Display A/D channels. Verify that the Counts value is between 1645 and 2675.
For machines with original CPU:
If not in range, measure the VEL supply on CPU board at TP5 referenced to ground at TP1 (10 to 15.23 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel.
If the VEL supply is not in range, remove Display to CPU cable and re-test. If in range, replace the display.
If not in range, measure VEL supply on Power Supply board at TP22 referenced to ground at TP16 (10 to 15.23 volts). If not in range then remove power supply to CPU cable and re-test. If still not in range, replace the power supply board.
If voltage is in range on the power supply board, replace the CPU board.
For machines with Integrated CPU:
If not in range, (Refer to section 5.6.3) measure the VEL supply on CPU board at TP213 referenced to ground at TP12 (10 to 15.23 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel.
If the VEL supply is not in range, remove Display to CPU cable and re-test. If in range, replace the display.
If still not in range, replace the CPU.</td></tr>
<tr><td>Exp Flow Sensor Fail</td><td>User Alarm</td><td>The system cannot read the calibration data stored in the sensor.</td><td>Operation continues with default values.</td><td>Replace the flow sensor.</td></tr>
<tr><td rowspan="2">Exp Reverse Flow
(5)</td><td rowspan="2">medium
(1)</td><td>In-range flow data available in mechanical ventilation</td><td>Negative flow on expiratory sensor during inspiration in circle system</td><td rowspan="2">Check flow sensor connections for “No Flow Sensor” alarm.
Check the breathing circuit
Perform flow sensor calibration.
Check insp/exp check valves.
Replace the flow sensors.
Check SIB to CPU cabling.
Replace the SIB board.
Replace the CPU board.</td></tr>
<tr><td colspan="2">Two consecutive breaths measured with “correct” flow seen by flow sensors</td></tr>
</table>

Message	Alarm type/ Priority	Enabling Criteria Removal Criteria	Alarm Condition	Service Repair
Flow Valve Failure (DAC) or (Current)	Minimum Monitoring (8) (9)		Incorrect feedback	Perform the flow valve test. Check the flow current sense from the service mode Display A/D channels. Should be near zero counts. If not, replace the CPU board. Check the cable to the flow valve from the CPU board. Check the flow valve resistance (approximately 1.75 ± 0.1 ohm). This must be tested at the flow valve, not through the cable from the CPU board. If not correct, replace the flow valve. Replace the CPU board.
Gas Inlet Valve Failure (7)	Minimum Shutdown (6)		Bootup test failure	Check the GIV current sense from service mode under Display A/D channels (2371 to 3884 counts). If out of range, check the CPU to gas inlet valve cabling. Then measure the gas inlet valve resistance to be 25 ± 2 ohms. If not, replace the gas inlet valve solenoid. Go to "Display I/O signals" screen. DPL switch status must be Off. If On is indicated, remove the bellows assembly. If On continues to be displayed, replace the SIB. Perform Cal bleed resistor from service mode to ensure there is no problem with the bleed resistor. Replace the SIB. Replace the CPU board.
Gas Inlet Valve Failure	Minimum Monitoring		Incorrect feedback	Perform the gas inlet valve test. Check the cable to the gas inlet valve from the CPU board. Check the gas inlet valve resistance (25 ± 2 ohms). Replace the CPU board.
Hardware Watchdog Failure (7)	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace the CPU board.
Heliox? or Heliox Mode is On	low		Control setting on ventilation setup menu.	When Heliox is used, the ventilator must adjust volume calculations. Check Heliox setting on the ventilator setup menu.

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
High O2	medium	In-range O_2 data available and alarm limit not = off	O_2 > high limit	Check O_2 limit. Is actual O_2 higher than limit setting? Verify O_2 calibration has been done correctly. Does calibration pass? If calibration does not pass, replace O_2 cell. If there is still a calibration problem, replace the SIB board.
		Alarm condition becomes false or enabling criteria becomes false.		
High Paw (2)	high (5)	In-range P_{aw} data available	$P_{aw} > P_{limit}$	Check Pressure limit setting is not set too low for ventilator settings and breathing circuit. Check the breathing circuit for occlusions. Perform flow sensor calibration. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false for 15 seconds or until the end of the next full inspiratory cycle.		
High VE	medium	In-range flow data available and alarm limit not = off	VE > high limit	Check ventilator settings and volume output. Check the breathing circuit and flow sensor connections. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or volume alarms state transition to standby (or off).		
High VTE	medium	In-range flow data available and alarm limit not = off	VTE > high limit	Check ventilator settings and volume output. Check the breathing circuit and flow sensor connections. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or volume alarms state transition to standby (or off).		
Insp Flow Sensor Fail	User Alarm	The system cannot read the calibration data stored in the sensor.	Operation continues with default values.	Replace the flow sensor.
Insp Reverse Flow (5)	medium (1)	In-range flow data available in mechanical ventilation	Negative flow on inspiratory sensor during expiration in circle system	Check flow sensor connections for “No Flow Sensor” alarm. Check the breathing circuit Perform flow sensor calibration. Check insp/exp check valves. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Two consecutive breaths measured with “correct” flow seen by flow sensors		

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
Inspiration Stopped (2), (3)	high		Drive gas safety switch engaged	Check the breathing circuit. Check ventilator flow output. Perform flow sensor calibration. Perform the pressure limit switch test in the service screen. If test fails, replace the SIB board or SIB to CPU cabling If problem persists, replace the CPU board.
Internal Ventilator Clock Too Fast (7)	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace the CPU board.
Internal Ventilator Clock Too Slow (7)	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Replace the CPU board.
Invalid Circuit Module	User Alarm	The system does not recognize the type of circuit module installed. Normally the system used the ID tabs to Identify circuits.		Make sure the module is correctly installed. Look for broken ID tabs or tape on the tabs. If persists, check: ▪ circuit identification board ▪ harness to SIB ▪ SIB ▪ cable from SIB to CPU board
Limit Task Light Use	User Alarm	The system is running on battery power.		
		No action is required. Turn off the light to save power.		
Loss of Backup Audio	User Alarm	The audio alarm will not sound for a CPU failure.	Monitor system operation.	Replace the CPU board.
Low Battery Voltage	User Alarm	Voltage is <11.65V while using battery power.	Manually ventilate the patient to save power.	Make sure power is connected and circuit breaker is closed. Check ventilator fuse.
Low Drive Gas Pres	User Alarm	The ventilator did not detect a rise in internal pressure when the flow valve opened.	Manually ventilate the patient.	Make sure that the appropriate gas supplies (O_2 or air) are connected and pressurized.
Low O2	high	In-range O_2 data available	O_2 < low limit	Check O_2 limit. Is actual O_2 lower than limit setting? Verify O_2 calibration has been done correctly. Does calibration pass? If calibration does not pass, replace O_2 sensor. If there is still a calibration problem, replace the SIB board.
		Alarm condition becomes false or enabling criteria becomes false.		

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
Low Paw	high (5)	In-range Paw data available	Peak airway pressure < $\lvert P_{min} \rvert$ + 4 for 20 consecutive seconds. P_{min} is the baseline pressure during a breath.	Check the breathing circuit for leaks. Check flow sensors hoses for leaks. Perform flow sensor calibration. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or transition from mechanical ventilation on to off.		
Low VE	high (5)	In-range flow data available and alarm limit not = off	VE < low limit	Check ventilator settings and volume output. Check the breathing circuit. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or volume alarms state transition to standby (or off).		
Low VTE	medium	In-range flow data available and alarm limit not = off	VTE < low limit	Check ventilator settings and volume output. Check the breathing circuit and flow sensor connections. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or volume alarms state transition to standby (or off).		
Manifold Pressure Sensor Failure	Minimum Monitoring (8) (9)		Cal failure at bootup or DPL switch engaged and $P_{manifold}$ < 80 cm H_2O	Check the breathing circuit. Perform flow sensor calibration. If calibration fails, replace the SIB. Check DPL switch for proper operation using the service mode Test press. limit switch check. If DPL switch test fails, replace the SIB.
High Pressure Limit Reached	Minimum Monitoring (8) (9)		DPL engaged and Paw < 90 cm H_2O and Pmanifold < 80 cm H_2O	Check the breathing circuit. Perform flow sensor calibration. If calibration fails, replace the SIB. Check the DPL switch for proper operation using the service mode Test press. limit switch check. If DPL switch test fails, replace the SIB.
Memory (EEPROM) Fail	User Alarm	The system cannot access some stored values.	Default settings are used. Ventilation is still possible but service is necessary.	Replace the CPU board.
Memory (flash) Failure (7)	Minimum Shutdown (6)		CRC failure	Replace the CPU board.

Message	Alarm type/ Priority	Enabling Criteria / Removal Criteria	Alarm Condition	Service Repair
Memory (RAM) Failure (7)	Minimum Shutdown (6)		Walking pattern test failure	Replace the CPU board.
Memory (Redundant Storage) Fail	Minimum Monitoring (8) (9)		Memory failure of system parameter(s)	Replace the CPU board.
Memory (video) Failure (7)	Minimum Shutdown (6		Walking pattern test failure	Replace the CPU board.
Monitoring Only	User Alarm	A severe malfunction prevents mechanical ventilation. Other alarms may also occur.		Ventilate manually. Cycle system power (On-Standby-On). If the alarm clears, restart mechanical ventilation. If persists, replace: • CPU board
No Circuit Module	User Alarm	The patient circuit module is not installed.		Install a module. Refer to the setup section. Optical sensors look for tabs on the back of the module. Is the module assembled? are the sensors dirty? If persists, check: • Circuit Identification Board • harness to SIB • SIB • cable from SIB to CPU board
No CO_2 absorption	User Alarm	The canisters are open (out of the circuit) but the bypass mechanism prevents a leak (optional feature)		User setting. Close the canister release to remove CO_2 from exhaled gas.
No Exp Flow Sensor	medium (1)		No expiratory sensor connected	Check flow sensor connections for "No Flow Sensor" alarm. Replace expiratory flow sensors.
		Expiratory flow sensor is connected		
No Insp Flow Sensor	medium (1)		No inspiratory sensor connected	Check flow sensor connections for "No Flow Sensor" alarm. Replace inspiratory flow sensor.
		Inspiratory flow sensor is connected		
No O_2 pressure	User Alarm	The O_2 supply has failed.	Air flow will continue. Ventilate manually if necessary.	Connect a pipeline supply or install an O_2 cylinder.
O_2 Flush Failure	User Alarm	The pressure switch that detects flush flow has seen a very long flush (≥30 sec).	This alarm occurs if you hold down the Flush button for more than 30 seconds.	If persists, check: • O2 flush switch • cable to CPU board

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
O_2 sensor out of circ	User Alarm	No breathing circuit module installed.		Install a breathing circuit module and an O_2 sensor.
On Battery - Power OK?	User Alarm	The mains supply is not connected or has failed and the system is using battery power.	Ventilate manually to save power. At full charge, the battery permits approx. 30 min of mechanical ventilation.	Make sure power is connected and circuit breaker is closed. Check ventilator fuse.
Patient Circuit Leak?	User Alarm	Exhaled volume <50% of inspired volume for at least 30 seconds (mechanical ventilation).		Check breathing circuit and flow sensor connections.
Paw < -10 cm H_2O	high (5)	In-range Paw data available	Paw < -10 cm H_2O	Check the breathing circuit. Perform flow sensor calibration (10). Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false.		
PEEP Not Achieved	low	In-range Paw data available	Pmin does not reach within 2 cm H_2O of PEEP by end of mechanical expiration for 6 breaths in a row.	Check settings for not enough expiration time. Check the breathing circuit. Occlusions Check scavenging Check ventilator output with PEEP off Perform flow sensor calibration. Check that the patient airway pressure display matches the airway pressure gage. If they match, the problem may be pneumatic, (supply pressure, regulator, inlet or flow valve, etc.). Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Alarm condition becomes false or any control setting changed (except Plimit) or mechanical ventilation transition on to off.		

Message	Alarm type/ Priority	Enabling Criteria / Removal Criteria	Alarm Condition	Service Repair
Positive SIB Vref Out-of-Range	Minimum Shutdown (6)		SIB +12V supply voltage out-of-range	First, verify that the +15V Analog Supply Counts value is between1914 and 2262. If not in range, see the +15V Analog Out-of-Range alarm for diagnostics. Then, check the +12V SIB Supply. Verify that the Counts value is between 1779 and 2322. **For machines with original CPU:** If +12V SIB Supply A/D count is not in range, measure SIB +12V on CPU board at TP9 referenced to ground at TP1 (11.4 to 12.8 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel. If the SIB +12V supply is not in range, remove SIB to CPU cable and re-test. If still not in range, replace the CPU board. If voltage is in range on the CPU board, replace the SIB to CPU cable or the SIB. **For machines with Integrated CPU:** If +12V SIB Supply A/D count is not in range, remove SIB to CPU cable and recheck the counts. If not in range, replace the CPU board. If +12V SIB Supply A/D count is in range, replace the SIB to CPU cable or the SIB.
Pres Control Available (1.X and 3.X)	low	Enabling: — Removal: Alarm condition becomes false.	V_T Compensation Off is active	Check the breathing circuit and flow sensor connections. Check the flow sensors for proper connection. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
Pres Control (Mode) NOT Avail.	Medium (pressure control); else low	Enabling: Ventilator not fully functional and pressure control mode not available Removal: Alarm condition becomes false.		Check the breathing circuit and flow sensor connections. Check the flow sensors for proper connection. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Removal Criteria	Service Repair
Pres/Vol Mon Inactive	User Alarm	Outlet selection switch is set to auxiliary gas outlet.		Connect the patient circuit to the auxiliary gas outlet or set the switch to the common gas outlet for normal operation.	
Pressure Limit Switch Failure (4.X)	Minimum Monitoring	A pressure safety switch activated at a Paw <90 cmH_2O and Pmanifold <80 cmH_2O.	Ventilate manually. Monitoring is still available. Extreme control combinations may cause this alarm.		Check control settings. Refer to Troubleshooting Flowcharts (Section 5.5.5, *"High intrinsic PEEP troubleshooting"*)
Replace O2 Sensor	low	Sensor connected	O_2 < 5%	Alarm condition becomes false.	Verify O_2 calibration has been done correctly. Does calibration pass? If calibration does not pass, replace O_2 cell. If there is still a calibration problem, replace the SIB board.
Schedule Service Cal	low	1. Replaced CPU board 2. Calibration data corrupted			Perform all calibrations in service mode.
Select gas outlet	medium		Patient breathing detected in ACGO -- 3 breaths detected in a 30 sec window	User presses the alarm silence switch.	Check ventilator settings and ACGO switch position.
Service Calibration	User Alarm	Internal calibrations are necessary for maximum accuracy.	The system is operational.		Service Mode: • Perform all calibrations 4.X - Refer to Section 4a.3.24 3.X - Refer to Section 4b.10
Software Error	Minimum Shutdown (6)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.		Replace: • Software • CPU board
Software Operating System Error	Immediate Shutdown	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.		Replace: • Software • CPU board
Software Watchdog Failure (7)	Minimum Shutdown (6)		Time-out or incorrect code executed		Replace the CPU board.
Sustained Airway Pressure (7)	Minimum Shutdown (6)	Paw > 100 cm H_2O for 10 seconds.			Check tubing for kinks, blockages, disconnects. Calibrate the flow sensors. If persists, check: • bellows pop-off • exhalation valve • SIB

Message	Alarm type/ Priority	Enabling Criteria / Removal Criteria	Alarm Condition	Service Repair
Sustained Paw	high (5)	In-range Paw data available	Paw >= sustained limit for 15 seconds.	Check absorber gage to see if the indicated sustained Paw is present. Check the breathing circuit. Perform flow sensor calibration. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
System Leak?	low	In-range flow data available	$V_{delivered}$ > larger of V_{TI} + Pmax(CF)+0.3(V_T) or V_{TI} + Pmax(CF)+200 Where CF = compressibility factor = 10	Check flow sensors connections. Check drive gas. If Heliox is used, check that Heliox is selected on the ventilator setup menu. Check the breathing circuit and drive circuit. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Removal: Four consecutive breaths measured with “correct volume” seen by flow sensors		
Unable To Drive Bellows (1.X and 3.X)	low	In-range Paw and manifold pressure	Manifold pressure > Paw + 10 + 0.25·F_I Where F_I = flow output from the flow valve in L/min	Check the breathing circuit for leaks or hose occlusions. Perform flow sensor calibration. Check the drive gas check valve. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Removal: Alarm condition becomes false or transition from mechanical ventilation on to off.		
Vaux_ref Out-of-Range	Minimum Shutdown (6)		+5.8V out-of-range	**For machines with original CPU:** Check the 5.8 Voltage Test from service mode under Display A/D channels. Verify that the Counts value is between 1997 and 2565. If not in range, measure the 5.8 V supply on CPU board at TP8 referenced to ground at TP1 (4.99 to 6.09 volts). If this voltage is in range, replace the CPU board because the problem is in the A/D channel. If not in range, (Refer to section 5.6.1) measure the 5.8 V supply on Power Supply board at TP19 referenced to ground at TP16 (4.99 to 6.09 volts). If not in range then remove power supply to CPU cable and re-test. If still not in range, replace the power supply board. If voltage is in range on the power supply board, replace the CPU board. **For machines with Integrated CPU:** Replace the CPU board.

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Removal Criteria	Service Repair
Ventilate Manually: XXXXXX	Minimum Shutdown -or- Minimum Monitoring				Refer to specific alarm message represented by XXXXXX.
Vext_ref Out-of-Range	Minimum Shutdown (6)		+1.225V out-of-range		Replace the CPU board.
Volume Apnea	medium	In-range flow data available	No measured breaths in the last 30 seconds	A breath is measured or apnea alarm detection off (cardiac bypass “in progress” or ACGO on).	Check that mechanical ventilation is on. Check the breathing circuit. Check ventilator settings and volume output.
Volume Apnea > 2 min (3)	high (5)	In-range flow data available	No measured breaths in the last 120 seconds	A breath is measured or apnea alarm detection off (cardiac bypass “in progress” or ACGO on).	Check that mechanical ventilation is on. Check the breathing circuit. Check ventilator settings and volume output.
VT Not Achieved	low	In-range flow data available	$V_{TI} < V_T$ - (bigger of (0.1· V_T or 5 mL)) for 6 mechanical breaths in a row	Alarm condition becomes false (i.e., 1 breath exceeding threshold) or mechanical ventilation transition on to off.	Check ventilator settings, is P_{limit} set too low for volume setting? Check drive gas. Check the breathing circuit and flow sensor connections. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
VT Compensation Off (1.X and 3.X)	medium (1)		Active ventilation mode is backup volume	Alarm condition becomes false.	Check the breathing circuit and flow sensor connections. Check the flow sensors for proper connection. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.

Message	Alarm type/ Priority	Enabling Criteria	Alarm Condition	Service Repair
		Removal Criteria		
V_{TE} > Insp V_T (2)	low	In-range flow data available	V_{TE} > larger of (V_{TI} + $0.3 \cdot V_T$ or V_{TI} + 100) for 6 consecutive mechanical breaths in circle system	Check flow sensor connections. Check ventilator settings. Check the breathing circuit and flow sensor connections. Perform flow sensor calibration. Replace the flow sensors. Check SIB to CPU cabling. Replace the SIB board. Replace the CPU board.
		Four consecutive breaths measured with “correct volume” seen by flow sensors		

Alarm Message footnotes:

(1) These alarms will de-escalate to low priority following user acknowledgment by pressing the alarm silence switch.
(2) These alarms also have associated text displayed in the user messages window.
(3) These alarm messages do not have an elapsed time indication.
(4) This alarm is enunciated at the maximum volume level and is not silenceable.
(5) Serial connection to the RGM suppresses audio for these alarms
(6) All minimum system shutdown alarms have high priority audio characteristics.

- **If the user presses the alarm silence key, the high priority audio is silenced for 120 seconds.)**
- **If the shutdown condition occurs during non-mechanical ventilation with the Bag/Vent switch in Vent or during mechanical ventilation and the user moves the Bag/Vent switch to Bag, the high priority audio is silenced for 120 seconds.**
- **If the Bag/Vent switch is moved from Bag to Vent while a shutdown condition is active and the audio silenced, the high priority audio is generated (once again).**

(7) The software will try to cause a reset of the processor after the user presses the control wheel (in response to the shutdown message).
(8) All minimum system monitoring alarms have medium priority audio characteristics.
(9) All messages appear in the user messages window.
(10) Flow sensors are also used to measure pressures.
(11) The sustained pressure threshold is calculated from the pressure limit setting. When mechanical ventilation is on, the sustained limit is calculated as follows: for pressure limits < 30 cmH_2O, the sustained pressure limit is 6 cm H2O; for Plimit between 30 and 60 cmH_2O, the sustained limit is 20% of the pressure limit (Plimit); for pressure limits >60 cmH_2O, the sustained pressure limit is 12 cm H_2O. If both PEEP and Mechanical ventilation are on, the sustained pressure limit increases by PEEP - 2 cmH_2O (the compensated weight of the bellows). When mechanical ventilation is off, the sustained pressure limit is calculated as follows: for pressure limits ≤60 cmH_2O, the sustained pressure limit is 50% of the pressure limit (Plimit); for pressure limits >60 cm H_2O, the sustained pressure limit is 30 cmH_2O.

5.4 Mechanical/electrical troubleshooting guide

For machines with the original CPU board, the power supply circuits are located on a separate, power supply board (PSB).

For machines with an Integrated CPU, the power supply circuits are located on two modules: the AC to DC converters are on a universal power supply (PS), the regulated power circuits are integrated into the CPU board (IntCPU).

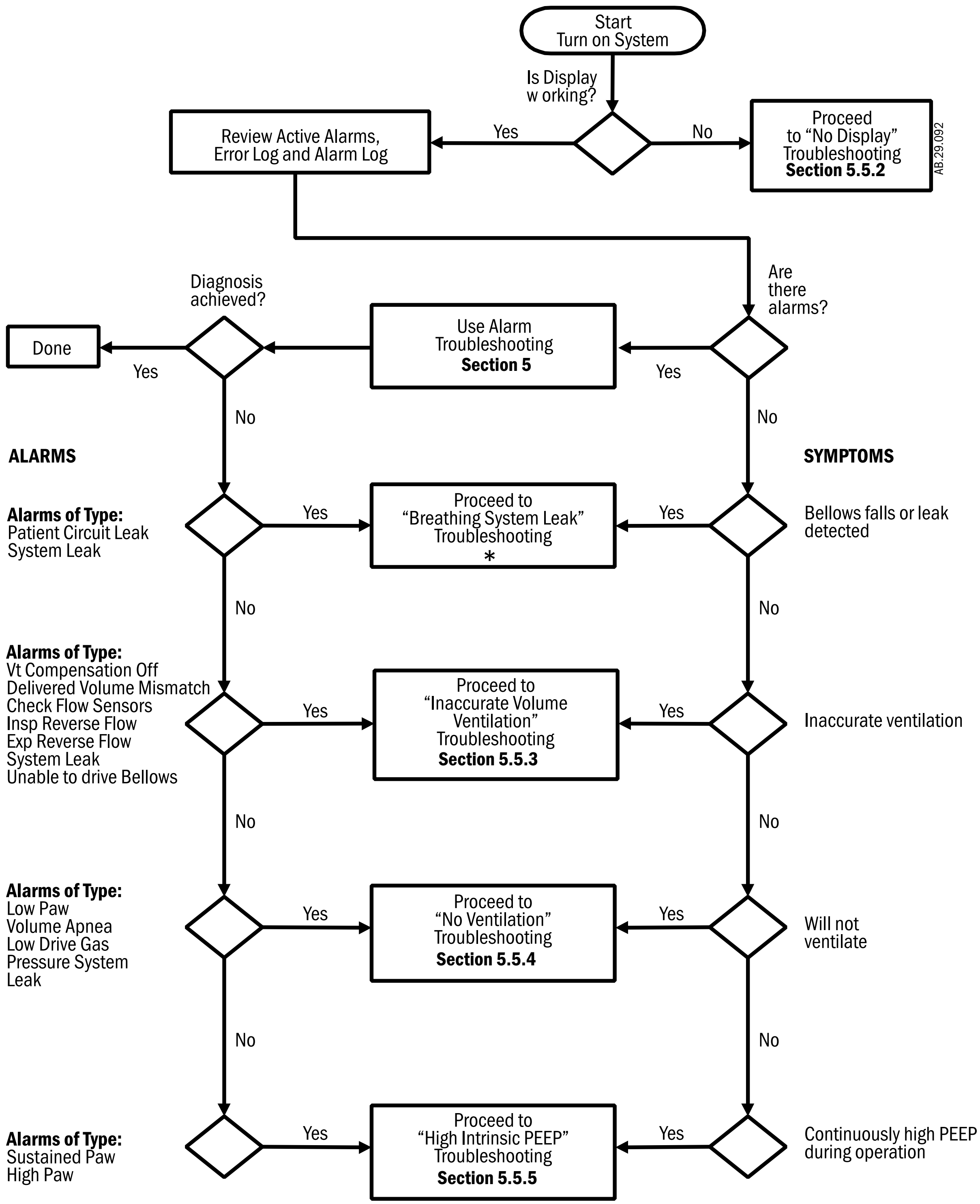
For power supply test point, refer to Section 5.6.

Symptom	Probable cause	Action
System on, AC LED on, no display		Refer to section 5.5.2, No display troubleshooting.
AC LED not on	1. Power cord	1. Is the cord plugged in?
	2. AC power	2. Is the power outlet o.k.?
	3. Circuit breaker	3. Check main circuit breaker in the AC Inlet module.
	4. 50-pin cable, front panel to CPU board	4. Check cable connection.
	5. Power supply board	5. Verify output voltages of power supply. Replace PSB/CPU.
	6. Membrane switch LED	6. Replace membrane keyboard.
No battery	1. Battery cable disconnected	1. Connect cable.
	2. Battery power less than 7V while running on battery power	2. Charge battery.
	3. Battery fuse blown	3. Replace battery fuse.
	4. Defective battery	4. Replace battery.
Alarms display, but not audible	1. Audio set too low	1. Adjust audio from menu.
	2. Speaker cable	2. Ensure cable is plugged in.
	3. Speaker	3. Replace speaker.
	4. CPU board	4. Replace CPU board.
Bellows does not expand or tends to collapse during ventilation.	1. Leak in the breathing circuit	1. Check breathing circuit and absorber for leaks.
	2. Bellows not installed properly	2. Check the bellows to rim attachment. Make sure bellows ring roll is into groove under rim.
	3. Tear or leak in bellows.	3. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions.
	4. Insufficient fresh gas flow	4. Check that settings on flowmeters are adequate.
	5. Improperly functioning pressure relief valve in bellows assembly	5. Check the pressure relief valve and seal for damage. Reseat.
Bellows distended and/or slips off base.	1. Bellows retention problem	1. Check/replace bellows.
	2. Bellows assembly exhaust restricted	2. Check the waste gas scavenging system for high vacuum or blockage.
	3. Bellows assembly pressure relief valve problem	3. Control port plugged or drive gas inlet hose blocked.
Continuous flow of supply gas before machine is turned ON.	1. External hose leak.	1. Check hose.
	2. GIV leak.	2. Check/repair GIV solenoid.

Bellows does not descend during inspiration.	1. Normal 2. Leak in breathing system.	1. If the fresh gas flow is greater than tidal volume, the bellows may not descend. 2. Check for leaks in drive gas circuit. Are twin tube assemblies on the pneumatic engine lifted all the way into the interface cuff?
Ventilator will not turn on when remote on/off switch is turned on and AC LED is on	1. Machine interface harness 2. Remote on/off switch 3. Power supply board	1. Ensure cable is plugged in properly at switch and CPU board (J5). 2. Replace switch 3. Replace power supply board
Erratic pressure waveform Slow exhalation pressure release	• Slight to moderate valve leakage • O-Ring Seal, Housing to Main Manifold • Alignment of seat and seal after assembly • Loose mounting screws • Exhalation valve assembly	1. Check operation of drive gas check valve. 2. Replace drive gas check valve. 3. Inspect and reassemble the exhalation valve assembly; make sure to put it together correctly.
Mechanically delivered volumes decrease significantly immediately following use of O_2 Flush.	Failure to cease Volume Compensation when Flush is used. • Flush switch • Flush regulator out of adjustment	1. Go to “Display I/O signals” screen in Service Mode (Section 5.2). Press and release flush button. Look for proper switch action. Before replacing switch, do step 2. 2. Check that output of flush regulator is within specifications: 131 +0/-7 kPa (19 +0/-1 psi) (Section 6.5 of Aestiva Machine Service Manual). 3. Check wire harness connections at switch and SIB. 4. Replace CPU board.

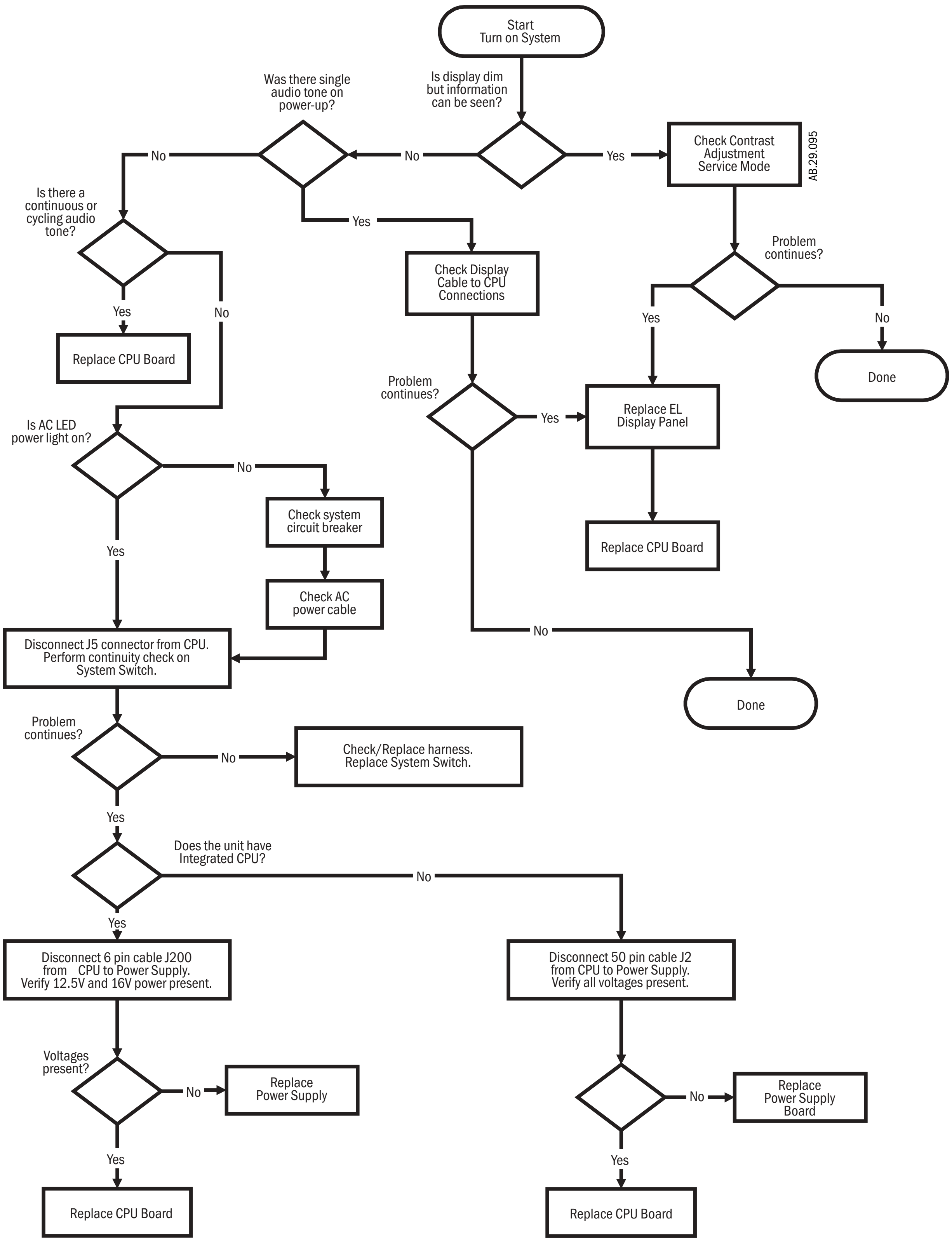
5.5 Troubleshooting Flowcharts

5.5.1 Ventilator assessment process

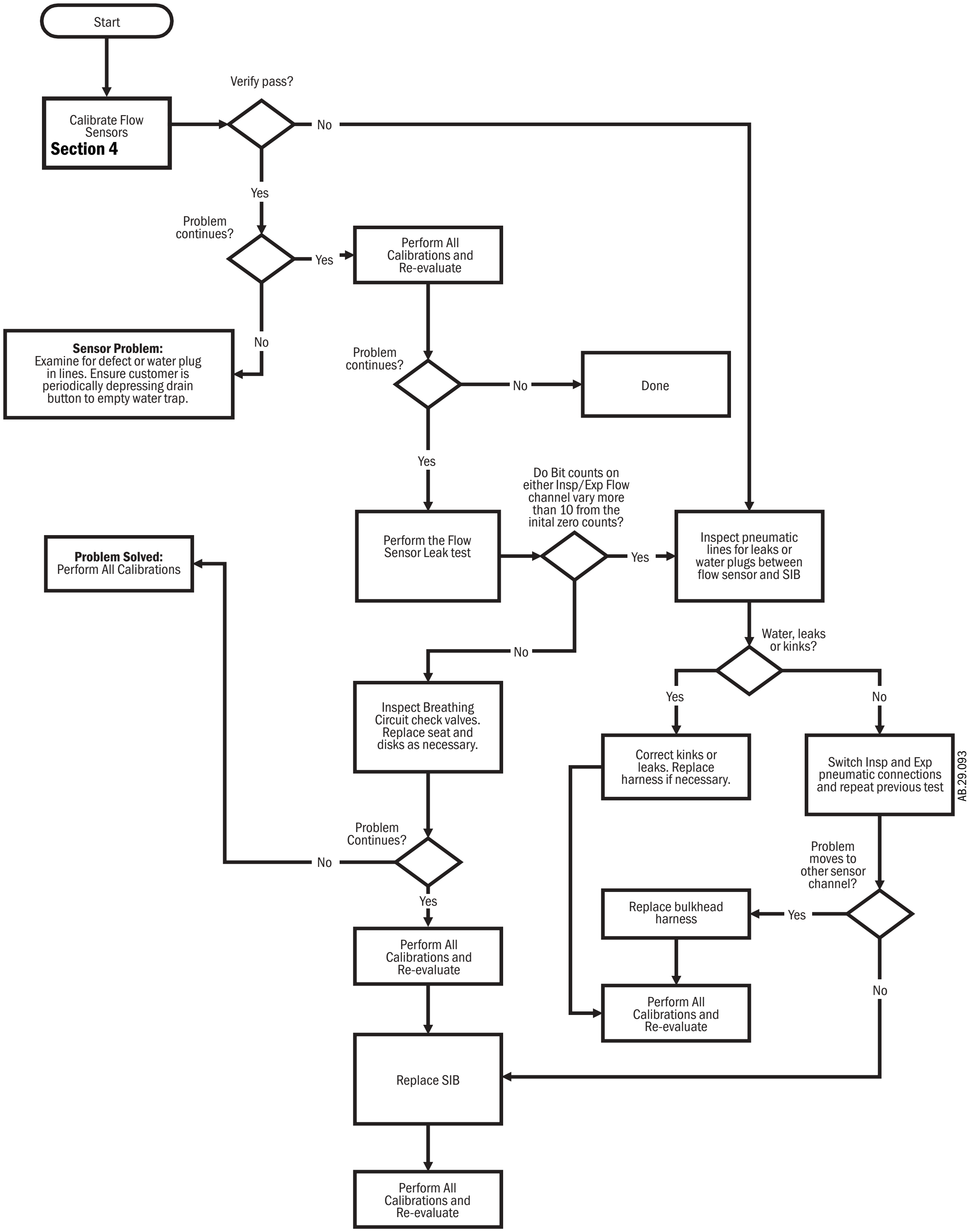


* Refer to Section 7.2, *"Breathing System Leak Tests,"* in the Aestiva Machine service manual, 1006-0452-000.

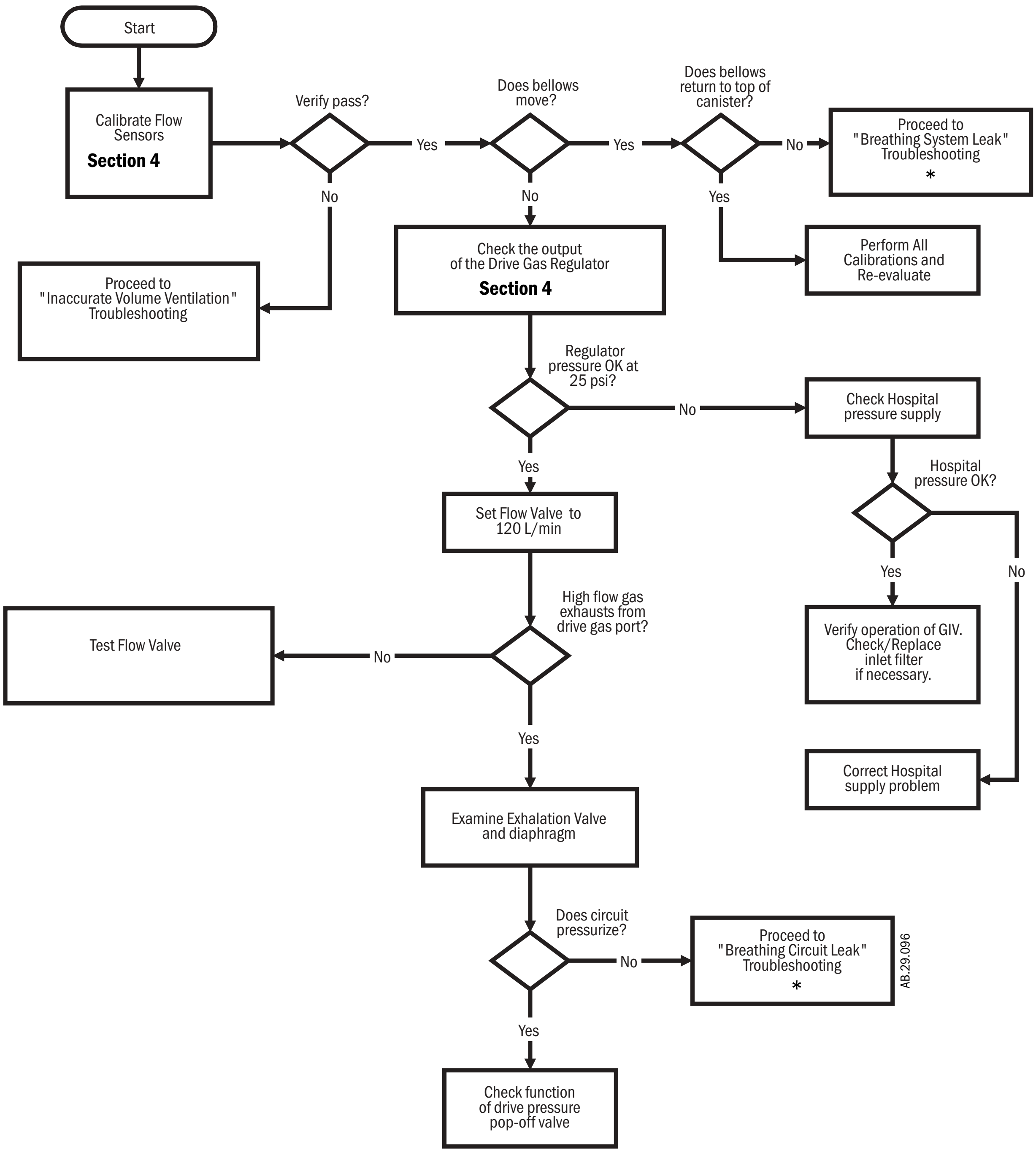
5.5.2 No display troubleshooting



5.5.3 Inaccurate volume ventilation troubleshooting

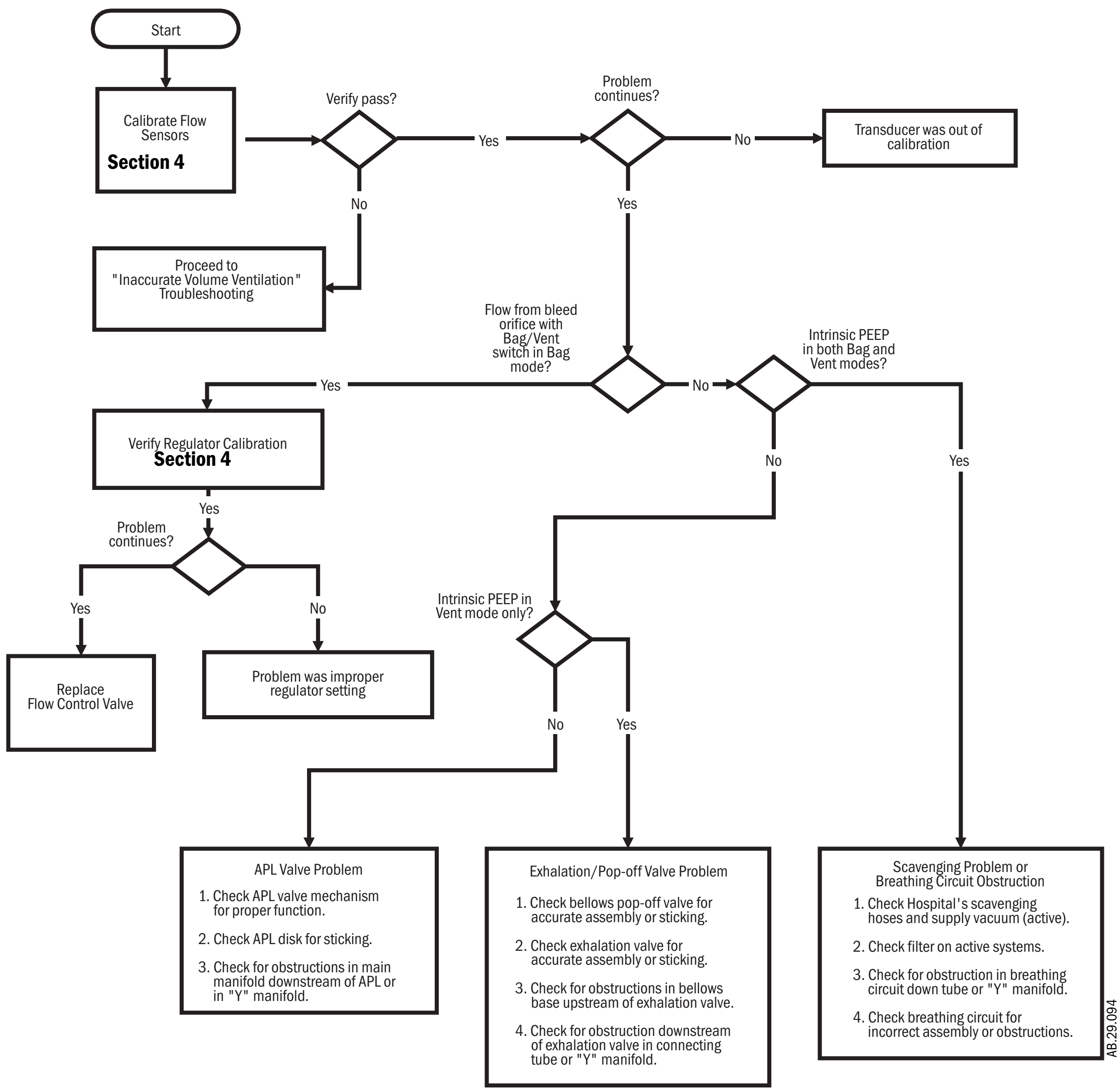


5.5.4 No ventilation troubleshooting



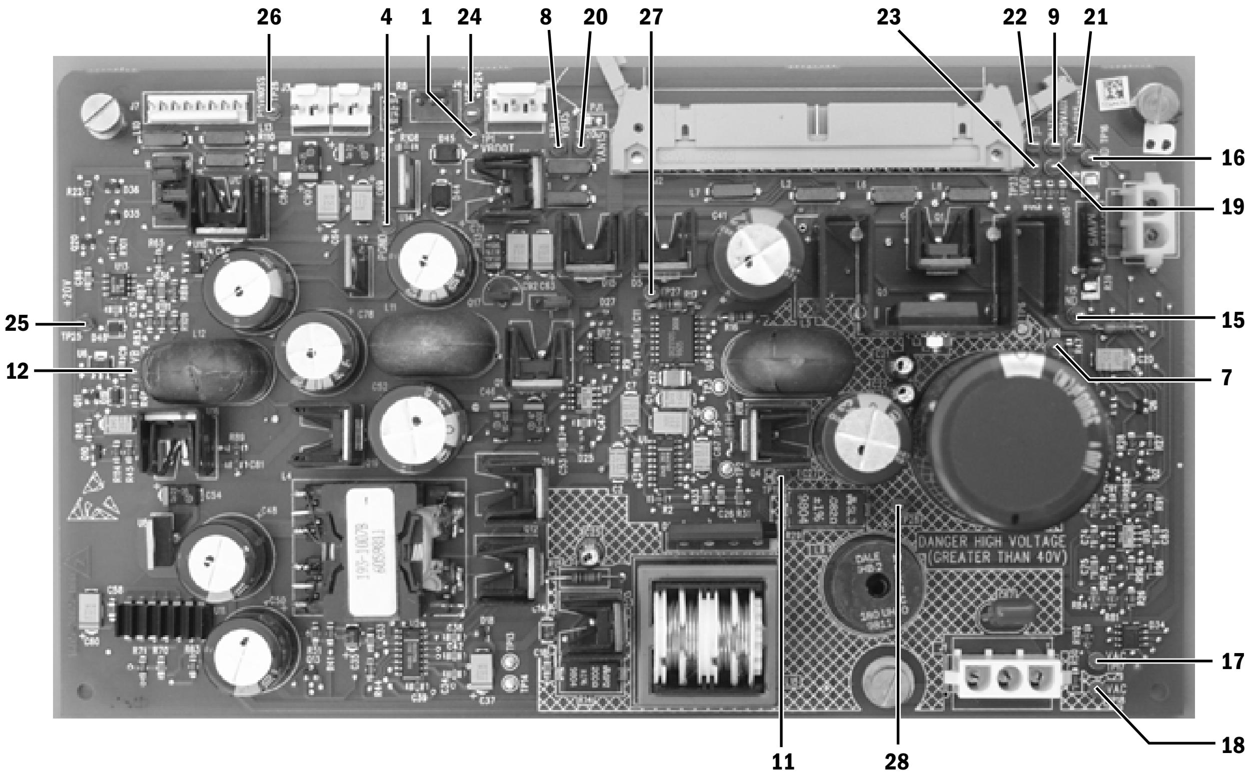
* Refer to Section 7.2, *"Breathing System Leak Tests,"* in the Aestiva Machine service manual, 1006-0452-000.

5.5.5 High intrinsic PEEP troubleshooting



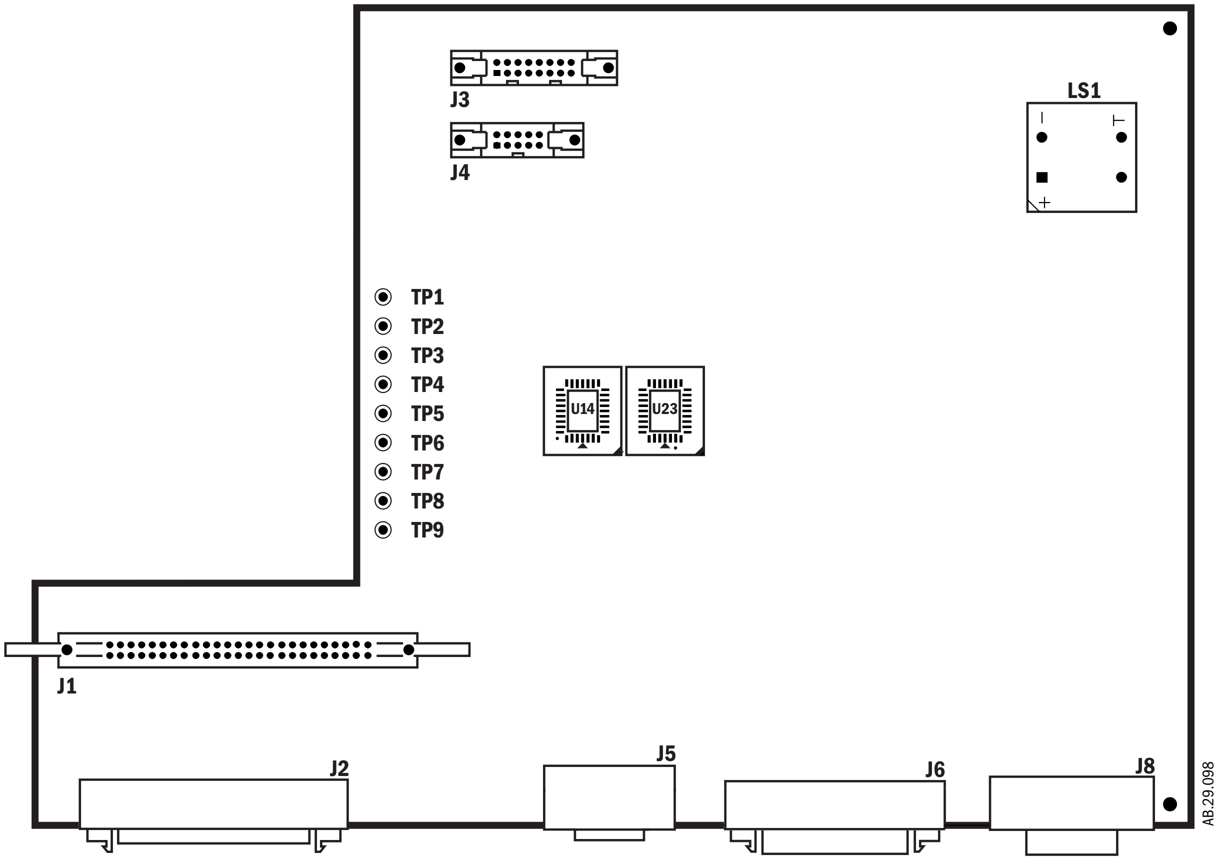
5.6 Power supply test points

5.6.1 Power supply board (original CPU)



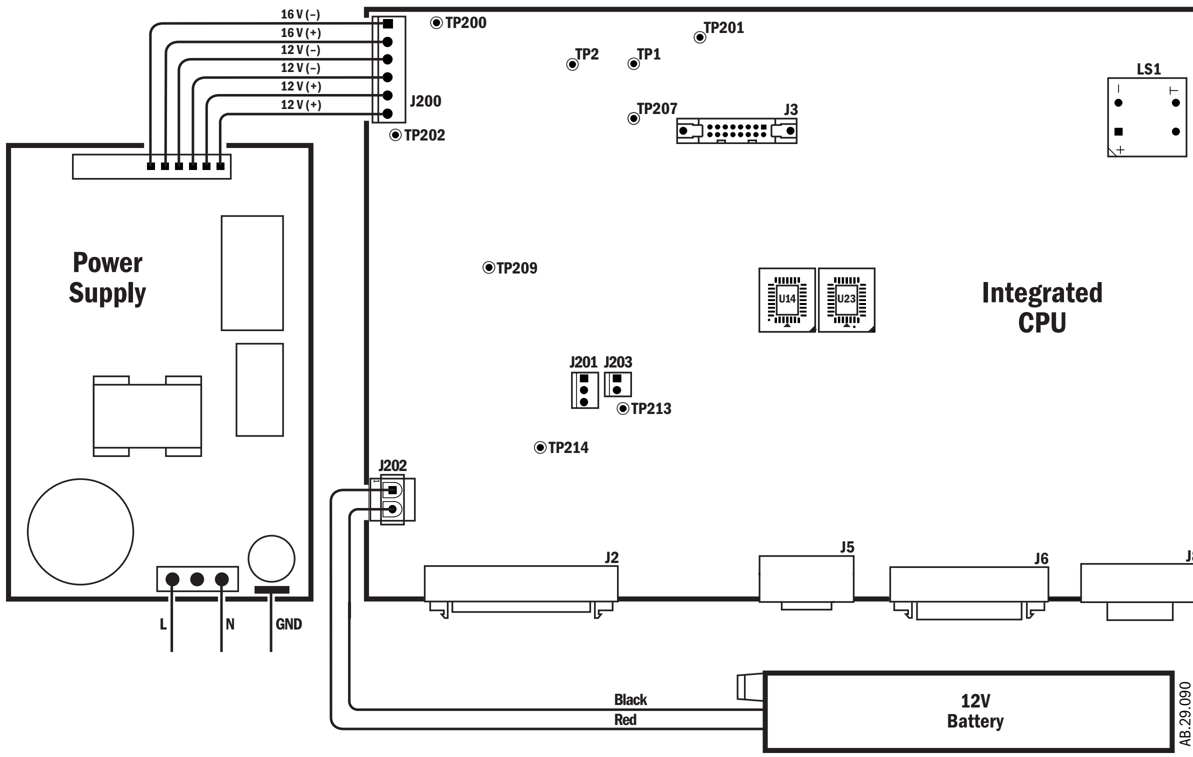
TP	Name	Typical Value	Description
1	VBOOT	+15V	Supply to power primary regulator
4	PGND	0V	Power ground
7	VIN	+ 50V	Rectified voltage from transformer (30-60 Vdc)
8	VBUS	+16.5V	Primary regulator output (±5%)
9	BATT_P	+13.3 V	Battery voltage
11	PGND	0V	Power ground
12	VB	+16V	Power bus from VBUS or battery (±5%)
15	DGND	0V	Digital Ground
16	DGND	0V	Digital Ground
17/18	VAC (1)/VAC (2)	35 Vac	AC from toroid (24-45 Vac); measured across TP17 and TP18
19	5R5_VAUX (+5.5–5.8V)	+5.6V	Supply for inlet valve, flow valve, and speaker (±5%)
20	VAN15 (-15V)	-15V	Analog -15V supply (±5%)
21	VAP15 (+15V)	+15V	Analog +15V supply (±5%)
22	VH_EL	+14.5V	Supply for EL display (±5%)
23	VDD	+5.0V	Supply for digital circuit (+3.68%, -3.05%)
24	VSW	+15V	Supply for VDD Fail Buzzer (±10%)
25	TP25 (+20V)	+20V	Intermediate supply stage before NOSS (task lights) output
26	P15V_NOSS (+12VLP)	+12V	Supply for task lights (±5%)
27	VB	+16V	Power bus from VBUS or battery (not short protected)
28	VBUS	+16.5V	Primary regulator output (not short protected)

5.6.2 Original CPU



TP	Name	Typical Value	Description
1	DGND	0V	Digital Ground
2	VDD	+5.0V	Supply for digital circuit (+3.68%, -3.05%)
3	P15V_NOSS (+12VLP)	+12V	Supply for task lights (±5%)
4	VSW	+15V	Supply for VDD Fail Buzzer (±10%)
5	VH_EL	+14.5V	Supply for EL display (±5%)
6	VAN15 (-15V)	-15V	Analog -15V supply (±5%)
7	VAP15 (+15V)	+15V	Analog +15V supply (±5%)
8	5R5_VAUX (+5.5–5.8V)	+5.6V	Supply for inlet valve, flow valve, and speaker (±5%)
9	SIB_12V	+12V	Analog +12V (±5%) supply to SIB

5.6.3 Power supply (Integrated CPU)



TP	Name	Typical Value	Description
1	+15V	+15V	Analog +15V supply
2	-15V	-15V	Analog -15V supply
200	VCHGR	+16V	From power supply
201	PGND	0V	Power (chassis) ground
202	VMAIN	+12.5V	From power supply
207	AGND	0V	Analog ground
209	+5.8V	+5.8V	Supply for inlet valve, flow valve, speaker
213	VH_EL	+14.5V	Supply for EL display
214	+12VLP	+12V	Supply for light package

Note The power supply outputs are +16 volts and +12.5 volts.

- The +16 volts is used to charge the battery. It is only available when the machine is connected to an AC supply.
- The +12.5 volts is used to generate the regulated voltages on the CPU board. In case of power outage, the CPU power circuits are supplied by the battery.

Notes

6 Maintenance

In this section

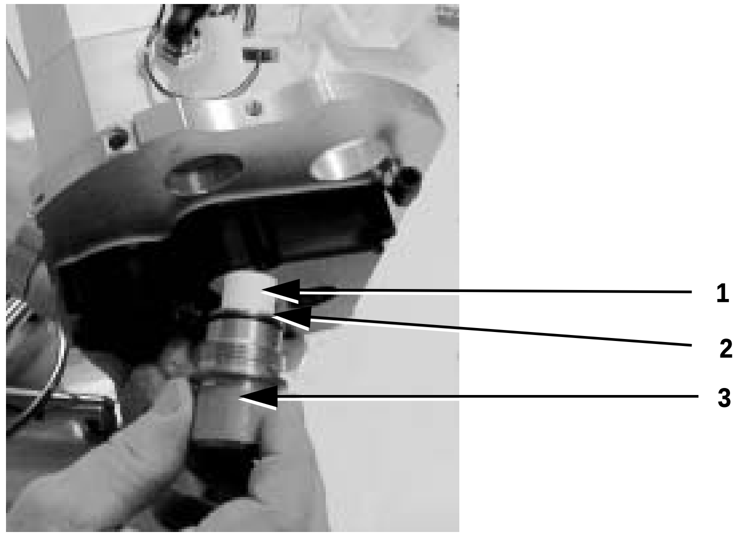
This section details select maintenance procedures that apply to the ventilator portion of the Aestiva Anesthesia Machine.

Note: For maintenance intervals, see Section 5 of the Aestiva Anesthesia Machine Service Manual.

⚠ **WARNING** Do not perform testing or maintenance on this instrument while it is being used to ventilate a patient. Possible injury can result.

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

6.1 Supply gas inlet filter



1. **Element assembly**
2. **O-ring, install into filter body prior to assembly**
3. **Filter cap**

Figure 6-1 • Filter body assembly on bottom of ventilator manifold

1. Remove the rear cover of the breathing system.
2. Locate the filter cap at the bottom of the vent engine.
3. Unscrew the filter cap and replace the filter.
4. Check the condition of the o-ring on the filter cap. Replace if cracked or torn.
5. Reinstall the filter and the filter cap.
6. Perform the Preoperative Checkout Procedure in the Aestiva Anesthesia System Operation Manual.

⚠ **CAUTION** Cross threading the filter bowl can cause debris to accumulate on the filter resulting in shorter useful life of the filter.

⚠ **CAUTION** Once you start the threads on the filter body, with the O-ring mounted to the body, do not back out the filter body unless you take it all the way out and restart the mounting. If the body is partially unscrewed or backed out from the manifold seat, the O-ring will slip out of place and result in an unacceptable leak.

6.2 Free breathing valve maintenance

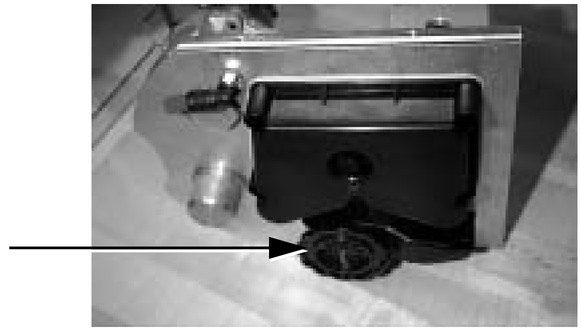
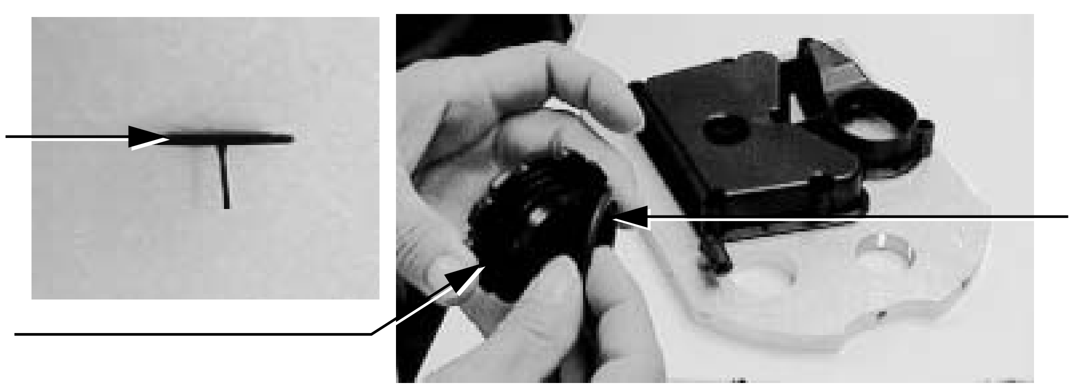


Figure 6-2 • Free breathing valve

1. Remove the absorber rear cover.
2. Unscrew the valve seat from the bottom of the ventilator engine manifold. It should be hand tight.
3. Inspect the flapper and valve seat for nicks, debris and cleanliness.
4. Pull the tail of the new free breathing valve flapper through the center of the valve seat until it locks in place.
5. Trim the tail in line with the bottom of the valve seat.
6. Replace the O-ring. Lubricate with a thin film of KRYTOX™.
7. Back the seat threads counter clockwise until you feel the thread engage. Hand screw the assembly into the manifold.
8. Perform the Preoperative Checkout Procedure in the Aestiva Operation Manual.

1



3

2

1. Flapper
2. Valve seat
3. O-ring

Figure 6-3 • Free breathing valve flapper and O-ring

6.3 MOPV differential relief valve test

⚠ **WARNING** Objects in the breathing system can stop gas flow to the patient. This can cause injury or death:

- Do not use a test plug that is small enough to fall into the breathing system.
- Make sure that there are no test plugs or other objects caught in the breathing system.

1. Turn all flow control valves to their minimum setting.
2. Set the Bag/Vent switch to Vent.
3. Attach a patient circuit to the breathing system.
4. Occlude the patient port.
5. Remove the rear cover from the breathing system.
6. Remove the scavenging assembly and plug the scavenging port with a test plug.
7. Push the flush button to fill the bellows. The inspiratory pressure gauge should not exceed 60 cm H_2O with the flush button pushed (will typically be 50–55 cm H_2O).
8. Release the flush button. Within 4 seconds, the absorber pressure gauge should fall to between 20 and 40 cm H_2O. After it reaches this pressure, it may continue to fall but at a much slower rate.
9. Remove the test plug from the scavenging port.

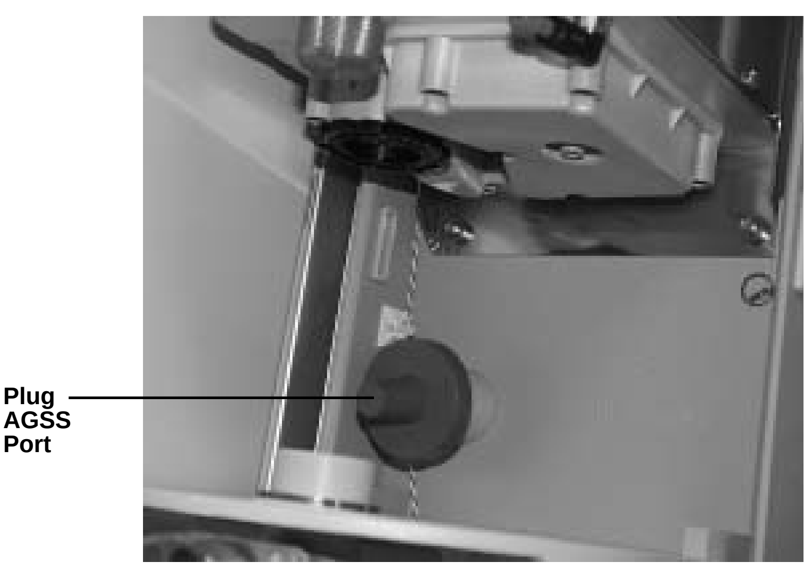


Figure 6-4 • Plugging the AGSS port

6.4 MOPV pressure relief valve test

⚠ **WARNING** Objects in the breathing system can stop gas flow to the patient. This can cause injury or death:

- Do not use a test plug that is small enough to fall into the breathing system.
- Make sure that there are no test plugs or other objects caught in the breathing system.

Note: For this test, the breathing system must be taken apart and the exhalation valve removed. This test involves plugging the 2 silicone ports beneath the exhalation valve (drive gas and exhalation valve ports). The drive gas port, which is the one offset from center, has to be plugged below the take off port for the drive pressure limit switch.

1. Using the standpipe tube from the exhalation valve, and with the u-cup seal side of the tube up, push the standpipe tube down the silicone drive gas port until it is approximately 1/2 inch (15mm) from the blue seal. Pushing the standpipe tube all the way down to the seal may cause the test to fail.

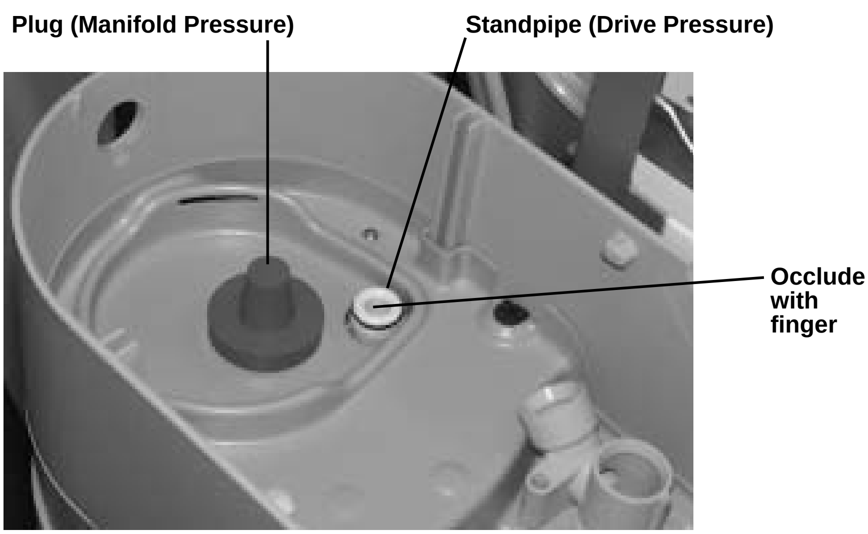


Figure 6-5 • Occluding the standpipe tube

2. Plug the other silicone port (exhalation valve manifold pressure) with a test plug.
3. Set the system switch to On and enter the Service Mode.
4. Select “Flow Valve Test Tool” from the menu.
5. Select and activate a flow of 20 LPM.

6. Occlude the top of the standpipe tube with your finger, making sure the tube remains 1/2 inch (15mm) above the blue seal.
7. Check the manifold pressure reading on the service screen. The MOPV valve is functioning correctly if the steady state pressure reading is <120cm H_2O.
8. Set the system switch to Standby.
9. Remove the test plug from the exhalation valve port.
10. Remove the standpipe from the port and reinstall in the exhalation valve.
11. Reassemble the breathing system.
12. Perform the Preoperative Checkout Procedure in the Aestiva Operation Manual.

Notes

7 Repair Procedures

In this section

This section covers the repair and replacement procedures for the Aestiva 7900 Ventilator and its related components.

⚠ **WARNING** Post-Service Checkout is required after you complete this section. You must perform Section 3, “Post-Service Checkout,” after performing any maintenance, service, or repair. Failure to do so may result in patient injury.

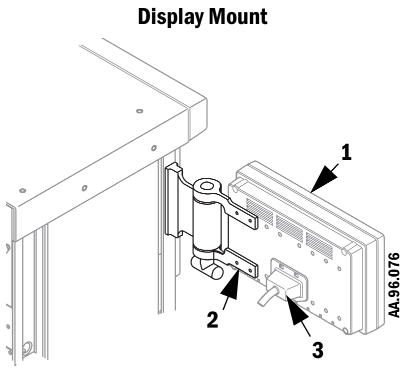
⚠ **WARNING** When servicing the ventilator, extreme care must be taken to avoid introducing foreign debris, particularly metal chips generated by screw threads, into the pneumatic flow passages of the ventilator. Failure to do so can result in damage to the flow valve and possible injury to the patient.

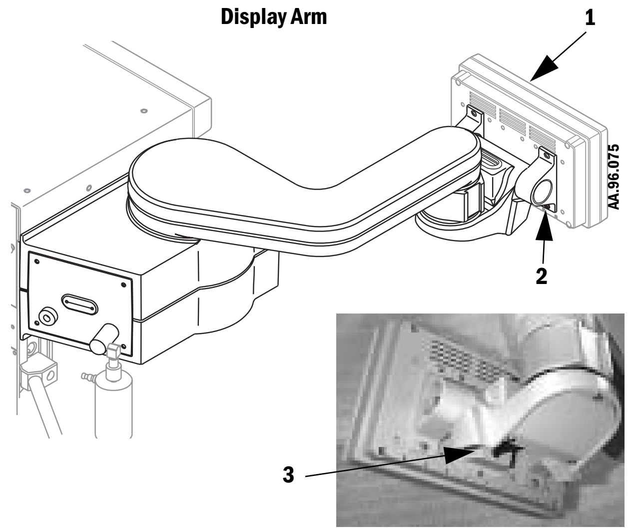
⚠ **WARNING** The ventilator must be off and unplugged before you perform any disassembly procedures to avoid injury.

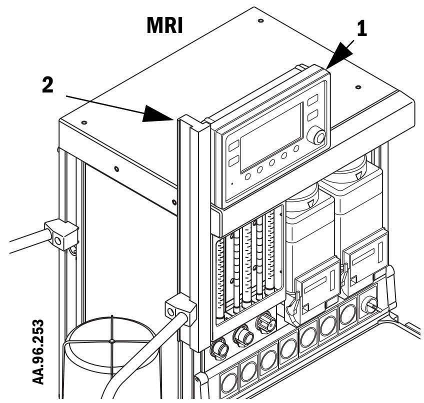
7.1 Control panel assembly

The control panel assembly is mounted on either a Folding Display Mount or on a repositionable Display Arm. Signals between the control panel and the CPU board are sent through a 50-pin connector cable that passes through the side of the machine (and through the outboard arm if equipped) and connects to the rear of the control panel.

For the Aestiva/5 MRI machine, the display is centrally mounted above the flowhead.







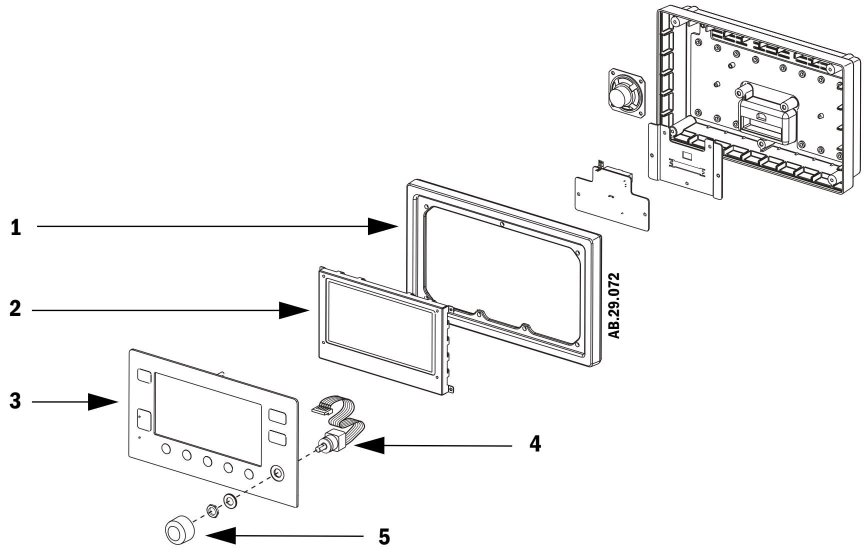
1. **Control panel**
2. **Mounting brackets**
3. **Connector cover**

Figure 7-1 • Ventilator control panel

To remove the control panel assembly:

1. Remove the screws from the connector cover and slide the cover back.
2. Disconnect the 50-pin connector cable.
3. Remove the screws that attach the control panel to the mounting brackets.
4. Remove the control panel.

7.2 Keyboard and EL display



1. **Front housing**
2. **EL display**
3. **Keyboard**
4. **Rotary encoder switch**
5. **Control knob**

Figure 7-2 • Keyboard and EL Display

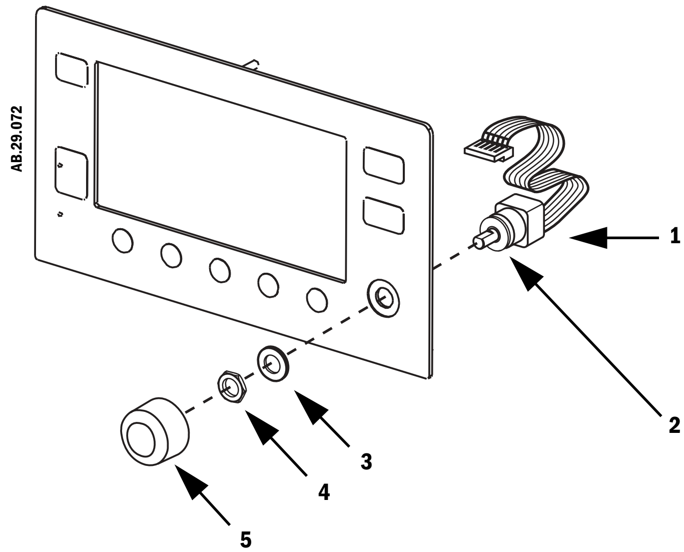
⚠ **CAUTION** Use an approved static control workstation and wrist grounding strap.

Note For MRI machines, refer to the MRI service manual supplement regarding the EMC shield.

To remove the keyboard and EL display:

1. Follow the instructions in Section 7.1 to remove the control panel assembly.
2. Loosen the screws on the rear corners of the control panel assembly.
3. Remove the back cover assembly.
4. To separate the front and rear assemblies, disconnect the 50-pin ribbon cable from connector J2 of the keyboard.
5. Remove the 20-pin ribbon cable from its connector on the EL display.
6. Remove the four M3 Keps nuts from mounting studs on keyboard and remove the EL display.
7. Remove the seven M4 Keps nuts from keyboard studs and remove keyboard from the front housing.
8. To replace the encoder switch, see Section 7.3.
9. When you replace the keyboard, remove the protective film from the back of the new keyboard window, clean, and check for scratches.
10. Assemble in reverse order.
11. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.3 Encoder switch



1. **Encoder switch with harness**
2. **Locking washer**
3. **Flat washer**
4. **Mounting nut**
5. **Control knob**

Figure 7-3 • Encoder switch

To replace the encoder switch:

1. To access the encoder switch, follow the disassembly instructions in Section 7.2.
2. Pull the control knob off the encoder shaft.
3. Disconnect the encoder harness from the back of the keyboard panel.
4. Remove the mounting nut and flat washer using a 14-mm wrench.
5. Gently pull the encoder switch from the keyboard panel.
6. Place a lock washer on the shaft of the new encoder switch.
7. Align the shaft of the new encoder switch with the hole in the front panel circuit board, push it through and place a flat washer on the encoder shaft.
8. Replace the mounting nut using a 14-mm wrench.
9. Replace the knob.
10. Assemble in reverse order.
11. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.4 Alarm speaker

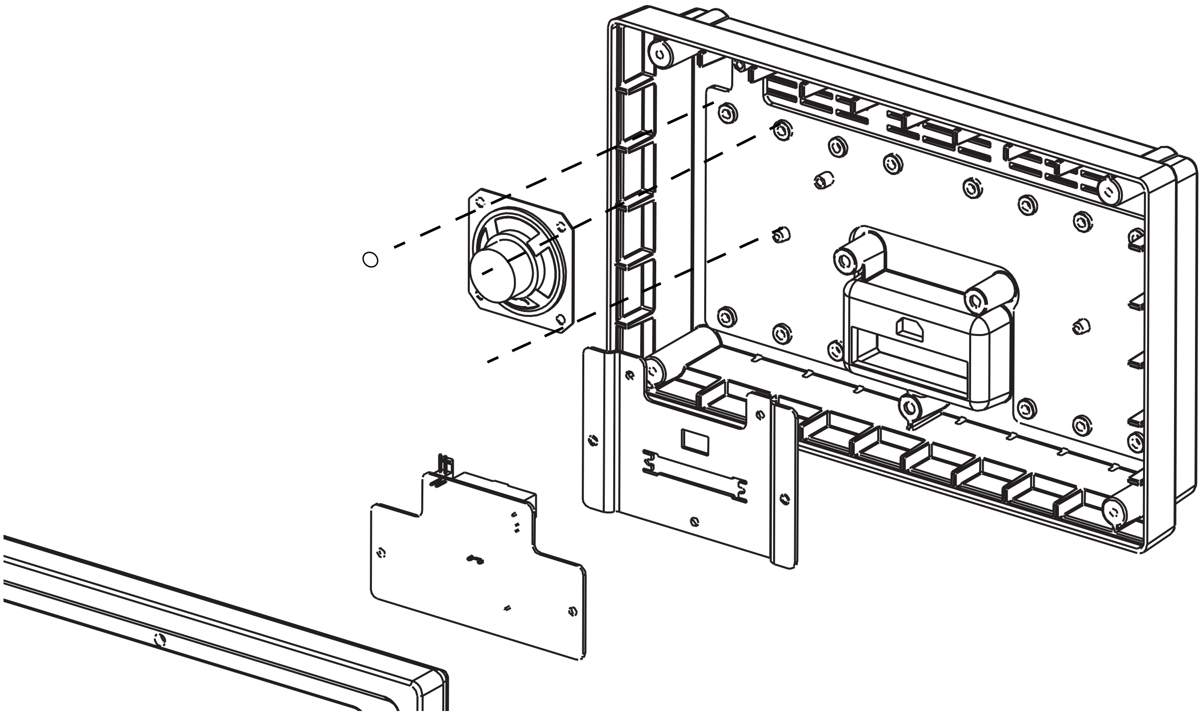


Figure 7-4 • Alarm speaker

To replace the alarm speaker:

1. To access the speaker, follow the disassembly instructions in Section 7.2.
2. Remove the two screws holding the alarm speaker to the housing.
3. Install the new alarm speaker using the previously removed screws.
4. Assemble in reverse order.
5. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.5 Access to electrical enclosure components

⚠ **WARNING** Disconnect the power cord from the outlet receptacle before attempting to remove or repair any circuit board to avoid shock hazard.

⚠ **WARNING** The AC inlet module is very heavy. Use caution when removing it from the anesthesia enclosure.

⚠ **CAUTION** Disconnect the internal battery before attempting to remove or repair any circuit board. Failure to do so may damage the internal electronics.

⚠ **CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

To remove the CPU board:

1. Disconnect the power cord from the outlet receptacle.
2. Remove the AC inlet module from the rear of the Aestiva Anesthesia Machine.
   - Loosen the two captive M4 screws.
   - Pulling on the two captive screws, cautiously slide the AC inlet module out only halfway from the enclosure. Use the two side handles (cutouts in the sheet metal) to lift out the AC inlet module from the enclosure.

⚠ **WARNING** The AC inlet module is very heavy. Use caution when removing it.

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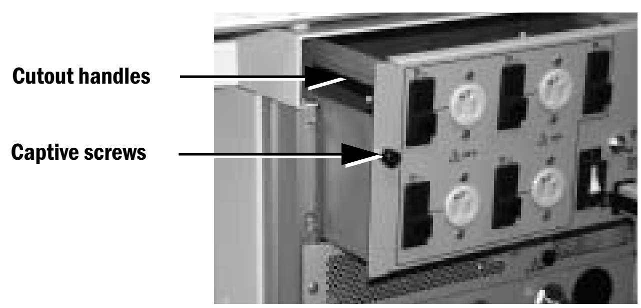
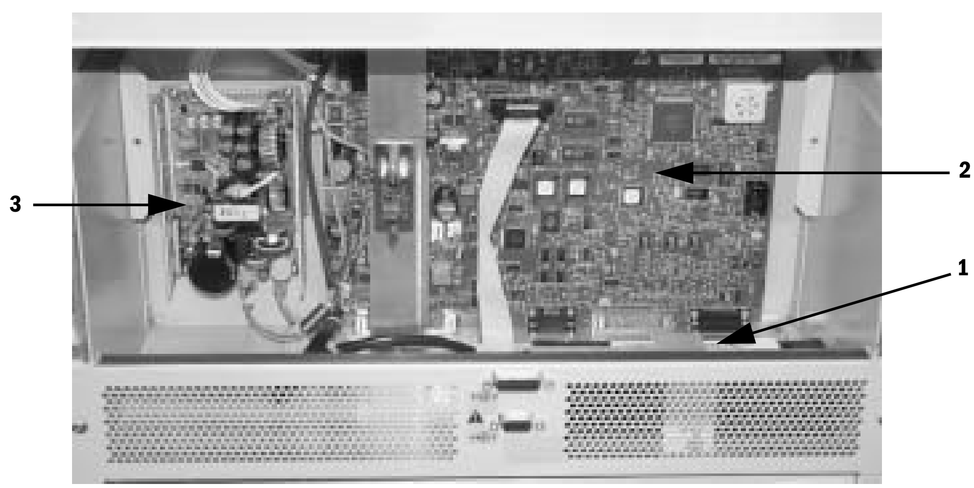


Figure 7-5 • AC Inlet module

3. Remove the cover of the electrical enclosure by removing the four Phillips head screws (two along top edge, one along each side).

1. **Battery**
2. **CPU board**
3. **Power supply board**
4. **Isolation transformer (toroid)**

Figure 7-6 • Electrical enclosure components (original CPU)



1. **Battery**
2. **Integrated CPU board**
3. **Power supply**

Figure 7-7 • Electrical enclosure components (integrated CPU)

7.5.1 CPU Board

To remove the CPU board, you must access the cable connections in the pneumatic enclosure.

⚠ **CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

1. Remove the machines rear panel (see Section 4 of the Aestiva Anesthesia Machine Service Manual).
2. Disconnect the four cable connectors from the bottom of the CPU board.

Note: For better accessibility to the cable connectors, remove the four mounting screws for the pneumatic manifold standoffs, pull the manifold out slightly and lower it. Front accessibility can be gained by removing the vaporizers and removing the panel beneath the vaporizer manifold.

3. Disconnect the battery cable.
   - For the original CPU, the battery cable is connected to the Power Supply board.
   - For the Integrated CPU, the battery cable is connected to the CPU board.
4. Disconnect the two interface ribbon cables (one cable for Integrated CPU) near the top of the board. The cable(s) go to the DB-9 and DB-15 connectors on the back of the machine.
5. For the original CPU, disconnect the power supply ribbon cable at the CPU board.

   For the Integrated CPU, disconnect the power supply cable at the top of the CPU board and (if applicable) the task light harness connector.
6. Remove the three hex nuts holding the circuit board plate to the floor of the electrical enclosure.

   For the Integrated CPU, also remove the bracket that holds the power inlet connector (hex nut at bottom, screw at top).
7. Remove the screws that hold the CPU board to the back plate of the electrical enclosure.
8. Lift and remove the board from the electrical enclosure.

Note: Reuse the old gasket to insure an O_2 tight seal.

9. Transfer the EEPROMs (U14 and U23) from the old board to the new board. (See *Section 7.5.2 Firmware replacement procedure* for information on safely handling the EEPROMs.)
10. Install the new board by following these instructions in reverse order.
11. Perform the CPU board tests found in Section 7.5.2.
12. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.5.2 Firmware replacement procedure

⚠ CAUTION The circuit board and EEPROMs are electrostatic sensitive. Use an approved static control workstation and wrist grounding strap.

13. Place the CPU board on an approved static control workstation.
14. Note the label and orientation of each EEPROM to ensure they are properly transferred to the replacement board.
15. Use a PLCC chip extraction tool to remove the two EEPROMs, U14 and U23. Insert the two prongs on the extractor tool into the slotted corners of the EEPROM socket.
16. Install the new EEPROMs, noting the label to ensure the correct chip is placed in the correct socket. Align the EEPROM notch with the socket notch and press the chip down firmly.

CPU board tests

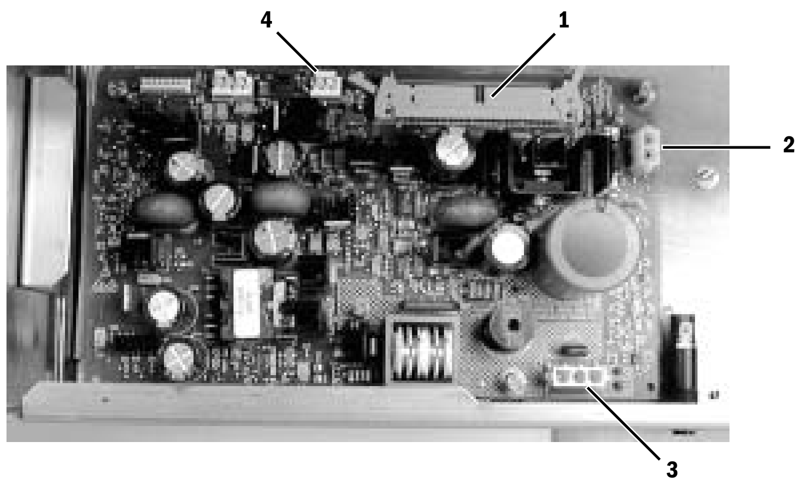
Whenever you replace the CPU board and/or the EEPROMs (U14 and U23), or perform the software upgrade, perform the following tests:

- Select the altitude (Section 4)*
- Select the drive gas (Section 4)*
- Cal O_2 Sensor (Section 4)
- Cal Flow Sensor (Section 4)
- Cal Pressure Sensitivity (Section 4)
- Cal Flow Valve (Section 4)
- Cal Bleed Resistor (Section 4)
- Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

* Even if these settings appear to be set correctly, they must be deliberately changed and set back to their proper setting.

7.5.3 Power supply board (for original CPU)

⚠ **CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.



1. **CPU cable connector**
2. **Battery cable connector**
3. **Toroid connector**
4. **Lighting cable connector**

Figure 7-8 • Power supply board (for original CPU)

1. Remove the AC inlet module and the electrical enclosure cover (Refer to section 7.5).
2. Disconnect the battery cable from the power supply board by pressing the lock tabs on either side of the connector and gently pulling on the connector.
3. Disconnect the 50-pin CPU ribbon cable between the CPU board and the power supply board by pulling out on the lock tabs on either side of the connector and gently pulling on the cable connector.
4. Disconnect the lighting cable by gently pulling on the connector.
5. Disconnect the connector from the toroid by pressing the lock tabs on either side and gently pulling on the connector.
6. Loosen the three captive screws at each corner of the power supply board.
7. Unlock the two Nylon retainers (on the corners of the board near the rear panel) by bending their tabs away from the board, and lift out the power supply board.
8. To install a new board, follow the removal instructions in reverse order.
9. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.5.4 Power supply (for Integrated CPU)

⚠ **CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

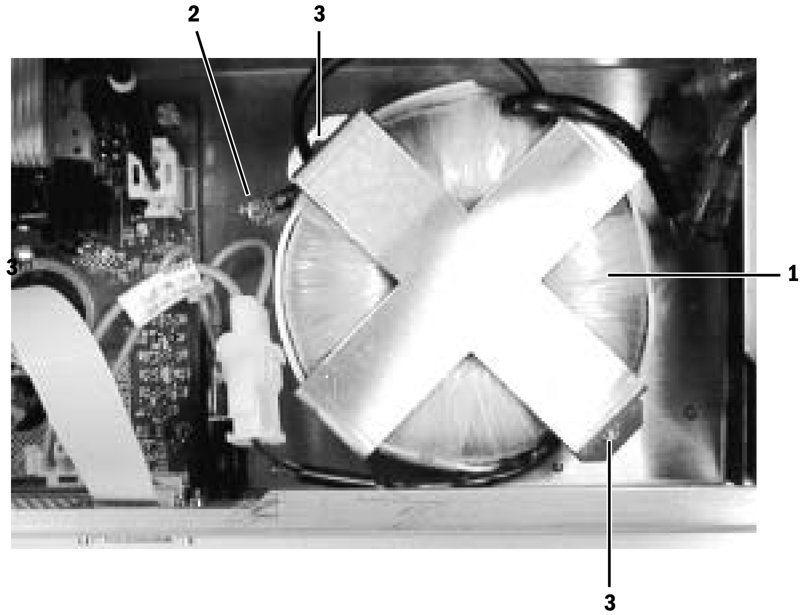
1. **Line power**
2. **Chassis ground**
3. **Power output**

Figure 7-9 • Power supply (for Integrated CPU)

1. Remove the AC inlet module and the electrical enclosure cover (Refer to section 7.5).
2. Disconnect the line power inlet connector and the ground wire at the bottom edge of the power supply.
3. Disconnect the power outlet connector at the top edge of the power supply.
4. Remove the two nuts that hold the power supply assembly to the back plate of the electrical enclosure.
5. Transfer the power supply mounting bracket to the new power supply.
6. To install a new power supply, follow the removal instructions in reverse order.
7. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.5.5 Toroid (original CPU only)

To remove the toroid, you must first remove the AC inlet module and the electronics compartment cover. The toroid is located in the electronics enclosure next to the power supply board.



1. **Toroid**
2. **Grounding lug**
3. **Mounting nuts**

Figure 7-10 • Isolation transformer (top view)

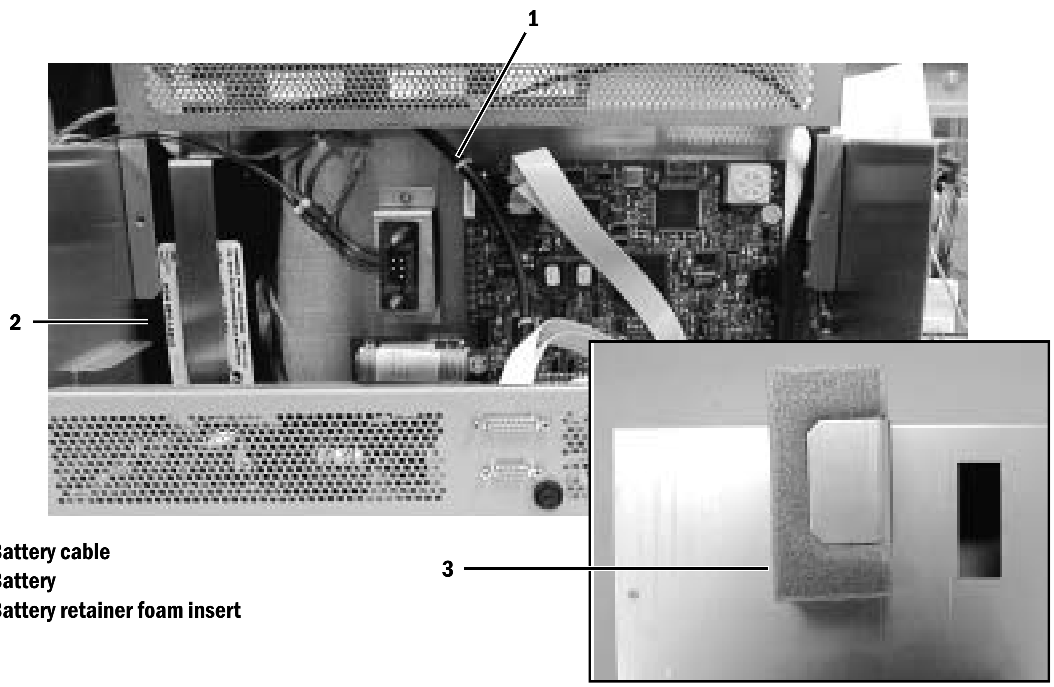
1. Remove the AC inlet module and the electrical enclosure cover (Refer to section 7.5).
2. Disconnect the battery cable from the power supply board by pressing the lock tabs on either side of the connector and gently pulling on the connector.
3. Disconnect the grounding lug using a 7-mm socket wrench.
4. Remove the two mounting nuts using a 7-mm socket wrench.
5. Remove the toroid.
6. Install a new toroid by following these instructions in reverse order and reconnecting like-colored connectors.
7. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.5.6 Battery

To remove the battery, you must first remove the AC inlet module and the electronics compartment cover.

Note Aestiva machines with the original CPU or with the Integrated CPU use the same battery. However, they are mounted differently.

- The battery for the original CPU is mounted on the back plate of the electrical enclosure. The enclosure cover includes a foam insert to keep the battery in place.
- The battery for the Integrated CPU is mounted on the floor of the electrical enclosure and does not require the foam insert on the enclosure cover.



1. **Battery cable**
2. **Battery**
3. **Battery retainer foam insert**

Figure 7-11 • Battery (original CPU shown)

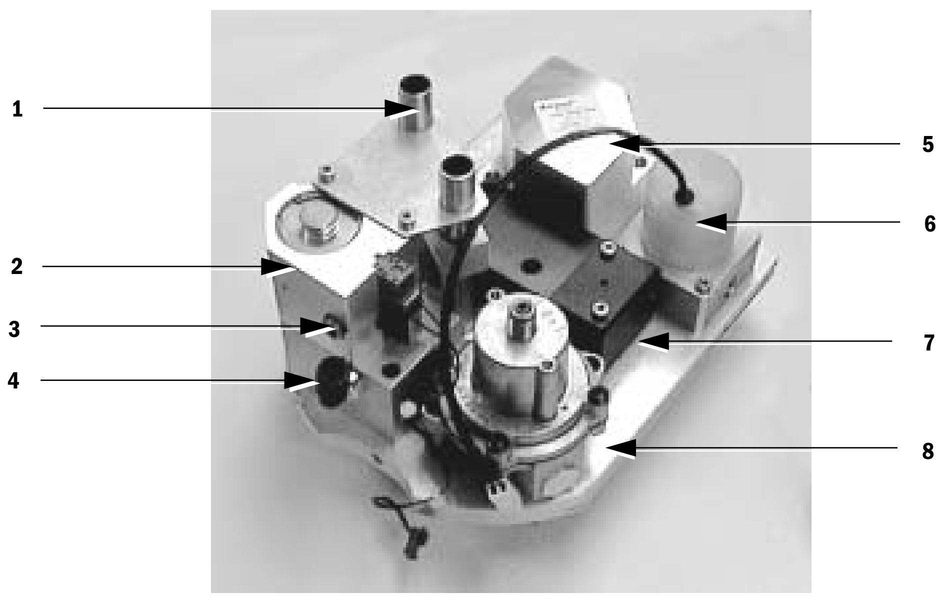
1. Remove the AC inlet module and the electrical enclosure cover (Refer to section 7.5).
2. Disconnect the battery cable by pressing the lock tabs on either side of the connector and gently pulling on the connector.
3. Remove the battery.
   - For original CPU machines, the battery is held in place with a metal strap (and the foam insert). Slide the battery to the right until it clears the strap and remove it.
   - For Integrated CPU machines, the battery is held in place with a formed bracket and the wall of the electrical enclosure. Remove the bracket to replace the battery.
4. Install a new battery by following these instructions in reverse order.
5. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.
6. Allow the battery to charge.

7.6 Vent Engine

The Vent Engine is located at the rear of the breathing system. As with the electronic circuit boards and the power module, each of the pneumatic subassemblies can be removed without having to remove other components.

The pneumatic subassemblies are:

- Gas inlet valve (GIV)
- Flow control valve
- Inlet filter
- Mechanical over pressure valve (MOPV)
- Non-relieving pressure regulator
- Free breathing valve
- Drive gas check valve



1. **Twin tube assembly**
2. **Gas Inlet Valve (GIV)**
3. **Lifter hex screw**
4. **Gas supply line**
5. **Drive gas check valve**
6. **Flow control valve**
7. **Mechanical overpressure relief valve (MOPV) — original style shown**
8. **Pressure regulator**

Figure 7-12 • Vent Engine

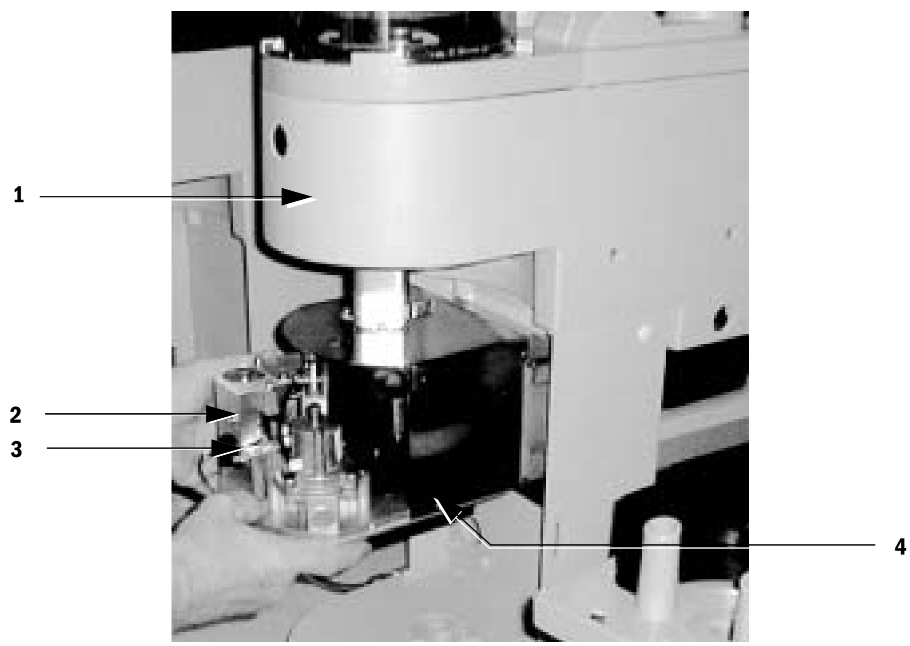
To remove the Vent Engine from the breathing system:

⚠ **CAUTION** Before servicing the Vent Engine you must turn the machine off, close the cylinder valves, disconnect the supply gases, and then bleed the pressure from the machine.

1. Loosen the thumbscrew and remove the rear cover of the breathing system.
2. Disconnect the supply gas line from the GIV fitting.
3. Disconnect the GIV and flow valve cables from the connector board at the top of the housing.
4. Loosen the two screws on both sides of the manifold plate. The manifold plate is grooved to allow the pneumatic assembly to slide into place.
5. Turn the lifter hex screw on the GIV to lower the double tube assembly clear of the exhalation valve interface cuff.
6. Slide the Vent Engine out of the breathing system frame and place on a work surface.

Note Newer Vent Engines include a spring on the inside tube to keep the tube assembly engaged with the interface cuff (Refer to section 8.7.6). Push down on the tube crossbar to disengage the tube assembly from the interface cuff before removing the Vent Engine.

7. To install the Vent Engine, perform these steps in reverse order.
8. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

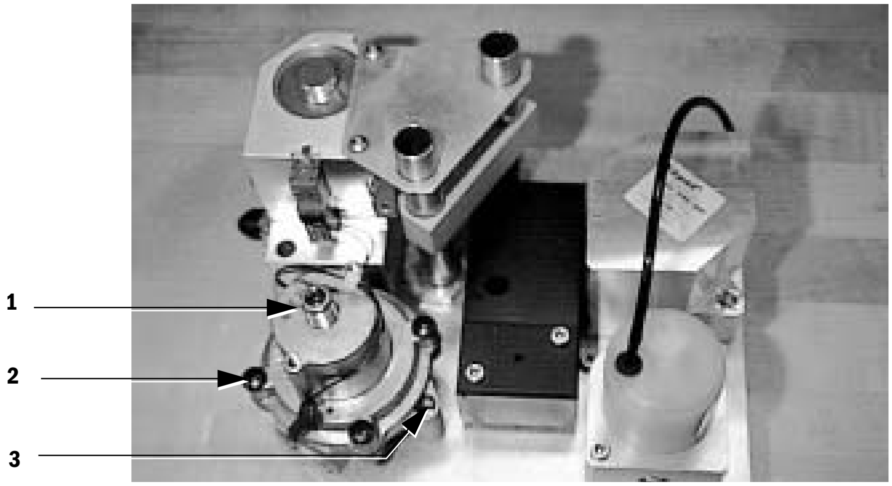


1. **Breathing system housing (rear)**
2. **Lever Screw**
3. **Vent Engine**
4. **Mounting screws**

Figure 7-13 • Vent Engine removal

7.7 Non-relieving regulator

The regulator is replaced as an assembly.



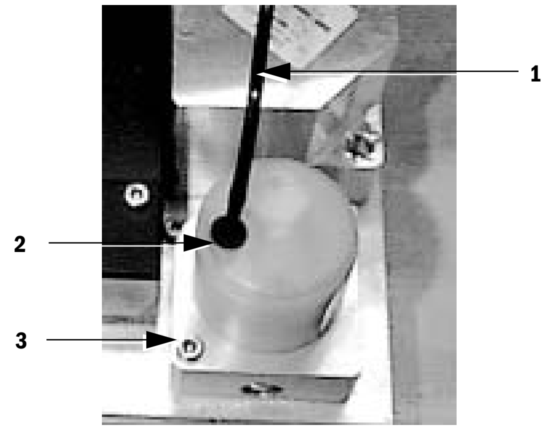
1. **Non-relieving regulator**
2. **Phillips head screws**
3. **Captive regulator mounting screws**

Figure 7-14 • Non-relieving regulator

To remove the non-relieving regulator:

1. Follow the instructions in Section 7.6 to remove the Vent Engine.
2. Do not remove the Phillips head screws (4) that hold the regulator together. Use a 3 mm hex wrench to loosen the two captive mounting screws.
3. Lift the regulator from the Vent Engine manifold.
4. Inspect seat and O-rings for damage. Replace as necessary before replacing the regulator.
5. Replace the regulator by following these instructions in reverse order.
6. Perform the regulator calibration procedure in Section 4.
7. Install the Vent Engine by following the steps in Section 7.6 in reverse order.
8. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.8 Flow control valve



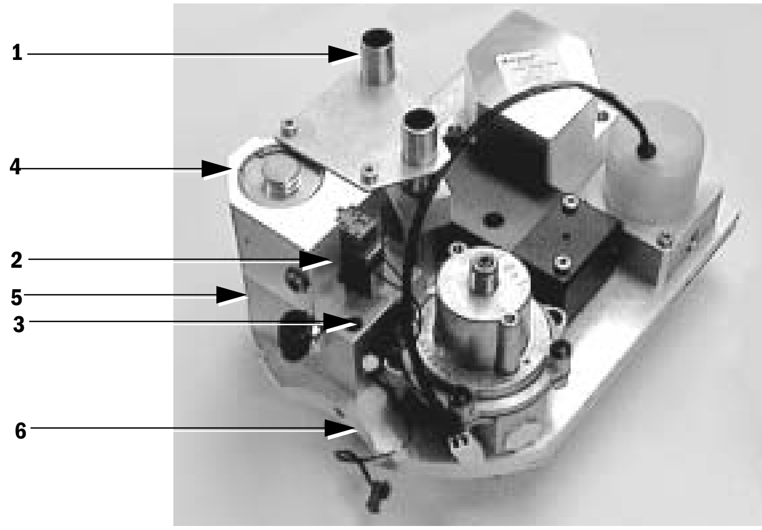
1. **Flow control valve cable**
2. **Flow control valve**
3. **Captive mounting screws (2)**

Figure 7-15 • Flow control valve

To service/replace the flow control valve:

1. Follow the instructions in Section 7.6 to remove the Vent Engine.
2. Use a 3 mm hex wrench to loosen the two captive mounting screws and lift out the flow control valve.
3. Examine the seat and two O-rings for damage.
   Replace as necessary.
4. Reinstall the flow control valve by following these instructions in reverse order.
5. Perform the flow valve test in Section 4.
6. Install the pneumatic assembly by following the steps in Section 7.6 in reverse order.
7. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.9 Gas inlet valve



1. **Tube guide plate**
2. **GIV solenoid switch**
3. **Captive mounting screws (2)**
4. **GIV**
5. **Inlet filter housing**
6. **Manifold plate**

Figure 7-16 • Gas Inlet Valve (GIV)

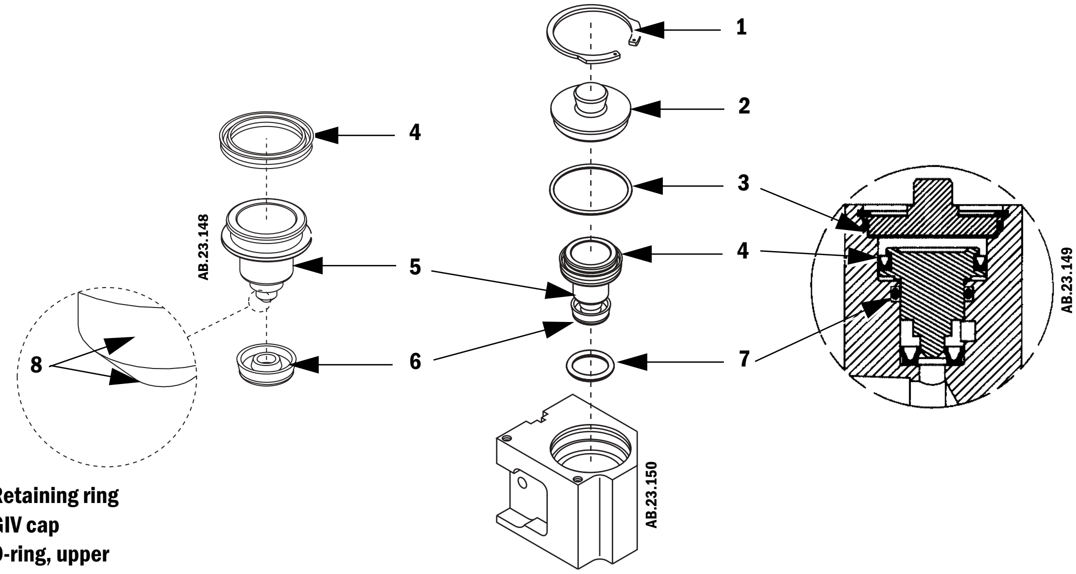
Follow the instructions in Section 7.6 to remove the Vent Engine.

To remove the solenoid switch:

1. Use a 1.5 mm hex wrench to remove the mounting screws from the GIV solenoid switch on the inlet valve.

To replace the gas inlet valve:

1. Remove the tube guide plate from the top of the GIV.
2. Remove the inlet filter underneath the manifold plate.
3. Use a 3 mm hex wrench to loosen the two captive inlet valve mounting screws.
4. Remove the GIV/inlet filter housing assembly.
5. To separate the GIV from the inlet filter housing, remove the two mounting screws from within the filter housing.
6. Examine the valve seat and O-rings in the manifold for damage. Replace as necessary.
7. Reassemble in reverse order.
8. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.



1. **Retaining ring**
2. **GIV cap**
3. **O-ring, upper**
4. **Upper U-cup seal**
5. **Shuttle**
6. **Lower U-cup seal**
7. **O-ring, lower**
8. **Apply KRYTOX**

Figure 7-17 • Gas inlet valve

To service the gas inlet valve (GIV):

Note: You can service the gas inlet valve without removing it from the Vent Engine.

1. Remove the tube guide plate from the top of the GIV.
2. Remove retaining ring and GIV cap.
3. Remove the shuttle and replace the lower O-ring and the lower U-cup seal. Lubricate the seal lightly with KRYTOX.

Note Use pneumatic pressure to remove the shuttle. Cover the shuttle with a soft cloth and apply pressure (connect the drive gas hose or use pipeline pressure) through the drive gas inlet.

4. Reinstall the shuttle and upper U-cup seal.
5. Reinstall and lubricate upper O-ring lightly with KRYTOX.
6. Reinstall inlet valve cap.
7. Install the retaining ring flat side out (away from the valve).
8. Reassemble in reverse order.
9. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

7.10 Mechanical Overpressure Valve (MOPV assembly)

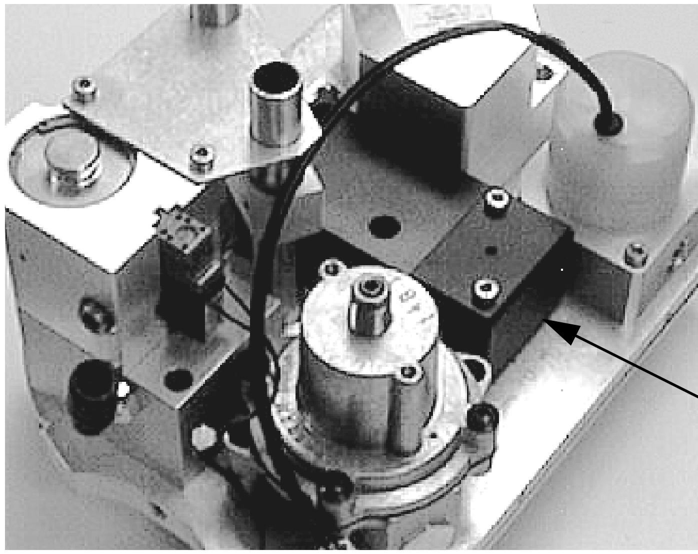


Figure 7-18 • Mechanical Overpressure Valve

Follow the instructions in Section 7.6 to remove the Vent Engine.

Note The MOPV housing for the Aestiva 7900 Ventilator has changed. The original housing, which was rectangular-shaped with a separate cover, has been replace by a one-piece molded housing.

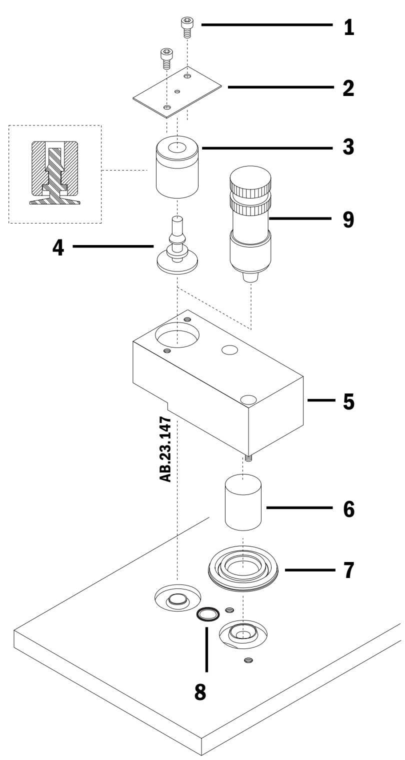
The molded housing is available in a kit that includes installation instructions (Refer to section 8.7.2). The alignment tool that was used with the original housing is no longer required with the molded housing.

7.10.1 To service the original MOPV assembly:

Note: Refer to Figure 7-19 for the following steps.

1. Remove the two cover screws and cover.
2. Remove the over pressure weight and seal assembly.
3. Replace the seal of the over pressure weight.
4. Remove the two screws holding the MOPV housing to the manifold plate and remove the MOPV housing.
5. Remove the differential pressure weight and diaphram.
6. Replace the o-ring over the center hole in the plate.
7. Replace the diaphram and differential pressure weight in the MOPV housing. The diaphram should be flush with the MOPV housing when properly installed.

8. Slide the MOPV housing into position, making sure the diaphram and o-ring remain in place.
9. Loosely replace the screws holding the MOPV housing to the plate.
10. Put the alignment tool through the over pressure relief valve opening until it seats in the plate.
11. Tighten the screws holding the MOPV housing to the plate.
12. Remove the alignment tool.
13. Replace the over pressure weight and diaphram assembly.
14. Replace the cover and screws.
15. Install the Vent Engine by following the steps in Section 7.6 in reverse order.
16. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.



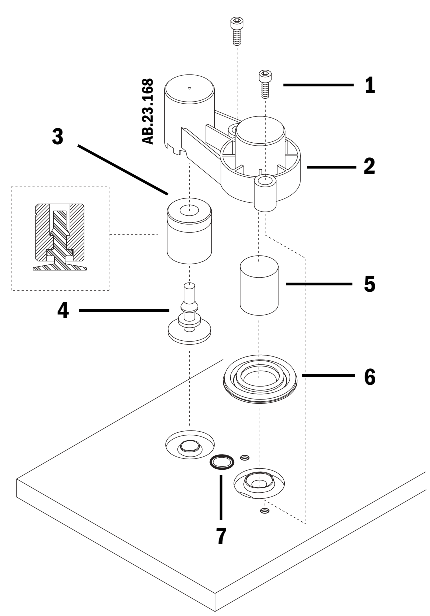
1. **Cover Screws**
2. **Cover**
3. **Over pressure weight**
4. **Seal, over pressure**
5. **Housing**
6. **Differential pressure weight**
7. **Diaphram, differential pressure**
8. **O-ring**
9. **Alignment tool**

Figure 7-19 • Mechanical Overpressure Valve, original housing

7.10.2 To service the MOPV assembly with the molded housing:

Note: Refer to Figure 7-20 for the following steps.

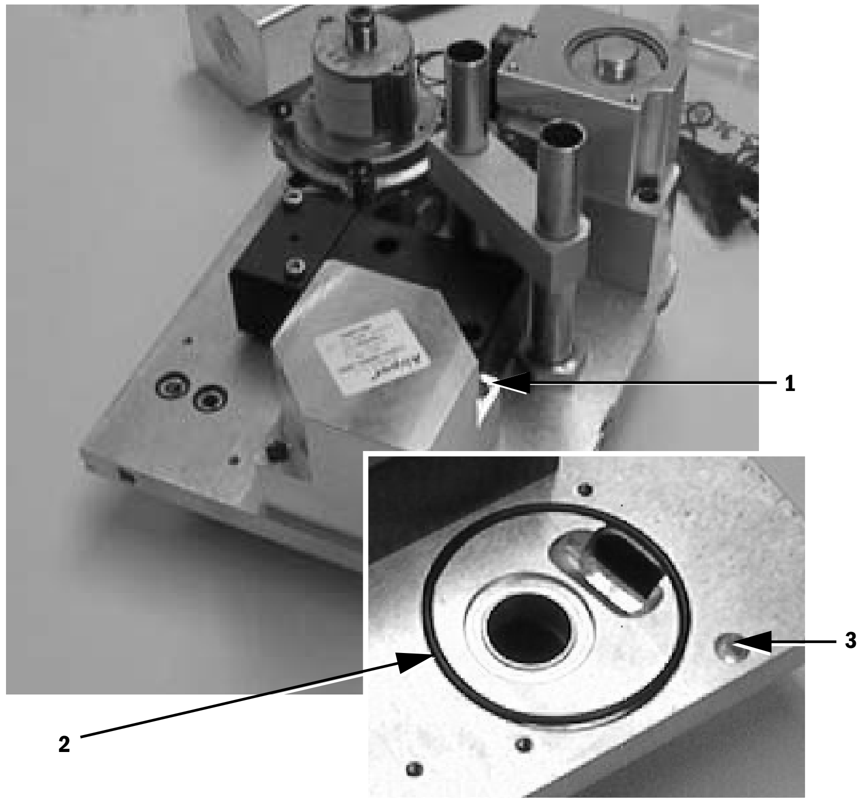
1. Remove the two screws and lift off the housing.
2. Remove the over pressure weight and seal assembly.
3. Replace the seal of the over pressure weight.
4. Remove the differential pressure weight and diaphram.
5. Replace the o-ring over the center hole in the plate.
6. Place the diaphragm (item 6) and the differential-pressure weight (item 5) over the corresponding seat in the manifold plate.
7. Place the over-pressure weight and seal assembly (items 3 and 4) over the corresponding seat in the manifold plate.
8. Place the molded housing over the weights so that the locating tabs are within the recess of the manifold plate and that it lies flat against the manifold plate. **Important:** Ensure that the diaphragm (item 6) is not pinched by the housing.
9. Start both housing mounting screws in the threaded holes.
10. Ensure that the locating tabs are still positioned in the recess of the manifold plate and that the diaphragm is not pinched, and then, tighten the mounting screws.
11. Install the Vent Engine by following the steps in Section 7.6 in reverse order.
12. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.



1. **Housing Screws**
2. **Housing**
3. **Over pressure weight**
4. **Seal, over pressure**
5. **Differential pressure weight**
6. **Diaphram, differential pressure**
7. **O-ring**

Figure 7-20 • Mechanical Overpressure Valve, molded housing

7.11 Drive gas check valve assembly



1. **Captive mounting screws**
2. **O-ring**
3. **Alignment hole**

Figure 7-21 • Drive gas check valve

⚠ **Caution** The internal components of the Drive Gas Check Valve are precisely positioned. Do not attempt to remove or reposition the glass sleeve or piston assembly

1. Follow the instructions in Section 7.6 to remove the Vent Engine.
2. Use a 3 mm hex wrench to loosen the drive gas check valve captive mounting screws.
3. Lift out the valve assembly.
4. Inspect the O-ring and valve seat for damage. Replace as necessary.
5. Reinstall the valve by aligning the check valve pin into the alignment hole.
6. Tighten the captive screws.
7. Install the Vent Engine by following the steps in Section 7.6 in reverse order.
8. Perform the Checkout Procedure found in Section 3 of the Aestiva Anesthesia Machine Service Manual.

Notes

8 Illustrated Parts

In this section This section contains assembly illustrations for easier identification of parts as they are disassembled. Aestiva 7900 Ventilator components are located throughout the Aestiva Anesthesia System.

8.1 Special instructions

Apply a thin coat of oxygen-use-approved lubricant to o-rings prior to installation (unless otherwise noted). Use:

- KRYTOX™ GPL 205,
  Datex-Ohmeda stock number 1001-3854-000

Some screws (as noted) require an anti-loosening bond. Use:

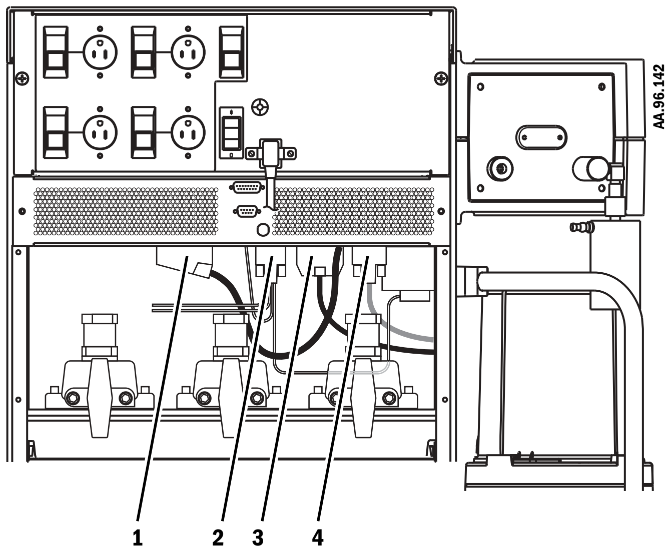
- Loctite #24231, screw lock,
  Datex-Ohmeda stock number 0220-5016-300

When you replace fittings, position the barb end in the same direction as the original fitting to make hose connections easier.

8.2 Service tools

Tool	**Stock Number**
Software Update Kit Using PC, Aestiva (does not include ventilator software)	1006-8376-000
Cable, PC, Software Update, Aestiva (included in update kit 1006-8376-000)	1006-3900-000
Software Media, 3.5" disk, Aestiva	Call Technical Support
Power Jumper Cable (provides power to ventilator with outlet box removed from machine)	1006-4014-000
MOPV alignment tool (included with MOPV elastomers service kit 1503-8017-000)	1503-3124-000

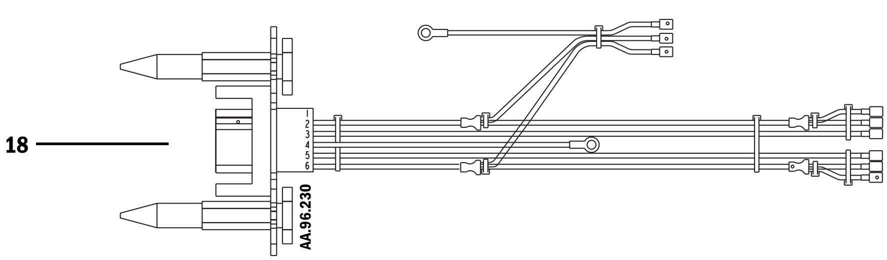
8.3 Ventilator Harnesses

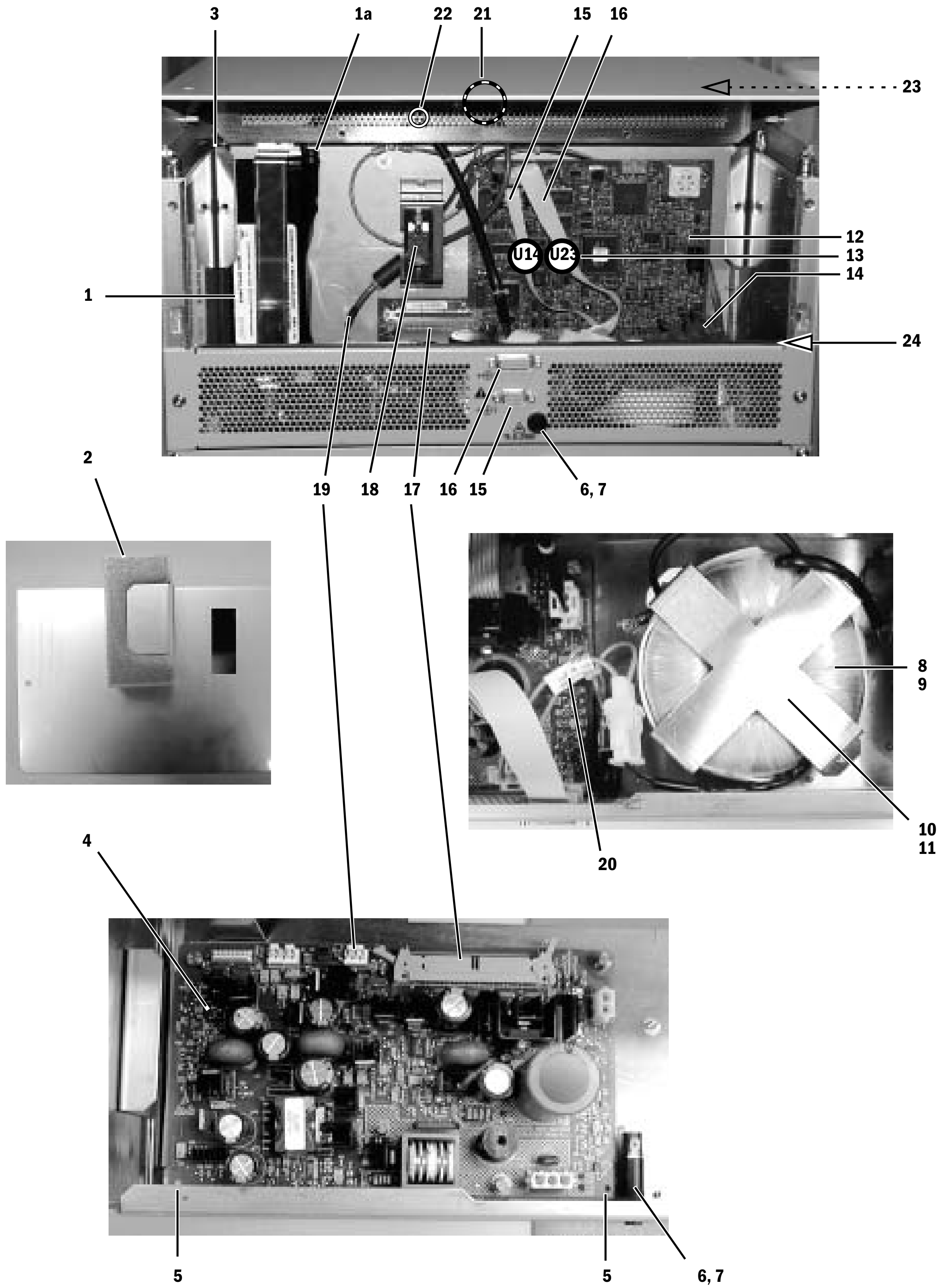


Item	Description	Stock Number
1	Harness, Kit CPU Board to display, (for display arm or folding mount)	1006-8056-000
	- Cover (slotted), display connector - Washer, rectangular - Screw, M3x6 SST - Lockwasher, M3	1006-1326 -000 1006-4287-000 9211-0430-063 9213-0430-003
2	Harness, CPU Board to System Switch and O_2 Flush Switch	1006-3707-000
3	Harness, CPU Board to Sensor Interface Board (SIB)	1006-3700-000
4	Harness, CPU Board to Pneumatic Connection Board (Vent Engine)	1006-3706-000

8.4 Electrical enclosure parts (original CPU)

Item	Description	Stock Number
1	Battery pack	1503-3045-000
1a	Fuse, battery, 4A 5x20 time delay	1503-3074-000
2	Battery support foam	1503-3021-000
3	Strip pad, battery	1006-1496-000
4	PCB, power supply, Service	1006-8394-000
5	PCB retainer/support, Nylon, (support 2 corners of power supply PCB	1006-3562-000
6	Fuse holder, rear panel	1001-3933-000
7	Fuse, 6.3A 5x20 time delay, rear panel	1202-3857-000
8	Toroid	1605-3015-000
9	Pad, vent toroid	1006-1497-000
10	Toroid hold-down bracket	1006-5113-000
11	Strip pad, toroid hold-down (cut to 1/2 length)	1006-1496-000
12	PCB, CPU (original - non integrated), Service (without EPROMS)	1006-8389-000
13	EPROM Kit, U14 and U23, Aestiva	Call Technical Support
14	Gasket, O_2 seal for CPU board (mounts under CPU bracket)	1006-5117-000
15	Ribbon cable, DB9 to CPU	1006-3702-000
16	Ribbon cable, DB25 to CPU	1006-3703-000
17	Harness, vent CPU to power supply	1006-3705-000
18	Harness, from AC input to toroid (includes connector, also goes to Tec 6 outlet)	1006-3795-000
19	Harness, to light strip	1006-3802-000
20	Harness, fuse to power supply PCB	1006-3794-000
21	Bushing, snap-in (cable grommet)	0208-0854-300
22	Twist lock (for securing cables)	1006-3564-000
23	Seal, conductive (adhesive backed), vent enclosure to top of machine	1006-1498-000
24	Seal, conductive (adhesive backed), vent enclosure to rear panel	1006-1525-000
25	Bracket, foam block support Screw, M3x6 Lockwasher, M3	1006-5111-000 9211-0430-063 9213-0430-003
26	Cover, electrical enclosure	1006-5110-000

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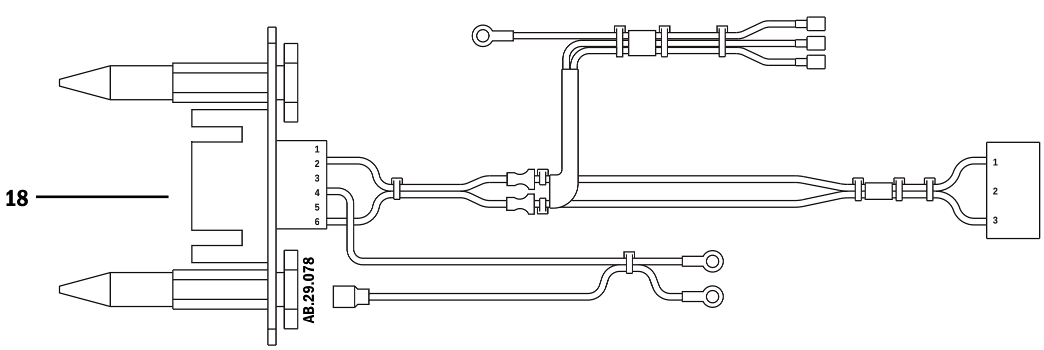
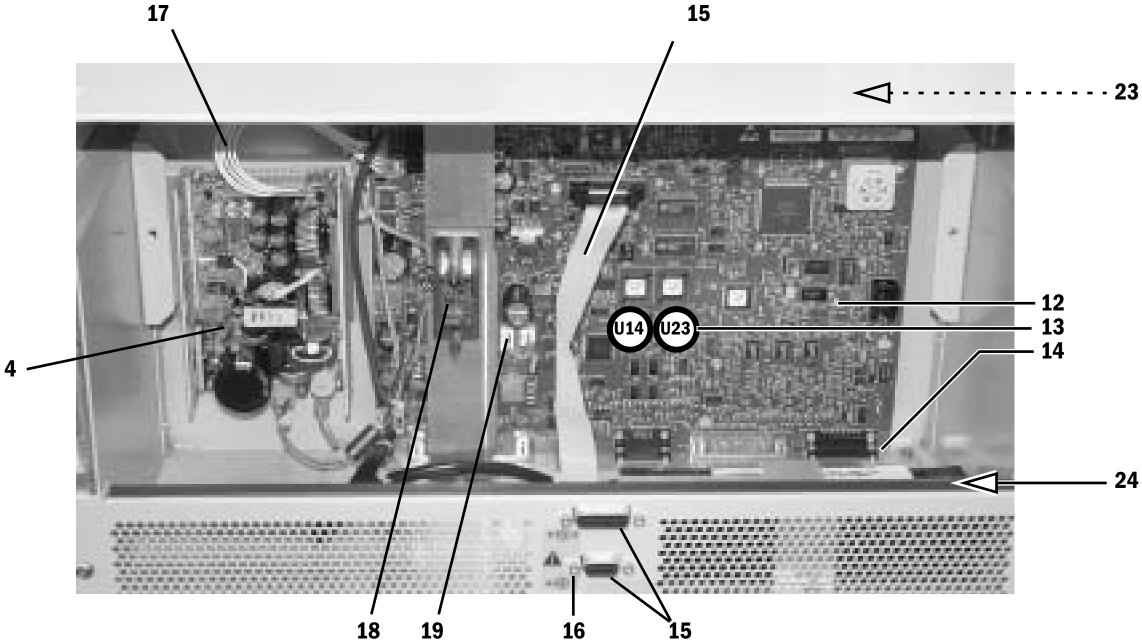
8.5 Electrical enclosure parts (integrated CPU)

Item	Description	Stock Number
1	Battery pack	1503-3045-000
1a	Fuse, battery, 4A 5x20 time delay	1503-3074-000
4	Power supply, Service	1006-4258-000
5	PCB retainer/support, Nylon, (support 2 corners of power supply PCB	1006-3562-000
12	PCB, CPU (integrated), Service (without EPROMS)	1006-8285-000
13	EPROM Kit, U14 and U23, Aestiva	Call Technical Support
14	Gasket, O_2 seal for CPU board (mounts under CPU bracket)	1006-5117-000
15	Ribbon cable, Serial/Serial Download, CPU to DB9 and DB25	1006-4260-000
16*	Standoff, #4-40 DSUB	1202-3092-000
17	Harness, power supply to CPU	1006-4261-000
18	Harness, from AC input to power supply (also goes to Tec 6 outlet)	1006-4259-000
19	Harness, from J201 of CPU to light strip	1006-3802-000
20	Cover, electrical enclosure	1006-4299-000
21	Bushing, snap-in (cable grommet)	0208-0854-300
22	Twist lock (for securing cables)	1006-3564-000
23	Seal, conductive (adhesive backed), vent enclosure to top of machine	1006-1498-000
24	Seal, conductive (adhesive backed), vent enclosure to rear panel	1006-1525-000

* Apply Loctite 242

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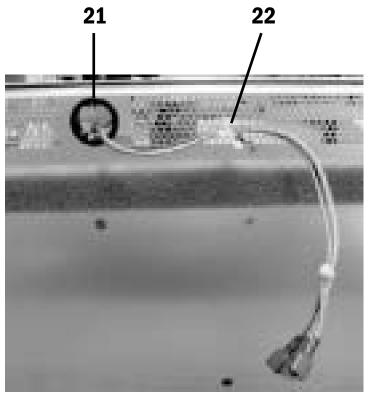
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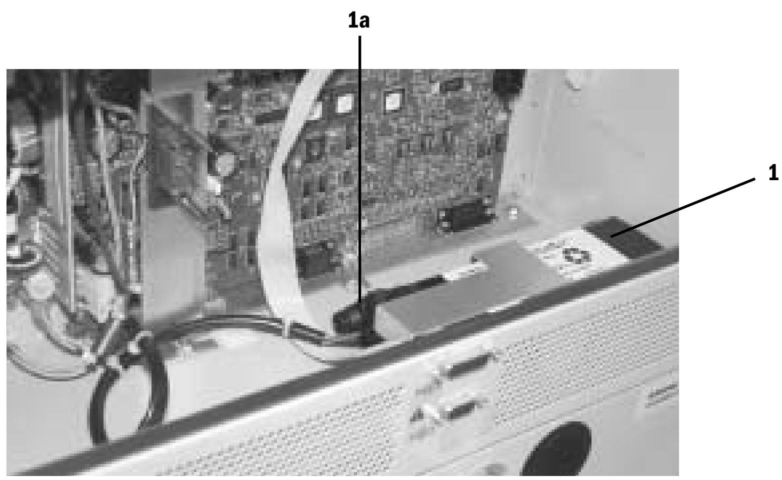
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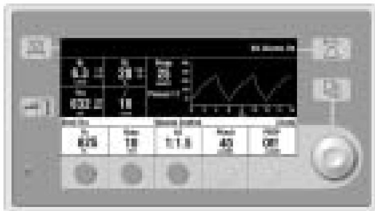
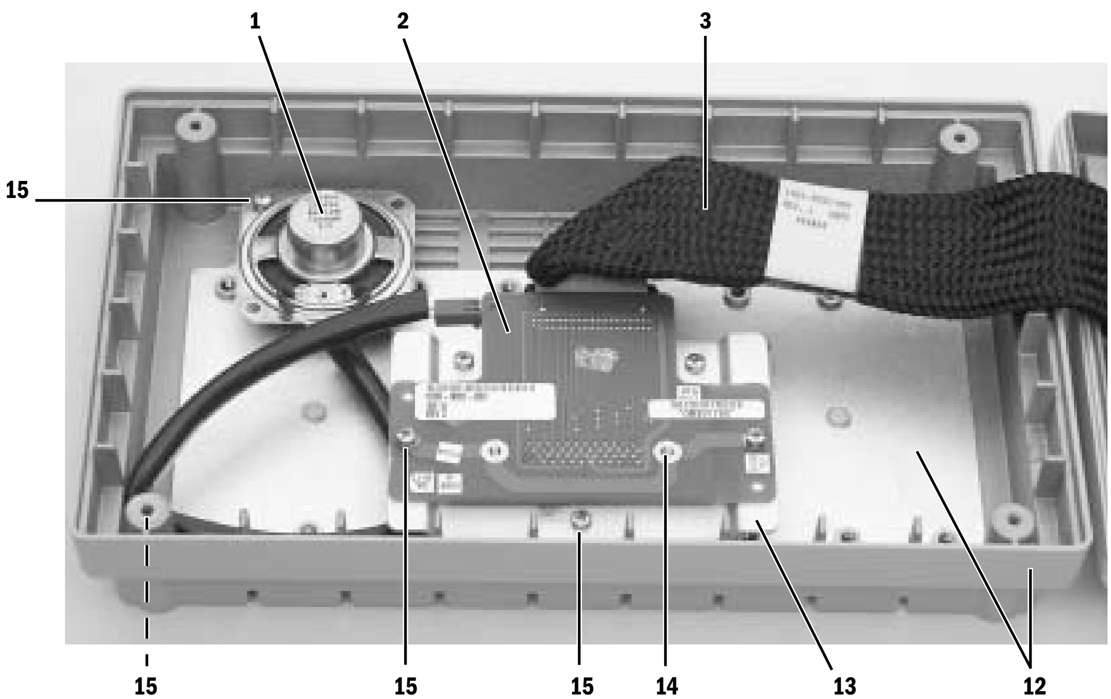
8.6 Display Module



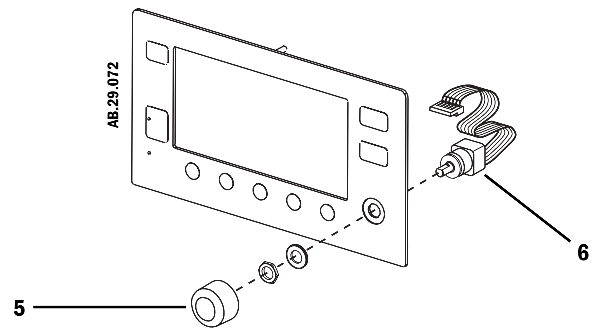
		Stock Number
	Aestiva 7900 Display, complete assembly	1006-8020-000

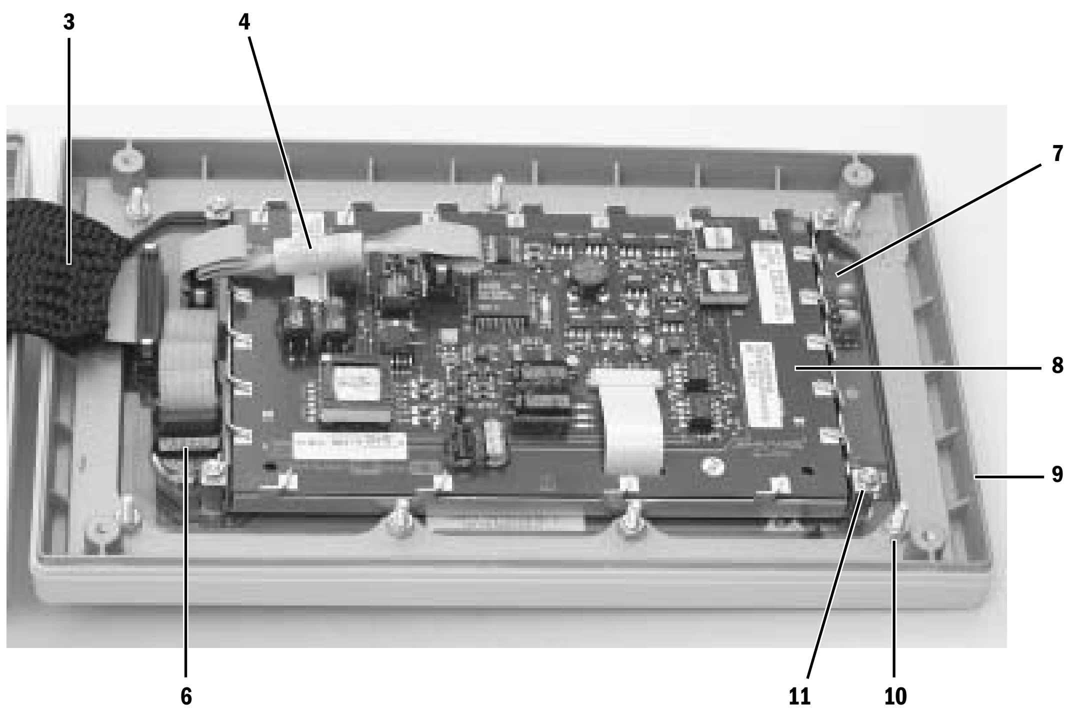
8.6.1 Rear housing parts



Item	Description	Stock Number
1	Speaker assembly, with leads	1503-3106-000
2	Connector board	1006-3682-000
3	Harness, connector board to front panel board (50 pin)	1503-3052-000
12	Rear housing, vent control display	1006-1242-000
13	Bracket, connector board mount	1006-1322-000
14	Screw, 2-56 x 5/16 PAN PH HD SST, rear panel DB connector (2)	0140-6110-105
15	Screw, M3 x 8 Sems (11)	0140-6219-130

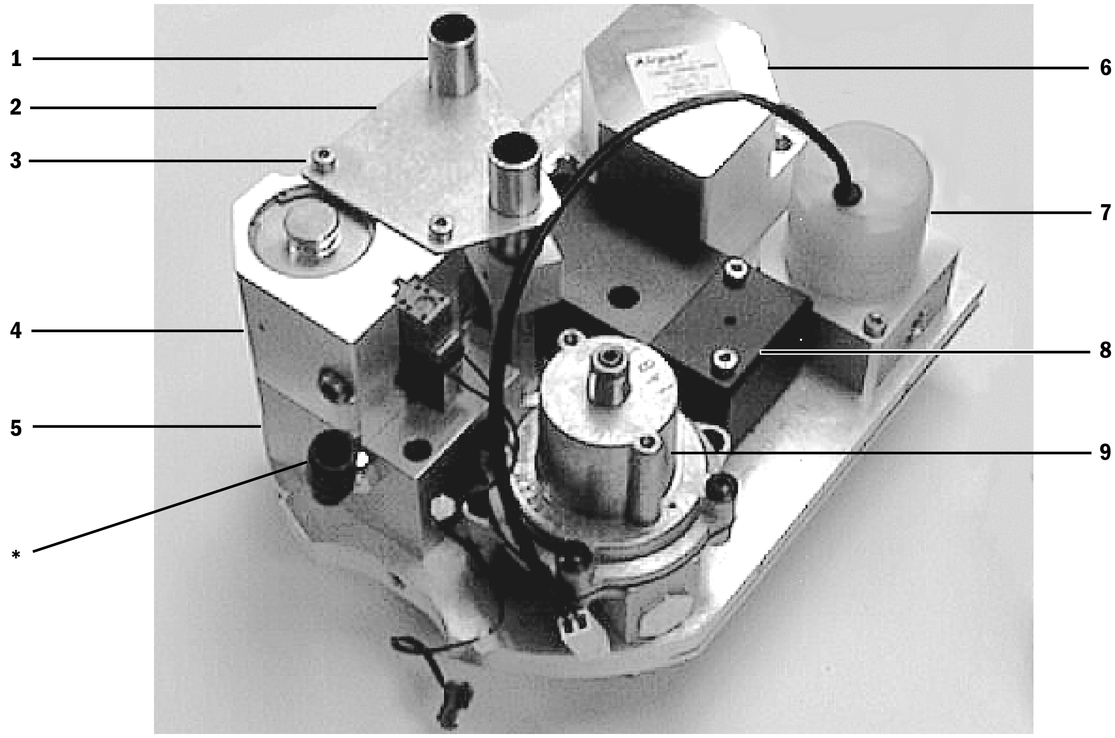
8.6.2 Front housing parts





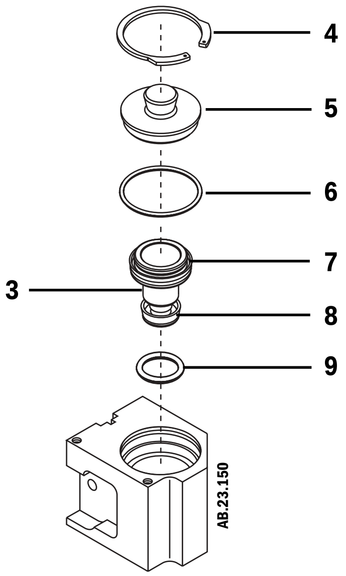
Item	Description	Stock Number
3	Harness, connector board to front panel board (50 pin)	1503-3052-000
4	Harness, display-keyboard with ferrite (20 pin)	1605-3072-000
5	Knob, soft touch, teal green	1006-4622-000
6	Rotary encoder, with cable and mounting hardware	1503-3012-000
7	Keyboard, front panel vent control display	1006-1325-000
8	EL display	1503-8010-000
9	Front housing, vent control display	1006-1241-000
10	Nut, Keps M4, keyboard/display mount (7)	0144-3717-314
11	Nut, Keps M3, display mount (4)	0144-3717-302

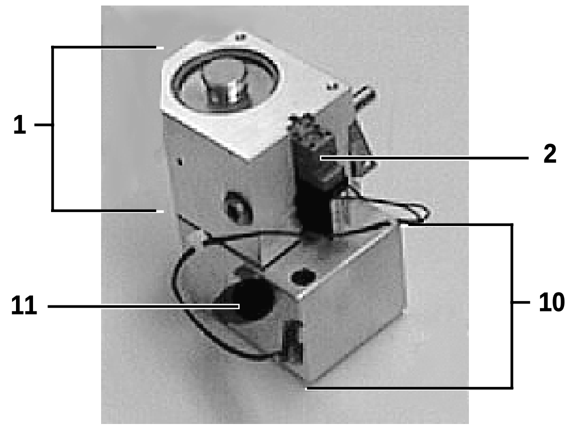
8.7 Aestiva 7900 Vent Engine



Item	Description	Stock Number
	Vent Engine Assembly, Service	1503-8101-000
1	Tube and collar assembly	Refer to section 8.7.6
2	Plate, Tube Guide	1503-3226-000
3	Screw	9211-0640-083
4	Gas inlet valve, GIV	Refer to section 8.7.1
5	Filter housing assembly, complete with elbow	Refer to section 8.7.1
6	Drive gas check valve	1503-3006-000
	O-ring under drive gas check	1503-3213-000
7	Flow control valve (HSC) BCG	1503-3218-000
	O-ring under flow control valve (2 each)	1503-3056-000
8	Mechanical Over Pressure Valve, MOPV (original style shown)	Refer to section 8.7.2
9	Regulator 172 KPA BCG	1504-3623-000
Not Shown		
	Hardware for securing Vent Engine to housing	
	Screw, M4x8 BT SKT HD (4)	0140-6226-118
	Lockwasher, M4 internal (4)	0144-1118-128
	* Drive Gas Hose Assembly	1503-3219-000

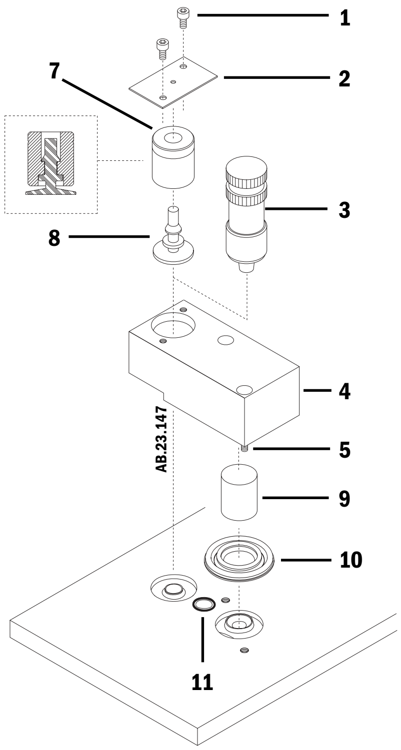
8.7.1 Gas Inlet Valve

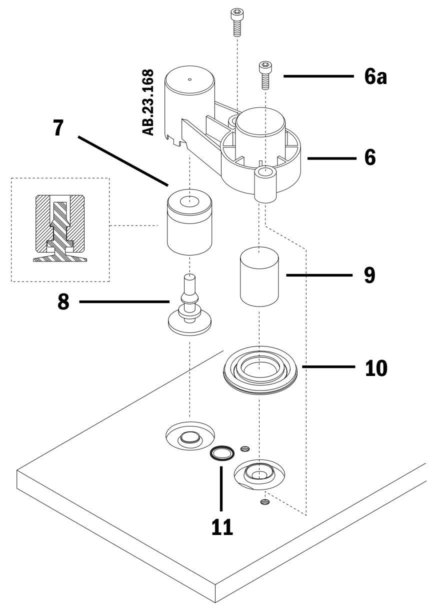




Item	Description	Stock Number
1	Gas Inlet Valve, assembly, complete with solenoid	1503-8111-000
2	Solenoid, 3-way NO (with mounting screw)	1503-3088-000
3	Shuttle, inlet valve	1503-5018-000
4	Retaining ring, 34.9 mm	1500-3158-000
5	Cap, inlet valve	1503-5006-000
6	O-ring, upper Viton	9221-3032-116
7	U-cup, upper EDPM (fits on shuttle valve)	1503-3090-000
8	U-cup, lower Viton (fits on shuttle valve)	1503-3089-000
9	O-ring, lower Viton	1503-3108-000
10	Filter housing assembly, complete with elbow	1503-8113-000
11	Elbow, 8mm tube	1006-3535-000
Not shown		
	O-rings on bottom of assembly (2)	1503-3056-000
	Screw, M4x20, filter housing to inlet valve (2)	0144-2124-218
	Screw, M4x20, inlet valve assembly to manifold (2)	0144-2124-218

8.7.2 Mechanical Over Pressure Valve (MOPV)



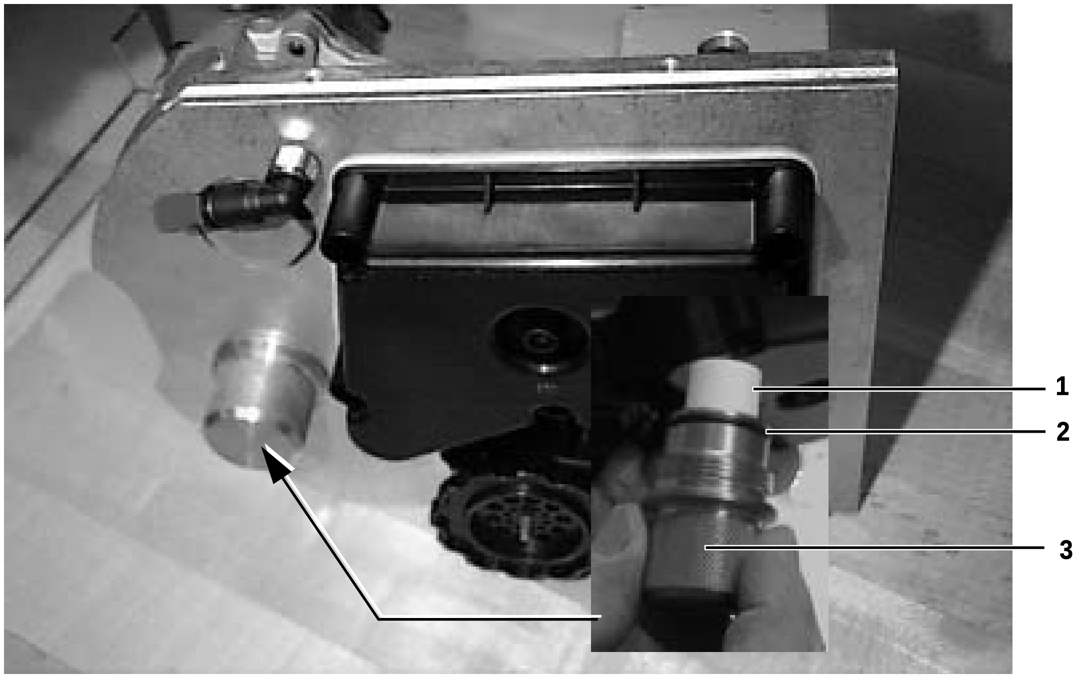


Item	Description	Stock Number
1	Screws M4 x 0.7 8mm	9211-0640-083
2	MOPV Cover	--------------------
3*	Alignment tool	1503-3124-000
4	Housing, machined, MOPV	--------------------
5	Screw M4 x 20	1503-3105-000
6**	Housing, molded, MOPV (kit includes housing and mounting screws)	1503-8124-000
	Housing, molded	--------------------
6a	Screw, M4x12 SKT HD CAP (2)	1102-3006-000
7	Weight, mechanical overpressure valve	1503-5015-000
8*	Seal, mechanical overpressure valve	1503-3016-000
9*	Weight, MOPV differential,	1503-5014-000
10*	Diaphragm, MOPV	1503-3025-000
11*	O-ring under MOPV assembly	1503-3056-000

* MOPV Elastomers Service Kit, 1503-8017-000, includes items 8 through 11 and an alignment tool (item 3).
* The alignment tool must be used when replacing seals in MOPV with machined acetal plastic housing.
* When replacing the diaphragm (item 10), the differential weight (item 9) must also be replaced.

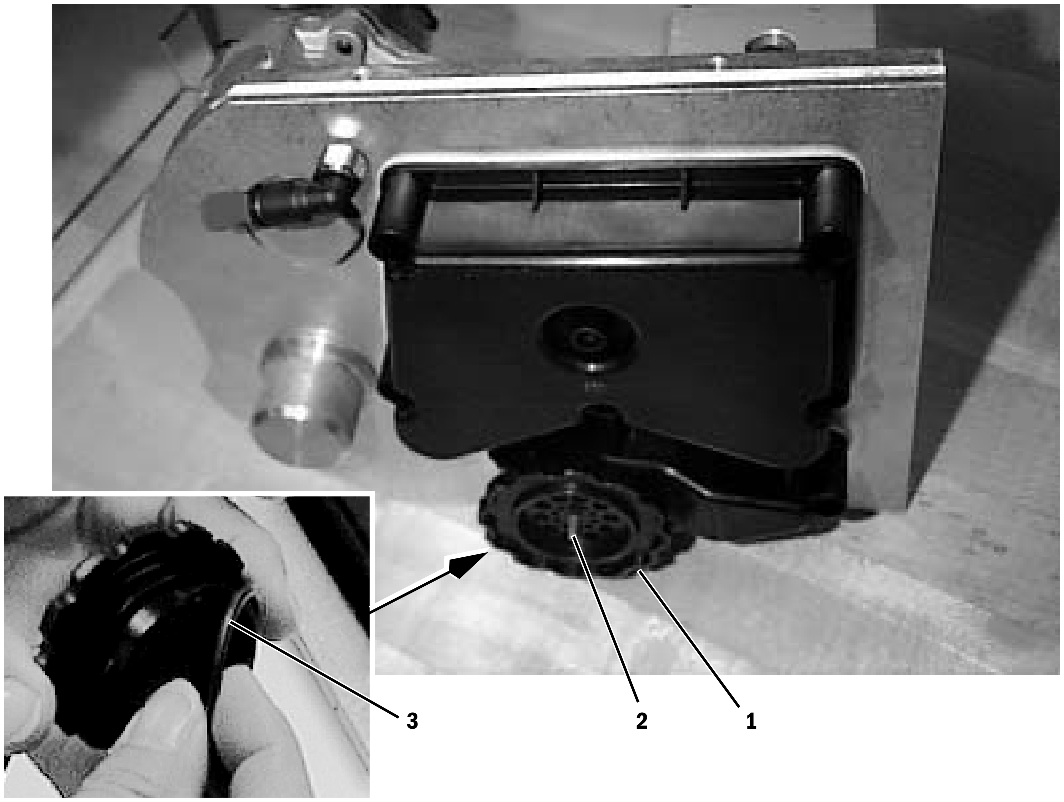
** The molded MOPV housing kit (item 6) replaces items 1 through 5.

8.7.3 Inlet filter



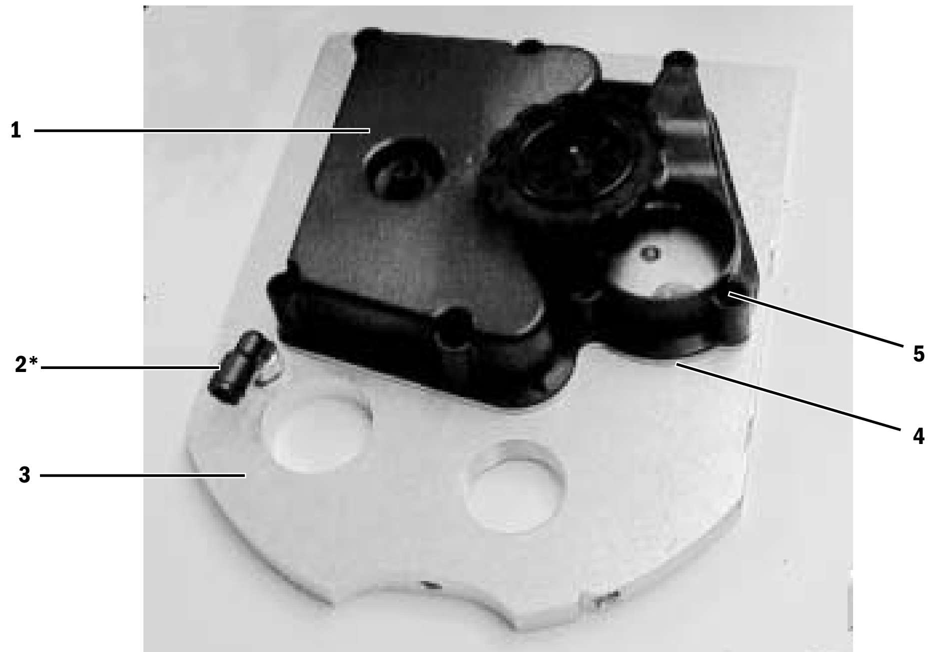
Item	Description	Stock Number
1	Filter, glass media TFL binder	1503-3211-000
2	O-ring for cap filter housing	1503-3224-000
3	Cap, filter housing	1503-3203-000

8.7.4 Free Breathing Valve



Item	Description	Stock Number
1	Seat, free breathing valve	1503-3204-000
2	Valve, flapper	0211-1454-100
3	O-ring	1503-3208-000

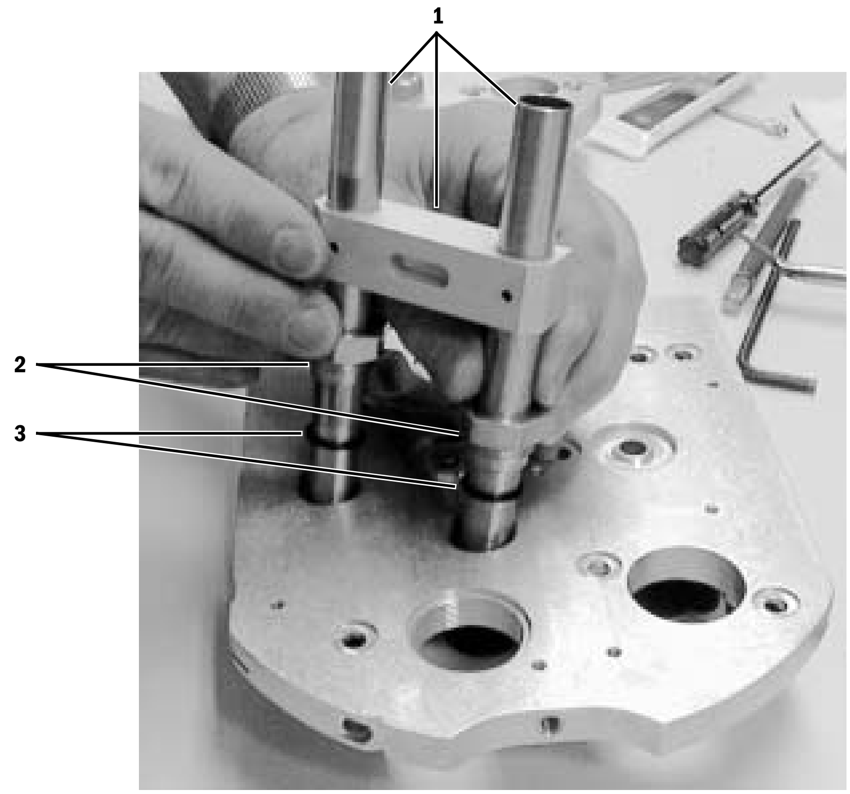
8.7.5 Manifold

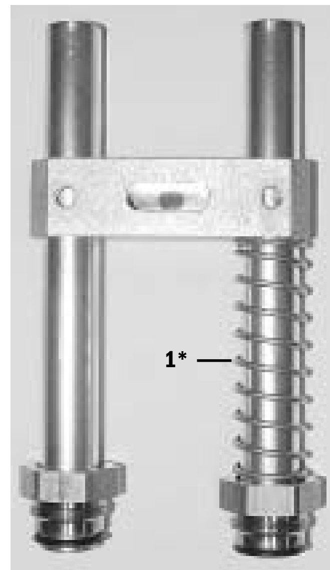


Item	Description	Stock Number
1	Housing, manifold vent	1503-3201-000
2*	Elbow, 6.35 mm (1/4 inch)	1006-3529-000
	Straight fitting, 6.35 mm (1/4 inch)	1504-3621-000
	Plug, 6.35 mm ((1/4 inch)	1503-3245-000
3	Plate, manifold vent	1503-8110-000
4	Manifold gasket	1503-3205-000
5	Screw, M4x8 mm (8)	9211-0640-083

* Now shipping with straight fitting

8.7.6 Tube Assembly

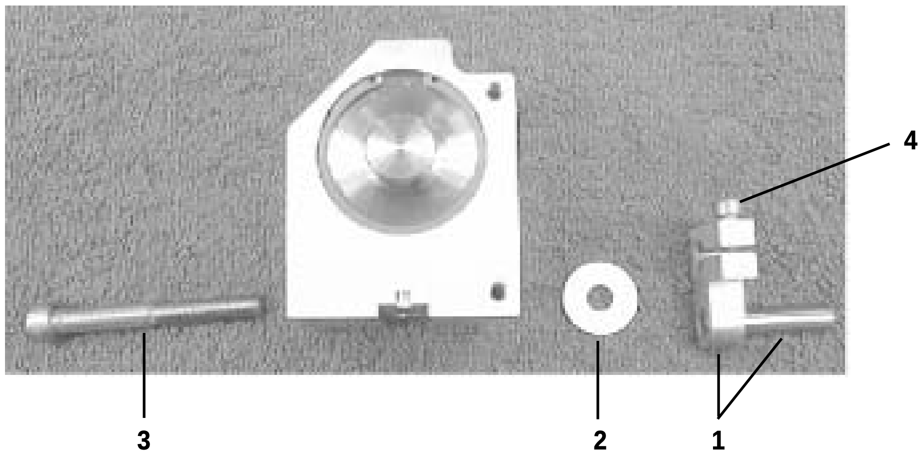




Item	Description	Stock Number
1*	Tube and collar assembly Spring (included with tube assembly)	1503-3215-000 1503-3842-000
2	Bushing, o-ring retainer (2)	1503-3217-000
3	O-ring (2)	1503-3240-000

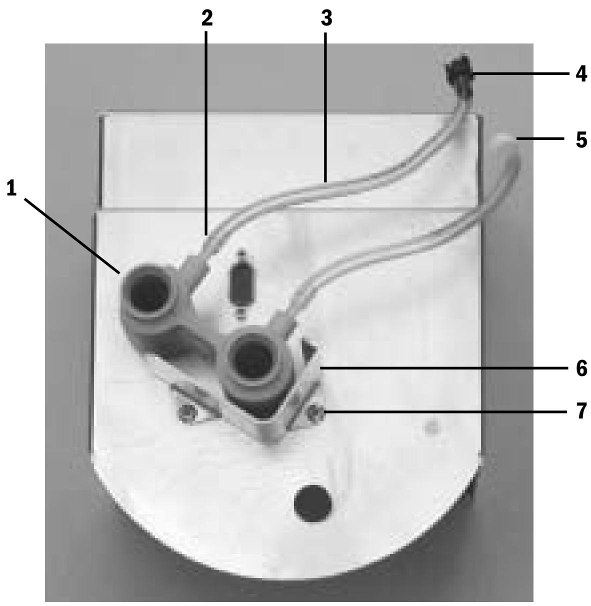
* Current tube assemblies include a spring on the inside tube to help keep the tube assembly engaged with the exhalation valve interface cuff when in place.

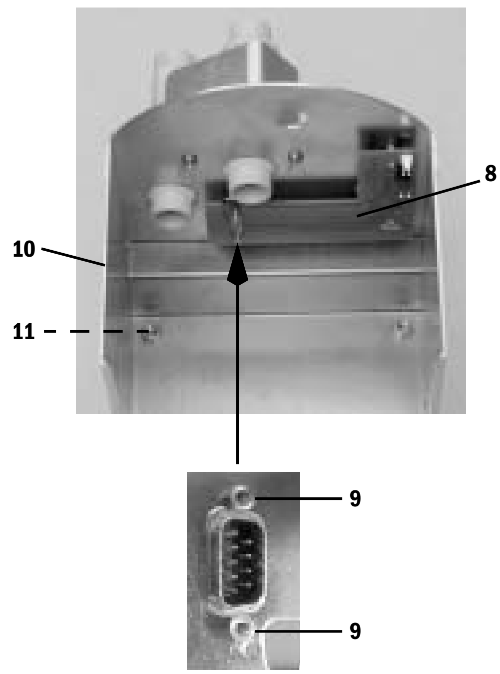
8.7.7 Twin Tube Lifter



Item	Description	Stack Number
1	Arm, tube positioner	1503-3225-000
2	Washer, brass	0202-4528-300
3	Screw	9211-0660-504
4	Screw	1102-3006-000

8.8 Vent Engine mounting bracket

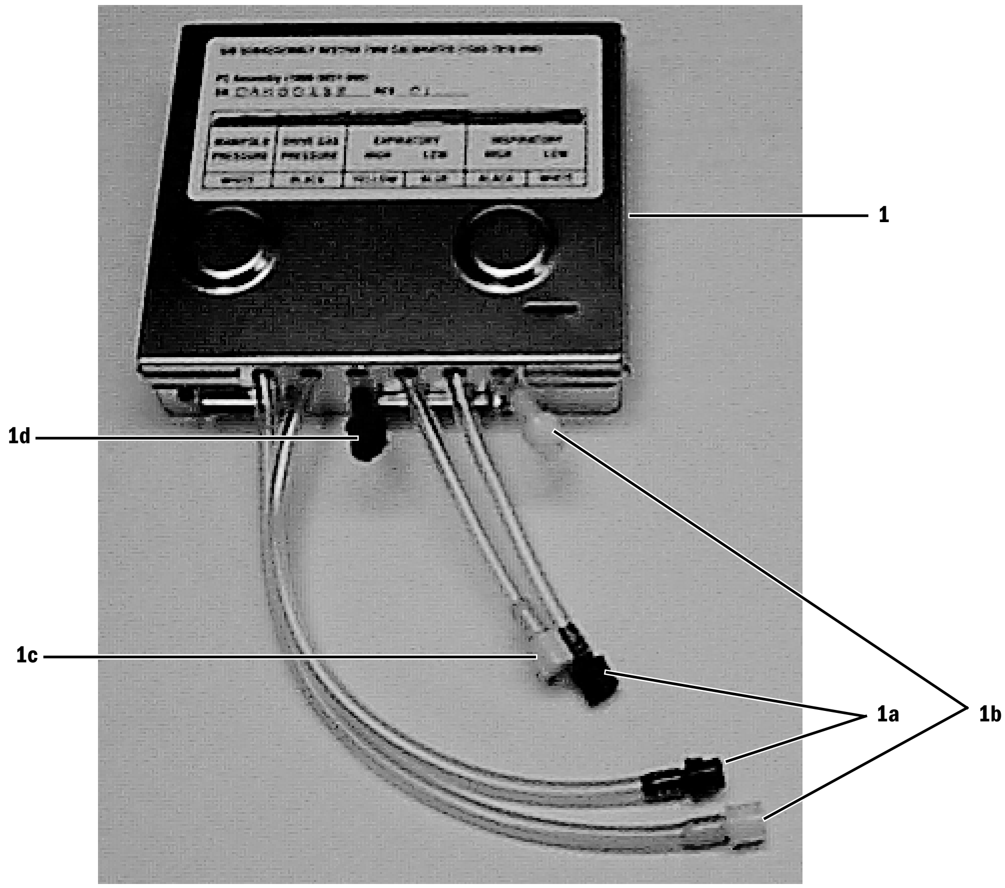




Item	Description	Stock Number
	Field Replaceable Vent Engine Housing (includes items 1 through 10)	1503-8042-000
1*	Cuff, exhalation valve interface	1503-3589-000
2*	Connector barb	1503-3241-000
3*	Tubing (specify 150 mm each)	0994-6370-010
4*	Coupling, inline BLK insert half 4-mm hose barb	1503-3237-000
5*	Coupling, inline WHT insert half 4-mm hose barb	1503-3236-000
6	Shield, cuff protector	1503-3214-000
7	Screw, M4x8	1006-3178-000
8	Pneumatic connector board	1006-3055-000
9	Locking post kit, DSub connector	1503-3822-000
10	Bracket, vent engine housing	1503-3206-000
11	Screw, SEMS M6 x 16	0144-2436-109

* Cuff interface assembly, 1503-8112, includes items 1 through 5.

8.9 Sensor Interface Board (SIB)



Item	Description	Stock Number
1	SIB assembly	1503-7010-000
1a	Coupling, inline, black	1503-3128-000
1b	Coupling, inline, white	1503-3119-000
1c	Coupling, inline, yellow	1503-3132-000
1d	Coupling, inline, blue	1503-3130-000

Notes

Aestiva/5 7900 Anesthesia Ventilator
Technical Reference Manual, English
1006 0453 000
05 04 D 01 01 02
Printed in USA