Technical Reference Manual

Vmax Encore

VIASYS® HEALTHCARE
Excellence For Life
RESPIRATORY CARE

L2707 Rev. A

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PRECAUTIONS

- Caution: Federal law restricts this device to sale by, or on order of, a physician.
- Caution: This device is not suitable for use in the presence of flammable anesthetics.
- Service of this device is restricted to factory-trained personnel.

EQUIPMENT CLASSIFICATION

Classification of the equipment described in this manual:

- Class 1
- Type BF Defibrillator Proof (ECG Module)
- Type B (Vmax® and Vmax Spectra 62J/62W)
- Mode of operation: Continuous

The Vmax Encore and Vmax Spectra 62J/62W comply with the Medical Device Directive MDD 93/42/EEC and have been approved to carry the CE Mark shown below.

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CONTENTS


Vmax
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CHAPTER 1
INTRODUCTION

VMAX ENCORE SERIES OVERVIEW

This manual provides procedures relevant to servicing, troubleshooting, and repairing the Vmax systems described in the following section. These procedures are intended for service and support personnel who have been trained and are authorized to service the Vmax systems.

VMAX INSTRUMENT CONFIGURATIONS

The Vmax Encore Series consists of four basic instrument configurations. All instruments can be ordered alone or with a selection of optional housings: a highly mobile cart, a mobile console, or a stationary table. These configurations can be utilized separately or hardware/software components can be combined in a number of ways to meet the needs of any specific cardiopulmonary laboratory. The four available instrument configurations are as follows:

- Vmax Encore 20 Pulmonary Spirometry Instrument
- Vmax Encore 22 Pulmonary Function Analysis Instrument
- Vmax Encore 29 Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 229 Pulmonary Function/Cardiopulmonary Exercise Testing Instrument

The Vmax Encore module can be positioned horizontally or vertically. The module can have a high profile in the horizontal position (a wide profile in the vertical position); or the module can have a low profile in the horizontal position (a narrow profile in the vertical position), depending on the model. The maximum height in the horizontal position (width in the vertical position) is 15.24 cm. Vmax Encore 20, 20c, 29c, and 29s have the low (narrow) profile.

By including or excluding hardware or software features, ten other configurations are available, making a total of 14 different instruments. These ten other configurations are as follows:

- Vmax Encore 20c Pulmonary Spirometry Instrument
- Vmax Encore 22d Pulmonary Function Analysis Instrument
- Vmax Encore 22lv Pulmonary Function Analysis Instrument
- Vmax Encore 29c Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 29n Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 29s Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 229c Pulmonary Function/Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 229d Pulmonary Function/Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 229lv Pulmonary Function/Cardiopulmonary Exercise Testing Instrument
- Vmax Encore 229n Pulmonary Function/Cardiopulmonary Exercise Testing Instrument

Optional for all instruments, except the Vmax Encore 20c Pulmonary Spirometry Instrument, is the Vmax Encore 62J/62W Autobox Body Plethysmograph.

VMAX ENCORE 20 PULMONARY SPIROMETRY INSTRUMENT

The Vmax Encore 20 is designed to be used as a lightweight, portable office or bedside pulmonary screening spirometer with the capability of controlling the Vmax Encore 62J/62W Autobox.

The Vmax Encore 20 includes the following components:

- The Encore module containing the Analyzer Assembly
- Desktop or notebook computer
- Program software
- Printer
- Mass flow sensor

VMAX ENCORE 22 PULMONARY FUNCTION ANALYSIS INSTRUMENT

The Vmax Encore 22 is designed to be used as a full-featured Pulmonary Function instrument with the capability of controlling the Vmax Spectra 62J/62W Autobox.

The Vmax Encore 22 includes the following major components:

- The Encore module containing the Analyzer Assembly and the Pneumatics Assembly
- Desktop or notebook computer
- Program software
- Printer
- Mass flow sensor
- Automated breathing valve
- 100% oxygen cylinder with gas valve
- DLCO mix cylinder with gas valve

VMAX ENCORE 29 CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 29 is designed to be used as a full-featured Metabolic Measurement instrument with the capability of controlling the Vmax Encore 62J/62W Autobox.

The Vmax Encore 29 includes the following components:

- The Encore module containing the Analyzer Assembly and the Pneumatics/Fan Assembly
- Desktop or notebook computer
- Program software
- Printer

- Mass flow sensor
- One-way breathing valve with tubing
- 26% oxygen calibration cylinder with gas regulator
- 4% carbon dioxide, 16% oxygen calibration cylinder with gas regulator

VMAX ENCORE 229 PULMONARY FUNCTION ANALYSIS/ CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 229 combines all the features and options of both the Vmax Encore 22 and Vmax Encore 29 instruments with the capability of controlling the Vmax Encore 62J/62W Autobox.

The Vmax Encore 229 includes the following components:

- The Encore module containing the Analyzer Assembly and the Pneumatics/Fan Assembly
- Desktop or notebook computer
- Program software
- Printer
- Mass flow sensor
- Automated breathing valve
- One-way breathing valve with tubing
- 100% oxygen cylinder with gas valve
- DLCO mix cylinder with gas valve
- 26% oxygen calibration cylinder with gas valve
- 4% carbon dioxide, 16% oxygen calibration cylinder with gas valve

VMAX ENCORE 20c PULMONARY SPIROMETRY INSTRUMENT

The Vmax Encore 20c is designed to perform the same tests as the Vmax Encore 20 instrument mentioned above but **without** the capability of controlling the Vmax Encore 62J/62W Autobox.

VMAX ENCORE 22d PULMONARY FUNCTION ANALYSIS INSTRUMENT

The Vmax Encore 22d is designed to perform the same tests as the Vmax Encore 22 instrument mentioned above with the exception of Gas Dilution Lung Volume testing which **is not** provided. The Vmax Encore 22d has the same components as the Vmax Encore 22 except the Analyzer Assembly does not contain an O_2 sensor or a CO_2 analyzer and O_2/CO_2 calibration gas is not included.

VMAX ENCORE 22lv PULMONARY FUNCTION ANALYSIS INSTRUMENT

The Vmax Encore 22lv is designed to perform the same tests as the Vmax Encore 22 instrument mentioned above with the exception of Diffusing Capacity testing which **is not** provided. The Vmax

Encore 22lv has the same components as the Vmax Encore 22 except the Analyzer Assembly does not contain a Multi-gas analyzer and DLCO mix calibration gas is not included.

VMAX ENCORE 29c CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 29c is designed to perform the same tests as the Vmax Encore 29 instrument mentioned above with the exception of Mixing Chamber exercise testing which **is not** provided. The only optional test available is Indirect Calorimetry for mechanically ventilated patients. The Vmax Encore 29c has the same components as the Vmax Encore 29 except all necessary valves and plumbing normally located in the Pneumatics/Fan Assembly are housed in the Analyzer Assembly and there is no Pneumatics/Fan Assembly.

VMAX ENCORE 29n NUTRITIONAL ASSESSMENT INSTRUMENT

The Vmax Encore 29 is designed to be used as a mobile Nutritional Assessment instrument with the capability of controlling the Vmax Encore 62J/62W Autobox.

The Vmax Encore 29n includes the following major components:

- The Encore module containing the Analyzer Assembly and the Pneumatics/Fan Assembly
- Desktop or notebook computer
- Program software
- Printer
- Mass flow sensor
- Dilution canopy
- 26% oxygen calibration cylinder with gas regulator
- 4% carbon dioxide, 16% oxygen calibration cylinder with gas regulator

VMAX ENCORE 29s CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 29s performs the same tests and has the same components as the Vmax Encore 29c. The Vmax Encore 29s does not provide spirometry testing and does not have a pneumatics/fan assembly.

VMAX ENCORE 229c PULMONARY FUNCTION/CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 229c performs the same tests as the Vmax Encore 229, with the exception of mixing chamber exercise testing and indirect calorimetry testing. The Vmax Encore 229c has the same components as the Vmax Encore 229, except that the pneumatics/fan assembly does not contain a mixing chamber. The ECG pod box is not included with this instrument.

VMAX ENCORE 229d PULMONARY FUNCTION/CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 229d is designed to perform the same tests as the Vmax Encore 229 instrument mentioned above with the exception of Gas Dilution Lung Volume testing which **is not** provided. The Vmax Encore 229d has the same components as the Vmax Encore 229 except the Analyzer Assembly does not contain an O_2 sensor or a CO_2 analyzer and O_2/CO_2 calibration gas is not included.

VMAX ENCORE 229lv PULMONARY FUNCTION/CARDIOPULMONARY EXERCISE TESTING ANALYSIS INSTRUMENT

The Vmax Encore 229lv is designed to perform the same tests as the Vmax Encore 229 instrument mentioned above with the exception of Diffusing Capacity testing which **is not** provided. The Vmax Encore 229lv has the same components as the Vmax Encore 229 except the Analyzer Assembly does not contain a Multi-gas analyzer and DLCO mix calibration gas is not included.

VMAX ENCORE 229n CARDIOPULMONARY EXERCISE TESTING INSTRUMENT

The Vmax Encore 229n combines all the features, options and applications of both the Vmax Encore 22 and Vmax Encore 29n instruments.

VMAX 62J/62W AUTOBOX BODY PLETHYSMOGRAPH

The Vmax 62J/62W Autobox is a full-featured Body Plethysmograph designed to interface with any Vmax instrument except the Vmax Encore 20c Instrument.

The Vmax 62J/62W includes the following major components.

- Cabin with adjustable chair
- Electronics Compartment
- Mass Flow Sensor
- 16% O_2, 4% CO_2 Calibration gas cylinder with Gas Valve

SYSTEM COMPONENTS

This section provides a general description of the components that combine to form the Vmax cardiopulmonary instruments; more detailed descriptions of each system can be found in the chapter ”System Description” on page 1.

Vmax Encore 20 Pulmonary Spirometry Instrument

Measurement components in the Vmax Encore 20 Pulmonary Spirometry Instrument:

- Pressure Transducers (3)
  - Barometric Pressure Transducer
  - Direction Pressure Transducer
  - Mouth Pressure Transducer
- Temperature Transducer
- Mass Flow Sensor Input
- Box Pressure Input

Vmax Encore 22 Pulmonary Function Analysis Instrument

Measurement components in the Vmax Encore 22 Pulmonary Function Analysis Instrument:

- Pressure Transducers (3)
  - Barometric Pressure Transducer
  - Direction Pressure Transducer
  - Mouth Pressure Transducer
- Temperature Transducer
- Mass Flow Sensor Input
- Box Pressure Input
- Multi-gas Analyzer
- O_2 Sensor
- CO_2 Analyzer

Vmax Encore 29 Cardiopulmonary Exercise Testing Instrument

Measurement components in the Vmax Encore 29 Cardiopulmonary Exercise Testing Instrument:

- Pressure Transducers (3)
  - Barometric Pressure Transducer
  - Direction Pressure Transducer
  - Mouth Pressure Transducer
- Temperature Transducer
- Mass Flow Sensor Input
- Box Pressure Input
- O_2 Sensor
- CO_2 Analyzer

Vmax Encore 229 Pulmonary Function/Cardiopulmonary Exercise Testing Instrument

Measurement components in the Vmax Encore 229 Pulmonary Function/Cardiopulmonary Exercise Testing Instrument:

- Pressure Transducers (3)
  - Barometric Pressure Transducer
  - Direction Pressure Transducer
  - Mouth Pressure Transducer
- Temperature Transducer
- Mass Flow Sensor Input
- Box Pressure Input
- Multi-gas Analyzer
- O_2 Sensor
- CO_2 Analyzer

All Systems

Other components included on all systems:

- Power Supply Transformer with Circuit Breaker
- Signal Processing and Valve Control Circuits
- Remote Start Input
- Printer Output
- Peripheral Device (POD) Input/Output (except on Vmax Encore 20 Spirometer)

- Sample Pump (except on Vmax Encore 20 Spirometer)
- Ambient Temperature Sensor
- Cooling Fan

Pneumatics/Fan Assembly

The Pneumatics/Fan Assembly manages the flow of the various gases delivered and analyzed during calibration and testing.

Vmax Encore 22 Pulmonary Function Lab

Pneumatic components in the Vmax Encore 22 Pulmonary Function Lab:

- Solenoid Valves (6)
- High-capacity Demand Regulator
- 3-way High-flow Input Valve for Oxygen and Diffusion Gases
- Perma Pure Calibration Tubing

Vmax Encore 29 Metabolic Measurement LC Cart

Pneumatic components in the Vmax Encore 29 Metabolic Measurement LC Cart:

- Solenoid Valves (5)
- Mixing Chamber/Blower Combination Unit with Mass Flow Sensor Adapter
- Blower Failure Alarm with 9V Battery
- Perma Pure Calibration Tubing

Vmax Encore 229 Pulmonary Function/Metabolic LC Cart

Pneumatic components in the Vmax Encore 229 Pulmonary Function/Metabolic LC Cart:

- Solenoid Valves (11)
- High-capacity Demand Regulator
- 3-way High-flow Input Valve for Oxygen and Diffusion Gases
- Mixing Chamber/Blower Combination Unit with Mass Flow Sensor Adapter
- Perma Pure Calibration Tubing

MASS FLOW SENSOR

The Vmax Encore Series instruments measure inspired and expired flow directly by using the highly accurate and very stable Mass Flow Sensor. The computer program electronically integrates flow signals to obtain volume measurements and makes the Mass Flow Sensor linear.

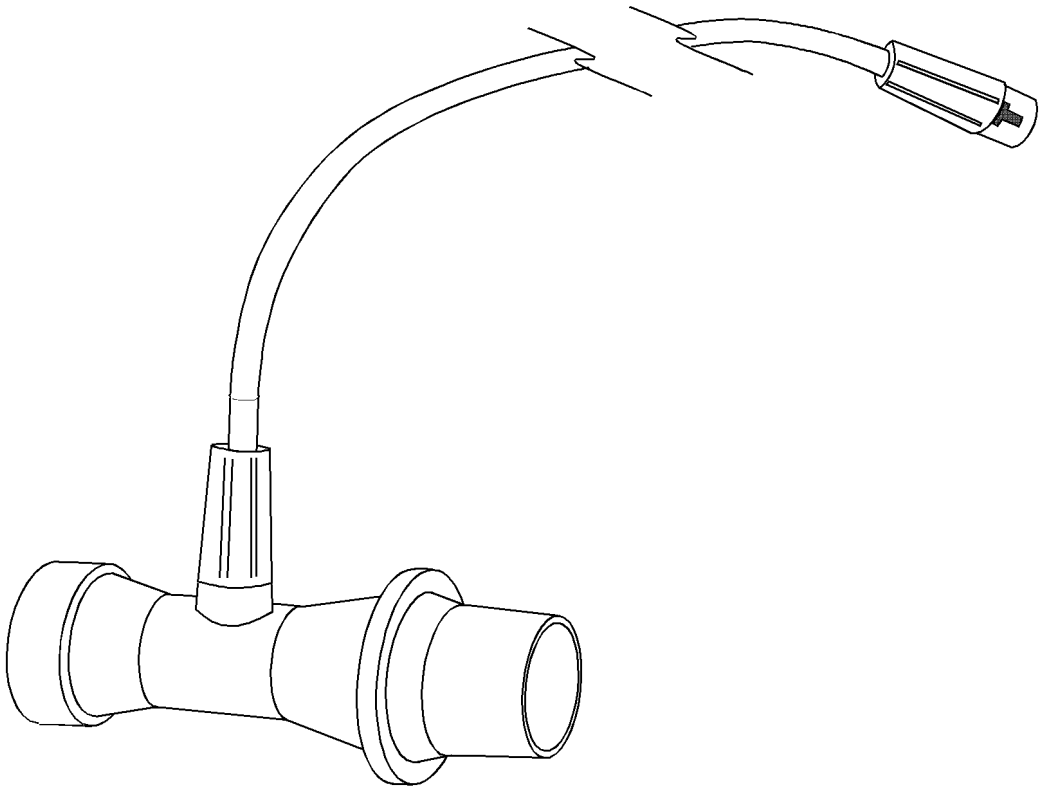

Figure 1-1 Mass Flow Sensor.

The electronic circuit of the Mass Flow Sensor monitors the resistance of the sensor filaments to determine their temperatures, so it is important that only the resistances of the filaments are measured. A new technique, Kelvin Sensing, and exclusive design are incorporated in the Vmax Encore Mass Flow Sensor to eliminate the influence of connector and cable resistance in the measurements.

The Mass Flow Sensor uses two metallic filaments to sense gas flow rate: a sensing filament and a reference filament. The reference filament tracks the temperature of gas whereas the sensing filament is maintained at a preset temperature above that of the reference filament. As gas flows through the sensor, the gas molecules remove heat from the sensing filament. To maintain the sensing filament at the same offset temperature, more power must be delivered to the sensing filament. This additional power is an accurate measurement of the mass flow rate through the sensor. Unlike volumetric flow, mass flow measurements are unaffected by changes in air pressure or temperature.

Since the reference filament resistance is determined by its temperature, the Kelvin Sensing provides accurate reading of the gas temperature as well. The relatively low thermal mass of the

filaments also makes it possible to track the rapidly changing gas temperatures encountered in all Vmax Encore diagnostic functions.

MULTI-GAS ANALYZER

The rapid-response Multi-gas Analyzer provides a real-time measurement of Carbon Monoxide (CO) and Methane (CH_4). Measurement of the gas concentration is made using a Non-dispersive Infrared (NDIR) technique. This technique involves directing a beam of infrared energy through a sample of the gas to be analyzed and measuring the amount of infrared energy that is absorbed.

In order to measure multiple gases in a single sample, the analyzer incorporates an assembly with multiple filters and detectors; this removes the requirement for the motorized filter wheel common on other infrared analyzers. The wavelength of each band is carefully chosen to measure only the desired gas.

O_2 Sensor

The oxygen sensor works on the principle of the electrochemical mechanism. It consists of a metal lead as the anode and a potassium hydroxide solution as the electrolyte.

CAUTION! During the course of servicing the equipment, wear eye and hand protection if you notice liquid on or around the O_2 sensor, and heed all safety notices that are included in the procedure.

WARNING! 

The O_2 sensor contains 10% Potassium Hydroxide (KOH), a CORROSIVE chemical. Contact with Potassium Hydroxide may cause irritation or severe chemical burns. Exposure may lead to acute and chronic damage to the individual.

R35 – Causes severe burn

R42 – May cause sensitization by inhalation

R36/37/38 – Irritating to eyes, respiratory system and skin

WARNING! 

The O_2 sensor contains lead (Pb), a chemical known to the state of California to cause cancer, birth defects, or other reproductive harm. Exposure may lead to acute and chronic damage to the individual and the fetus of a pregnant woman.

Emergency First Aid Procedures

In case of contact with the skin or eyes, immediately flush with water for at least 15 minutes and remove all contaminated clothing. Get medical attention immediately.

If ingested, give large amounts of water and DO NOT INDUCE VOMITING. Obtain medical attention immediately.

If inhaled, remove to fresh air and obtain medical attention immediately.

Disposal

Waste must be disposed of in accordance with Federal, State, and Local environmental control regulations.

The fast-response oxygen sensor is based on the electrochemical principle. The sensor provides the fast response time necessary for real-time breath-by-breath gas analysis. During operation, the oxygen is reduced at the cathode, generating a current that is proportional to the oxygen content in the sample.

CARBON DIOXIDE ANALYZER

As with the Multi-gas Analyzer discussed above, the Carbon Dioxide (CO_2) Analyzer uses the rapid-response Non-dispersive Infrared (NDIR) measurement technique. As with the oxygen analyzer, the sample chamber size has been greatly minimized to enhance response characteristics.

AUTOMATED BREATHING VALVE

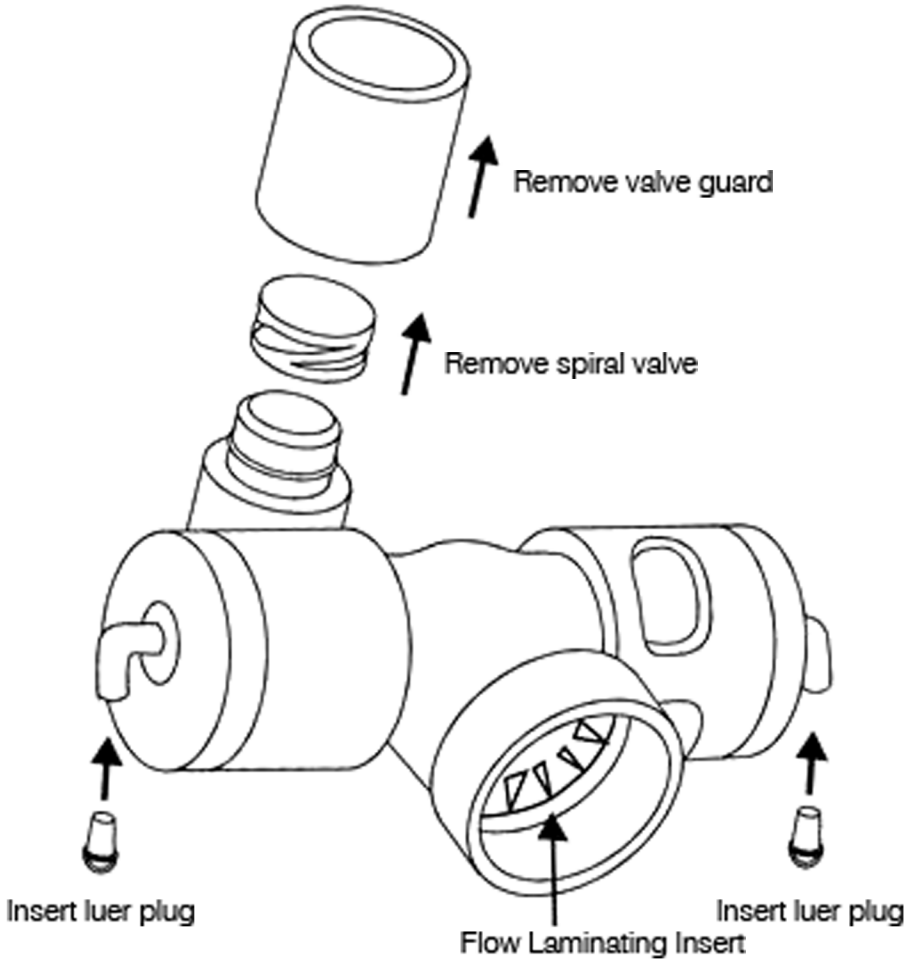

Figure 1-2 Automated Breathing Valve.

The automated breathing valve is used for the following tests: FRC, DLCO, max pressures, compliance, SBO2, P100, and intra-breath DLCO. The pneumatically driven valve automatically switches the patient between the various breathing circuit configurations, and between room air and the test gases. The computer program determines timing and control.

The valve is mounted on the flow sensor and is easily disinfected.

ONE-WAY BREATHING VALVE

The One-way Breathing Valve is used for mixing chamber exercise testing. The valve employs silicon spiral diaphragms for low flow resistance and easy disinfecting.

MIXING CHAMBER/BLOWER

A 2.6-liter mixing chamber is located in the Pneumatics/Fan Assembly. This chamber is used for mixing expired gas during exercise and calorimetry testing. The chamber also houses the variable volume, high capacity blower used for dilution testing. The blower volume is controlled by the computer and is continuously variable from 12–60 LPM.

The blower's on/off switch is located on the front of the Pneumatics/Fan Assembly. Safety circuitry will automatically turn the blower up to full volume if communication with the computer is lost for any reason.

A battery-powered alarm will sound if the blower's on/off switch is in the on position and there is a power loss to the Analyzer Assembly.

DEMAND REGULATOR

A high-capacity Demand Regulator is located in the Pneumatics Assembly. This regulator is used to deliver test gases (oxygen or diffusion mixture) to the patient on inspiratory demand during the FRC, SBO_2, P100, intra-breath, compliance, and DLCO tests. The delivered flow range is 0–6 LPS.

PERMA PURE® NAFION® DRYING TUBE

The calibration gas and the patient's exhaled gas pass through a Perma Pure drying tube before entering the gas analyzers. The absorption and evaporation properties of the Nafion material in the drying tube ensure that the relative humidity in the exhaled gas and in the calibration gas is equilibrated to ambient conditions (room air) when they are sampled in the analyzer. This results in a high degree of accuracy in the actual gas concentration measurements and removes the need for external drying crystals. The tube is wrapped in protective braiding to prevent pinching and crimping.

SOLENOID AND DEMAND VALVE CONTROL

All flushing, sealing, and gas flow control is provided by an integrated system of solenoid valves, one-way valves, and a high-capacity demand valve. The computer controls these valves automatically. The computer program is designed to take the operator through the appropriate steps of any given test, thereby insuring that all valves are in the correct position at all times. The internal pneumatic connections are of rigid construction and are tested at elevated pressures to insure excellent, long-term seals.

TEMPERATURE SENSOR

A temperature sensor is located inside the air circulation inlet port on the Analyzer Assembly to measure ambient room temperature. This makes operator-entry of the room temperature from a separate room thermometer unnecessary.

BAROMETRIC PRESSURE SENSOR

A barometric pressure sensor is located in the Analyzer Assembly to continuously measure ambient barometric pressure, making operator-entry of a reading from a barometer unnecessary. This same sensor also measures changes in gas sample line pressure so that adjustments in gas partial pressures can be calculated.

DIRECTION PRESSURE SENSOR

A direction pressure sensor is located in the Analyzer Assembly to determine the direction of the flow signal. This sensor provides for automatic detection of inspiratory and expiratory volumes.

MOUTH PRESSURE SENSOR

A mouth pressure sensor is located in the Analyzer Assembly to measure respiratory pressures at the mouth.

ANALOG I/O POD

An Analog I/O Pod is provided for interfacing external devices. The pod provides for the following device interfaces:

- Eight analog input
- Four analog output
- Three TTL output
- One analog heart rate input or SMC 3-Lead ECG input

CALIBRATION SYRINGE

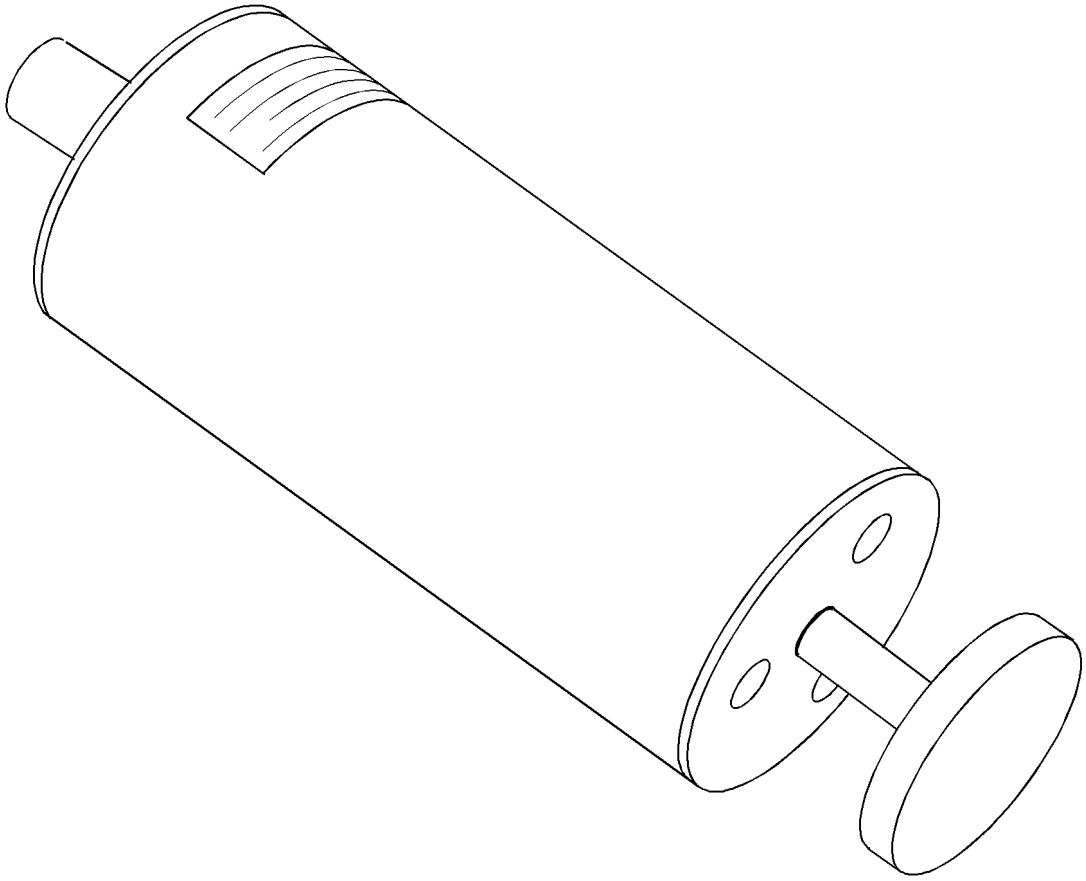

Figure 1-3 Calibration Syringe.

The 3.0-liter calibration syringe is included with the system for performing volume calibration, verifications, and quality assurance procedures.

VMAX ENCORE SERIES SPECIFICATIONS

All materials used in the construction of the Vmax Encore Series instruments, ***with the exception of the O2 Sensor***, are non-toxic and pose no safety risk to the patient or operator.

CAUTION! During the course of servicing the equipment, wear eye and hand protection if you notice liquid on or around the O_2 sensor, and heed all safety notices that are included in the procedure. For important safety information about the O_2 sensor, and for first-aid instructions, refer to the section "O2 Sensor" on page 1–10.

Table 1-1: Flow Volume/Gas Measurements

Flow Volume	
Type	Mass Flow Sensor
Range	0 – 16 LPS
Resolution	0.003 LPS from 0.20 – 16 LPS
Flow accuracy	±3% of reading or 0.25 LPS, whichever is greater, across the range of 0.2 to 12 LPS
Volume accuracy	±3% of reading or 0.050 L, whichever is greater
Resistance	<1.5 cmH_2O/LPS at 12 LPS
O_2 Analyzer	
Type	Electrochemical fuel cell
Range	0 – 100%
Resolution	0.01%
Accuracy	±0.02%
CO_2 Analyzer	
Type	Non-dispersive infrared, thermopile
Range	0 – 16%
Resolution	0.01%
Accuracy	±0.02% CO_2 across range of 0–10%. There is no accuracy specification above 10% CO_2.
Flash Multi-Gas[1]	
Type	Non-dispersive infrared, thermopile
Range	0 – 0.33% CO
	0 – 0.33% CH_4
	0 – 0.33% C_2H_2 (For investigational use only.)

Table 1-1: Flow Volume/Gas Measurements

Resolution	0.0005% CO
	0.0005% CH_4
	0.0005% C_2H_2 (For investigational use only.)
Accuracy	±0.003% CO
	±0.003% CH_4
	±0.003% C_2H_2 (For investigational use only.)

1. The Multi-Gas Analyzer is included only with diffusing-capacity testing applications.

Table 1-2: Transducers

Flow Direction (DIR) Range: ±2 cmH_2O	
Mouth Pressure (PM)	
Range	±300 cmH_2O
Accuracy	±1% (full scale)
Barometric/Sample Pressure (BP)	
Range	300 – 800 mmHg
Accuracy	±3 mmHg
Temperature (TEMP)	
Range	0 – 40ºC
Accuracy	±1°C
Dilution Flow	
Blower	12 – 60 LPM
	Manual ON/OFF switch
	Hi/Low O_2/CO_2 Flow Alarms

Table 1-3: Environmental Requirements

Operating	Temperature	5 – 40ºC
	Humidity	15 – 95%, non-condensing
Storage	Temperature	–20 to 50ºC
	Humidity	0 – 100%, non-condensing

Table 1-4: Internal Quality Assurance Gas Infusion Calibrator[1]

VE range for constant VO_2/VCO_2 stability	10 – >100 LPM Temporal Alignment Verification System Integrity

1. Included with the cardiopulmonary exercise testing application.
Due to continual product innovation, designs and specifications are subject to change without notice.
Caution: Federal law restricts this device to sale by or on the order of a physician.

Table 1-5: Electrical Requirements

Voltage	100 V AC to 240 V AC
Frequency	50/60 Hz
Phase	Single
Current	Console: Max. 12 A at 115 V AC
Leakage current	< 500 microampere at 240 V AC < 300 microampere at 120 V AC

Table 1-6: Dimensions and Weights

Modules (each)	38.1 cm high x 15.25 cm wide x 38.1 cm deep
	(15 in x 6 in x 15 in)
	26.2 kg average
Console	100 cm high x 58.4 cm wide x 94 cm deep
	(39.3 in x 23 in x 37 in)
	56.81 kg (125 lb)
Table	76 cm high x 122 cm wide x 76 cm deep
	(30 in x 48 in x 30 in)
	68.2 kg (150 lb)

Table 1-7: Standards[1]

Quality System Registration	ISO 13485/CMDR
FDA	510(k) market clearance
MDD 93/42/EEC	CE marked
Electrical Safety	EN 60601-1
EMC	EN 60601-1-2

1. Approvals apply to some or all instruments.


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CHAPTER 2
SYSTEM DESCRIPTION

GENERAL

Hardware assemblies and circuit boards of the Vmax Encore Series instruments have multiple functions and are compact in design; however, this does not mean more complicated hardware or circuitry. The most feature-packed Vmax Instrument, the Vmax Encore 229, has only four circuit boards and eight hardware devices enclosed in one module. This module houses the analyzer assembly and the pneumatics assembly. (Systems with fewer capabilities may have fewer components.)

Since the Vmax Encore 229 has the hardware features of all Vmax Encore Series instruments, it will be used to describe the individual components that make up those systems.

Figure 2-1 Vmax Encore 229 Assembly

MAIN CIRCUIT BOARDS

As stated earlier, there are four main circuit boards in the Vmax Encore 229. Systems with fewer hardware options may have fewer main circuit boards. Example: The Vmax Encore 20 has only two main circuit boards.

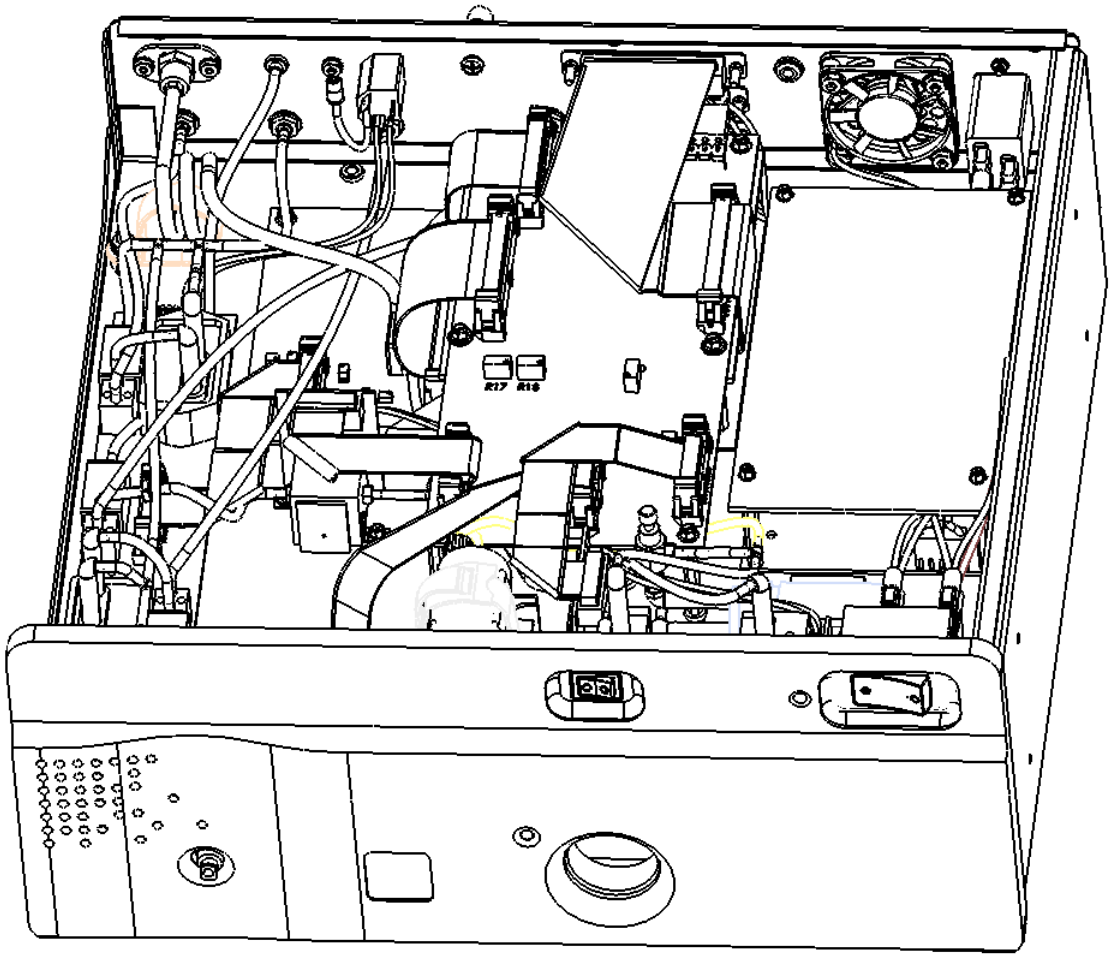


Figure 2-2 Encore assembly top view

The four main circuit boards of the Vmax Encore 229 and their locations:

Circuit Board	Module Location
Mass Flow Sensor Board	Analyzer Assembly
Analyzer Control Board	Analyzer Assembly
Pressure Board	Analyzer Assembly
Solenoid Board	Pneumatics/Fan Assembly

Note:

The gas analyzers in the Vmax Encore Series instruments have small pre-amp circuit boards mounted to them and are not included in this discussion. They will be discussed later with their respective analyzers.

With the exception of the Solenoid Board, each main circuit board has been designed for all Vmax Encore Series instruments. There are several versions of the Solenoid Board for various Vmax Encore Series instruments. Each of these Solenoid Boards is populated with a different set of solenoid valves for different Vmax Instrument configurations.

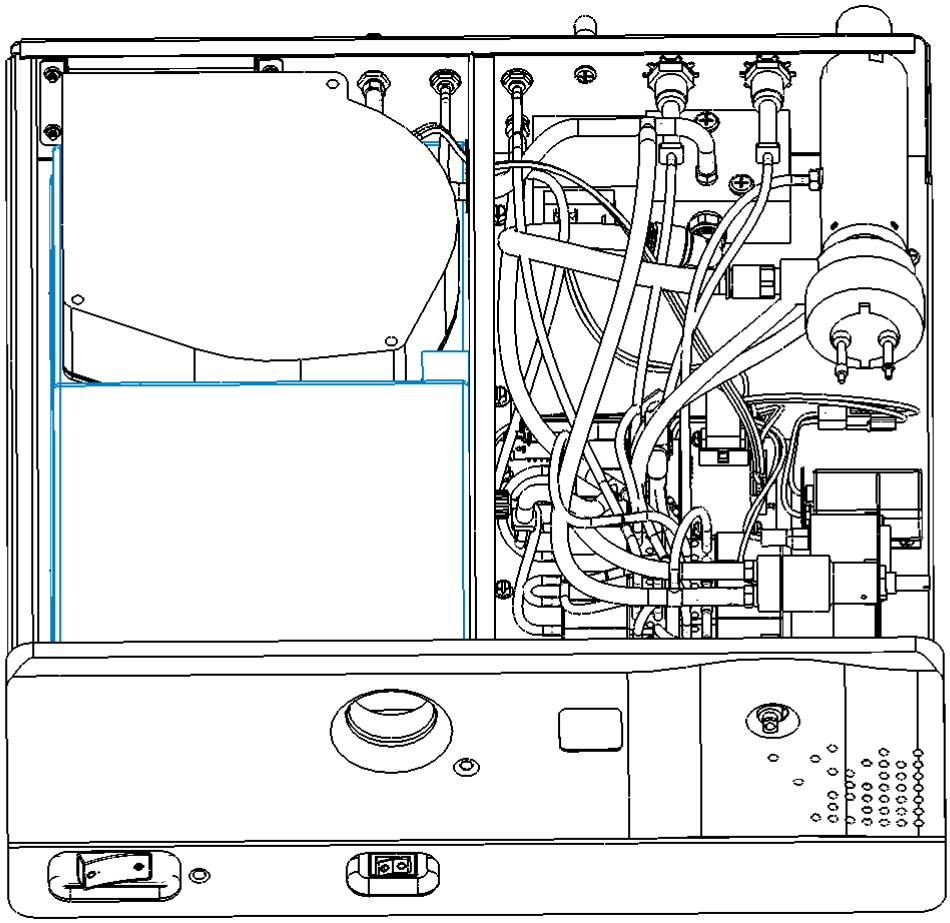


Figure 2-3 Encore assembly bottom view

MAIN HARDWARE DEVICES

The eight main hardware devices of the Vmax Encore 229 and their locations are:

Hardware Device	Module Location
Sample Pump	Analyzer Assembly
CO_2 Analyzer	Analyzer Assembly
O_2 Sensor	Analyzer Assembly
Multi-gas Analyzer	Analyzer Assembly
DC Power Supplies + 5 V DC +15 V DC - 15 V DC +24 V DC	Analyzer Assembly
Blower/Fan and Alarm Assembly	Pneumatics/Fan Assembly
Demand Valve	Pneumatics/Fan Assembly
3-Way Valve (SV0)	Pneumatics/Fan Assembly

BLOCK DIAGRAMS

A brief description will be given for the circuit board functions and hardware devices of the Vmax Encore 229. Only the differences between systems with fewer hardware options will be discussed in subsequent block diagram descriptions.

VMAX ENCORE 229 BLOCK DIAGRAM

The Vmax Encore 229 is a pulmonary function/cardiopulmonary exercise testing instrument. As stated earlier, this is the most feature-packed system of all Vmax Encore Series instruments. The Vmax Encore 229 contains a complete set of hardware devices (all available devices for the Vmax Encore Series instruments).

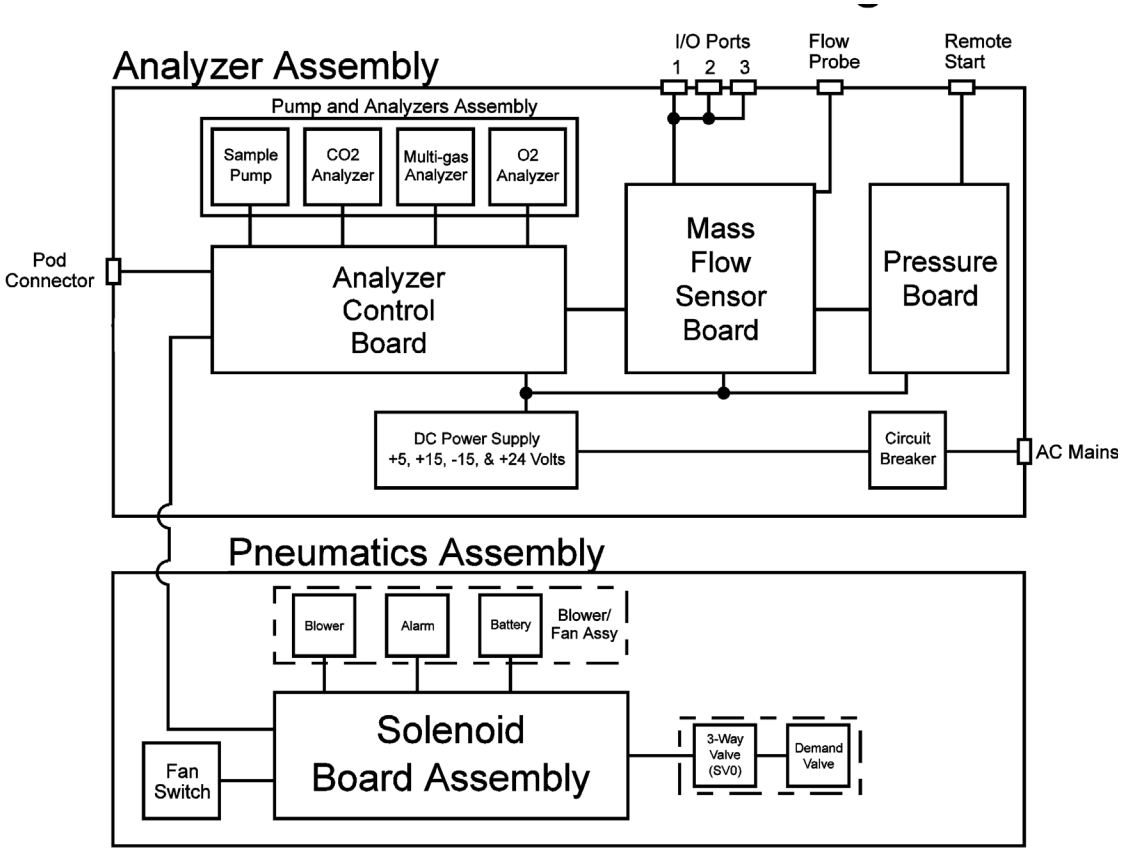


Figure 2-4 Vmax Encore 229 Block Diagram

Pump and Analyzers Assembly

The Pump and Analyzers Assembly is mounted in the front of the Analyzer Assembly of all Vmax Encore Series instruments that require analyzers. It houses the Sample Pump, the O_2 Sensor, the CO_2 Analyzer, and the Multi-gas Analyzer.

Sample Pump

The Sample Pump pulls sample gas through the analyzers from the gas source for analysis. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests and calibrations.
- Single Breath O_2 tests and calibrations.
- DLCO tests and calibrations.
- Cardiopulmonary Exercise tests and calibrations.
- Indirect Calorimetry tests and calibrations.

The sampled gas can be from two source types listed below.

- From gas cylinders during the calibration of the gas analyzers.
- From patient's exhaled breath during various tests.

For a description of the circuitry that operates the sample pump, see the section "Analyzer Control Board" on page 2–7.

O_2 Sensor

The O_2 Sensor measures the amount of oxygen in the gas sample. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests.
- Single Breath O_2 tests.
- Cardiopulmonary Exercise tests.
- Indirect Calorimetry tests.

For a description of the signal conditioning circuitry for the O_2 Sensor, see the section "Analyzer Control Board" on page 2–7.

CAUTION! During the course of servicing the equipment, wear eye and hand protection if you notice liquid on or around the O_2 sensor, and heed all safety notices that are included in the procedure. For important safety information about the O_2 sensor, and for first-aid instructions, refer to the section "O2 Sensor" on page 1–10.

CO_2 Analyzer

The CO_2 Analyzer measures the amount of carbon dioxide in the gas sample. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests.
- Single Breath O_2 tests.
- Cardiopulmonary Exercise tests.
- Indirect Calorimetry tests.

For a description of the signal conditioning circuitry for the CO2 Analyzer, see the section “Analyzer Control Board” on page 2–7.

Multi-gas Analyzer

The Multi-gas Analyzer measures the amount of carbon monoxide (CO), and methane (CH_4) in the gas sample. It is utilized only during DLCO tests and calibrations.

For a description of the signal conditioning circuitry for the Multi-gas Analyzer, see the section “Analyzer Control Board” on page 2–7.

Circuit Breaker

The Circuit Breaker is mounted in the right front corner (facing the front of the Vmax Instrument) of the Analyzer Assembly. It is the main power switch for the Vmax Encore Series instruments.

Mass Flow Sensor Board

The Mass Flow Sensor Board is the largest circuit board in the Analyzer Assembly. It is host to a multitude of functions such as housing the Mass Flow Sensor conditioning circuitry and the barometric pressure transducer. It conditions all pressure transducer signals, controls the system logic, multiplexes all system signals and converts system signals from analog to digital.

Analyzer Control Board

The Analyzer Control Board is mounted above the Mass Flow Sensor Board in the Analyzer Assembly. It also is host to a multitude of functions such as controlling the sample pump, the blower/fan, valve actuation on the Solenoid Board, analog and TTL outputs. It also conditions the gas analyzer signals, and multiplexes analog input and gas analyzer signals to the Mass Flow Sensor Board.

Pressure Board

The Pressure Board is mounted along the left wall (facing the front of the Vmax Instrument) of the Analyzer Assembly. It houses the temperature thermistor, sample/mouth pressure transducer, and the direction sense transducer. It houses the solenoid valves for switching from measuring sample/mouth pressure and barometric pressure. It houses the valve for switching between the Sample-in

port and the Breath-by-breath port on the rear of the Analyzer Assembly. It also busses remote start signal to the Mass Flow Sensor Board.

DC Power Supply

The DC power supply is mounted along the right side (facing the front of the Vmax instrument) of the Analyzer Assembly. It provides supply voltages for all electronic, electrical, and electromechanical devices of the Vmax Encore Series instruments. Circuit boards use the +5, +15, and –15 volt power supplies for the TTL and op-amp circuits. The solenoid valves on the Solenoid Board use the +5 Volt supply. The blower/fan in the Pneumatics/Fan Assembly uses the +24 Volt supply.

Solenoid Board

The Solenoid Board is mounted in the Pneumatics/Fan Assembly. It houses all solenoid valves except the 3-way diffusion/O_2 gas valve. It busses the power and control voltages to the blower/fan assembly, the 3-way valve, and the alarm transducer.

Blower/Fan Assembly (with Alarm Transducer)

The Blower/Fan Assembly is mounted in the Pneumatics/Fan Assembly. It acts as the mixing chamber in nutritional assessment and mixing chamber exercise studies. The fan in this assembly is the dilution fan used to pull gas (usually room air) across the patient's face in a dilution study. The Alarm Transducer is mounted to this assembly on the left side (facing the front of the Vmax Instrument).

> **Note:**
>
> The demand valve and the 3-way valve are combined as one assembly.

Demand Valve

The demand valve supplies test gas to the patient during DLCO, SBO_2, and N_2 washout lung-volumes tests. The gas delivered is O_2 or the 3-gas diffusion mixture, depending on the test. The 3-way valve (SV0) switches between the gasses. O_2 is the default gas selection when the 3-way valve is de-energized.

3-Way Valve (SV0)

The 3-Way valve is a solenoid valve coupled to a pneumatic valve to act as switch between two high-pressure gas sources. When the 3-way valve is de-energized, O_2 is the gas that feeds through to the demand and balloon valves. When the 3-way valve is energized, the multi-gas diffusion mixture is the gas that feeds through to the demand and balloon valves.

VMAX ENCORE 29 BLOCK DIAGRAM

The Vmax Encore 29 is a Cardiopulmonary Exercise Testing Instrument that contains only those hardware devices necessary to perform metabolic measurement tests and calibrations.

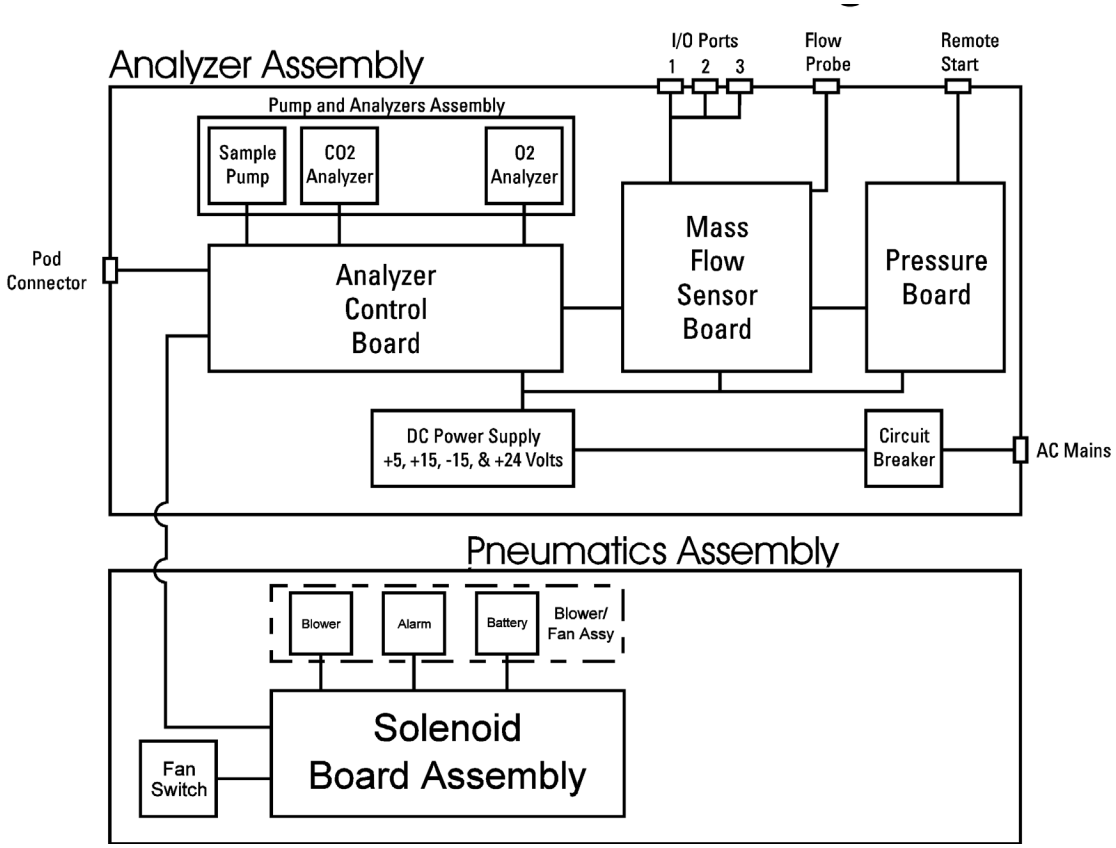


Figure 2-5 Vmax Encore 29 Block Diagram

Pump and Analyzers Assembly

The Pump and Analyzers Assembly in the Vmax Encore 29 differs from the one in the Vmax Encore 229 in two respects listed below.

- It does not have a multi-gas analyzer.
- The mounted devices (the sample pump, the O_2 sensor, and the CO_2 analyzer) are utilized only during the following tests.
  - Cardiopulmonary exercise tests and calibrations
  - Indirect calorimetry tests and calibrations

Hardware Devices Not Installed

The following devices are used only in pulmonary function tests where inspired test gases are required. These devices are not standard in the Vmax Encore 29 Instrument and are installed only when ordered as an option.

- Demand valve
- 3-way valve

VMAX ENCORE 22 BLOCK DIAGRAM

The Vmax Encore 22 is a Pulmonary Function Analysis Instrument. The modules of this system contain only those hardware devices necessary to perform Pulmonary Function tests and calibrations.

Note:

The blower/fan assembly is only used during metabolic measurement tests. This device is not standard in the Vmax Encore 22.

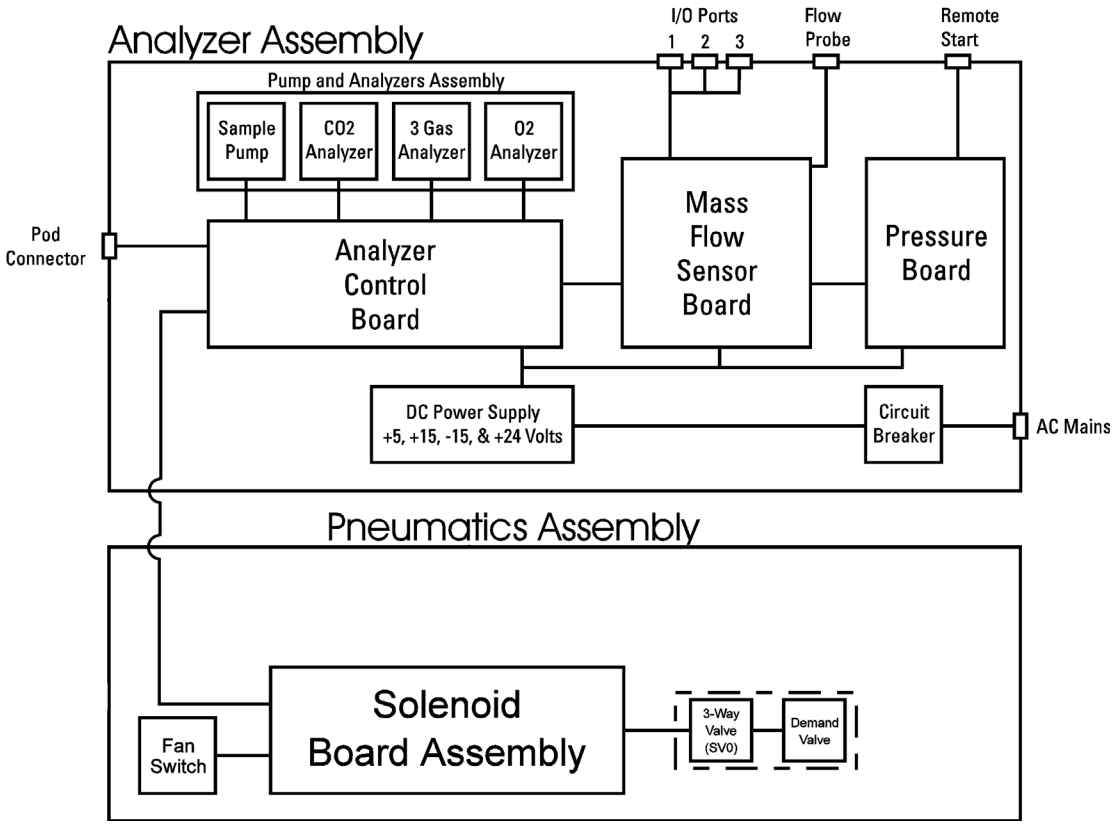


Figure 2-6 Vmax Encore 22 Block Diagram

Pump and Analyzers Assembly

The Pump and Analyzers Assembly in the Vmax Encore 22 is the same as the assembly in the Vmax Encore 229. The assembly houses the Sample Pump, the O_2 Sensor, the CO_2 Analyzer, and the Multi-gas Analyzer.

Sample Pump

The Sample Pump pulls sample gas through the analyzers from the gas source for analysis. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests.
- Single Breath O_2 tests.
- DLCO tests.

O_2 Sensor

The O_2 Sensor measures the amount of oxygen in the gas sample. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests and calibrations.
- Single Breath O_2 tests and calibrations.

CAUTION! During the course of servicing the equipment, wear eye and hand protection if you notice liquid on or around the O_2 sensor, and heed all safety notices that are included in the procedure. For important safety information about the O_2 sensor, and for first-aid instructions, refer to the section “O2 Sensor” on page 1–10.

CO_2 Analyzer

The CO_2 Analyzer measures the amount of carbon dioxide in the gas sample. It is utilized during the following tests along with their respective calibrations.

- N_2 Washout Lung Volumes tests and calibrations.
- Single Breath O_2 tests and calibrations.

Multi-gas Analyzer

The Multi-gas Analyzer measures the amount of carbon monoxide (CO), and methane (CH_4) in the gas sample. It is utilized only during DLCO tests and calibrations.

Hardware Devices Not Installed

The blower/fan assembly (with alarm transducer) is not installed.

Note:

The blower/fan assembly is only used during metabolic measurement tests. This device is not standard in the Vmax Encore 22.

VMAX ENCORE 20 BLOCK DIAGRAM

The Vmax Encore 20 is a Pulmonary Spirometry Instrument. This system does not have a lower module. The upper module contains only those hardware devices necessary to perform Pulmonary Function spirometry tests and calibrations.

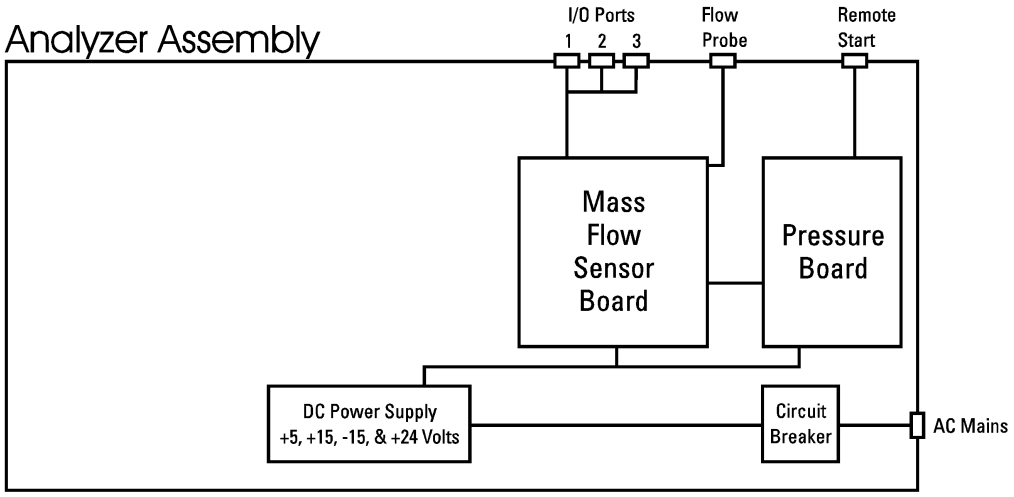


Figure 2-7 Vmax Encore 20 Block Diagram

Hardware Devices Not Installed:

Being a spirometry only system, the Vmax Encore 20 has no need for sample pumps or gas analyzers or the circuit board that controls any of those devices. Therefore, none of these devices are installed.

- Analyzer Control Board
- Pump and Analyzers Assembly

The following devices are all located in the pneumatics assembly, which is not part of the Vmax Encore 20 Instrument.

- Demand Valve
- 3-Way Valve
- Solenoid Board
- Blower/Fan Assembly (with Alarm Transducer)

MASS FLOW SENSOR BOARD

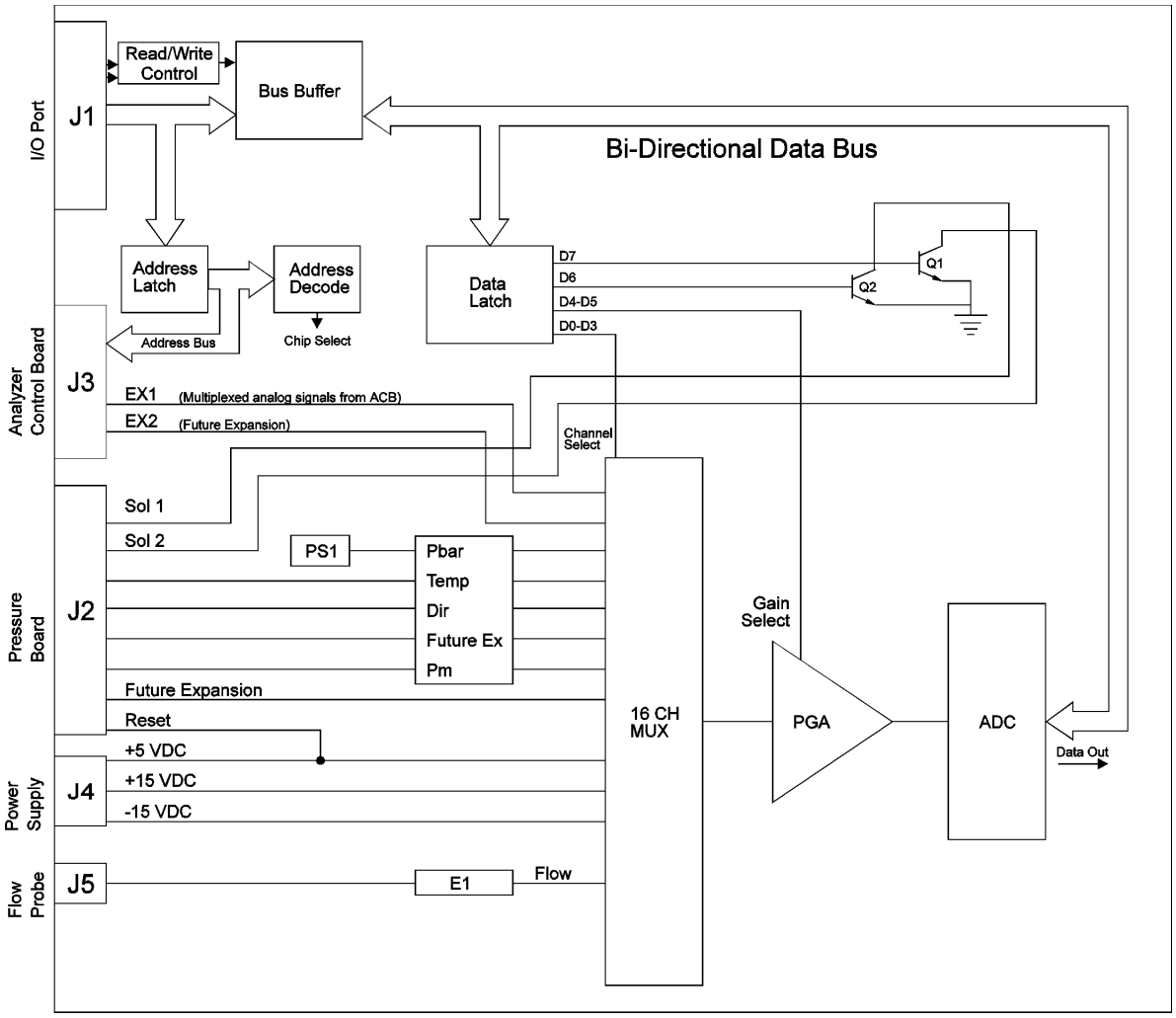


Figure 2-8 Mass Flow Sensor Board Block Diagram

The Mass Flow Sensor Board is the heart of the Vmax system. The block diagram of the circuit board is shown on the previous page and below is an enumerated list of the board's functions.

As stated earlier in the General description of this chapter, the Mass Flow Sensor Board is the largest circuit board in the Analyzer Assembly. It is host to a multitude of functions such as housing the Mass Flow Sensor conditioning circuitry and the barometric pressure transducer. It conditions all pressure transducer signals, controls the system logic, multiplexes all system signals and converts system signals from analog to digital.

MASS FLOW SENSOR BOARD FUNCTIONS

- Controls system logic and data flow to and from the PC.
- Provides buffering of I/O data for communicating with the PC
- Sensing and conditioning of the Mass Flow Sensor signal
- Generation of +10 V dc, -10 V dc and +10 V dc Aux
- Measure Sample and Barometric pressure
- Conditioning of the ambient temperature signal
- Conditioning of the Mouth Pressure and Direction Pressure signals
- Provides power, select logic, and drive voltage for the relays on the Pressure Board
- Decodes I/O data for A/D conversion and device control
- Provides A/D conversion for the following signals:
    - Dir (Direction)
    - E1 (Mass Flow Sensor signal)
    - PM (Mouth Pressure)
    - TEMP(Temperature)
    - +5 V dc/RS (+5 V dc and Reset Signal)
    - –15 V dc
    - +15 V dc
    - EX1 (Multiplexed signal from Analyzer Control Board
    - EX2 Not Used

SYSTEM LOGIC AND DATA FLOW

The System PC communicates with the Vmax Instrument through a bi-direction parallel printer port. From this port, eight data lines and two control lines are used to direct data to or from the PC.

The Vmax system logic consists of a read/write control circuit, a bi-directional bus transceiver (bus buffer), an address latch, an address bus, an address decoder, a data latch and a bi-directional data bus.

Read/Write Control

Read/Write control is a set by the two control lines provided through the bi-directional parallel printer port. In the write state, the bus transceiver is configured to pass data from the PC to the Vmax Instrument. In the read state, the bus transceiver is configured to pass data from the Vmax Instrument to the PC.

There are two write states: an address write state and a data write state. The address write state prepares a particular circuit on the Mass Flow Sensor Board or the Analyzer Control Board for the

following data read or data write operation. The data write state sets data on the data bus to be sent to the addressed circuit to control a particular function such as “Select a channel of the Mass Flow Sensor Board’s 16 channel multiplexer” or “Set an output voltage to an analog output channel”.

There is only one read state. During the read state data is being read by the PC from the A/D converter of the Mass Flow Sensor Board. The data being output by the A/D converter will be one of the 32 possible analog channels available from the Vmax Instrument (16 channels from the multiplexer on the Mass Flow Sensor Board and 16 channels from the multiplexer on the Analyzer Control Board multiplexed into EX1).

Address Latch and Address Decoder

The address latch is used in conjunction with the address decoder and address write state to select the Mass Flow Sensor zero, the Mass Flow Sensor clean, the data latch, the A/D converter, and the Analyzer Control Board’s valve select circuitry.

Data Latch

The data latch is used in conjunction with the address decoder and address write state to select the multiplexer channel, PGA gain, and Sol 1 and Sol2 (on Pressure Board) device drivers.

Bi-directional Data Bus

The bi-directional data bus is used in conjunction with the data write state and the read state. When the system is in the data write state, data on the data bus is sent to the device addressed during the previous address write state. When the system is in the read state, data on the data bus is sent out the I/O port to the PC.

MASS FLOW SENSOR CIRCUITRY

Depending on the test, the Mass Flow Sensor circuitry measures the flow. This circuitry is entirely different from previous generations of these products.

Mass Flow Sensor

The Mass Flow Sensor uses two metallic filaments to sense gas flow rate: a sensing filament and a reference filament. The reference filament monitors the temperature of gas while the sensing filament is maintained at a preset temperature (approximately 86ºC) above the temperature of the reference filament. As gas flows through the Mass Flow Sensor, the gas molecules remove heat from the sensing filament. To maintain the sensing filament offset temperature, more or less power is delivered to the sensing filament. This power change is an accurate measurement of the mass flow rate through the Mass Flow Sensor. Unlike volumetric flow, mass flow measurements are unaffected by changes in air pressure or temperature.

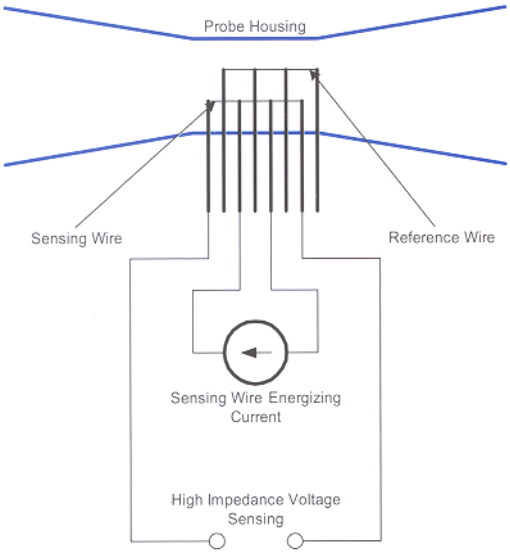


Figure 2-9 Mass Flow Sensor Circuit

The electronic circuit of the Mass Flow Sensor monitors the resistance of sensor filaments to determine their temperatures, so it is important that only the resistances of the filaments be measured. A new technique, Kelvin Sensing, and exclusive design are incorporated in the Vmax Encore Mass Flow Sensor to eliminate the influence of connector and cable resistance in the measurements.

The Vmax Mass Flow Sensor has eight metallic pins supporting the two filaments in the throat of the sensor. Currents are delivered to the filaments by sensor cables and these supporting pins. Resistances of the sensor cables, cable connectors, and the supporting pins can limit the accuracy of the filament resistance measurements. The new Vmax Encore Mass Flow Sensor gets around these limitations by employing an additional set of non-current carrying sensor cables and metal pins to provide the filament voltages to the electronic data processing circuits inside the Vmax module. This Kelvin Sensing arrangement provides filament resistance readings free of

contributions from the filament supports, cables, and connectors. As a result, the Vmax Encore Mass Flow Sensor is more sensitive and stable, and it stays calibrated over a longer period of time.

Since the reference filament resistance is determined by its temperature, Kelvin Sensing provides accurate reading of the gas temperature as well. The relatively low thermal mass of the filaments also gives the ability to track the rapidly changing gas temperatures encountered in all Vmax Encore diagnostic functions.

Error Amp and Power Amp

A1 is a high performance, low offset voltage drift amplifier, which is used to measure the difference (Error) in voltage between the “HOT” and “COLD” wires of the transducer. A1 has a gain of 1000 and drives A2, a power amplifier. A2 has a gain of 4 and is used to provide current to the sensor wires.

Auto Clean

The sensor wires of the transducer are automatically cleaned of deposits from the lung and mouth by intense heating when “Clean” is selected from the Vmax Mass Flow Sensor Calibration screen. During the “Clean” function, the computer provides a logic “0” to Q1, which in turn causes Q2 to conduct. Q2 then energizes K1, which applies a voltage to both sensor wires. The current, split equally between the wires, will be approximately 500 m A. The clean cycle lasts approximately 10 seconds.

Computer Controlled Calibration

The Mass Flow Sensor will always exhibit the following output voltage to flow curve. The output voltage at any given flow rate may vary from Mass Flow Sensor to Mass Flow Sensor, but the shape of the curve does not vary.

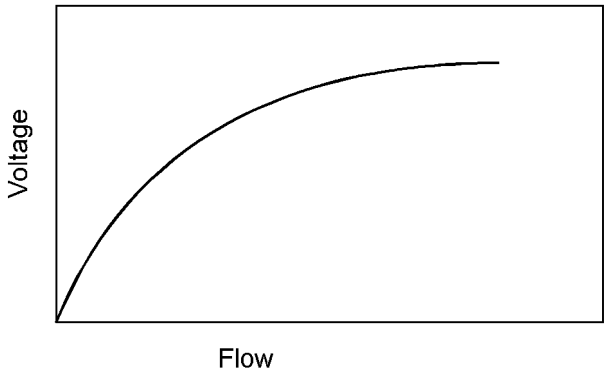


Figure 2-10 Mass Flow Sensor Constant Output Curve

Since the shape of the output curve is constant, the only variable is output voltage. Therefore, calibration consists of adjusting the slope (gain) of the output.

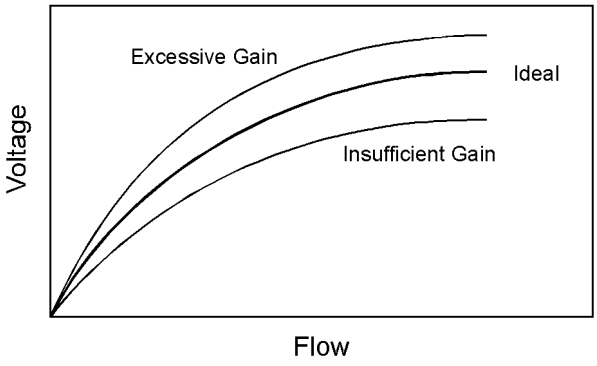


Figure 2-11 Output Voltage Gain Comparison to Ideal

The digital equivalent of the Mass Flow Sensor output signal is multiplied by a number determined during the calibration procedure to correct the gain.

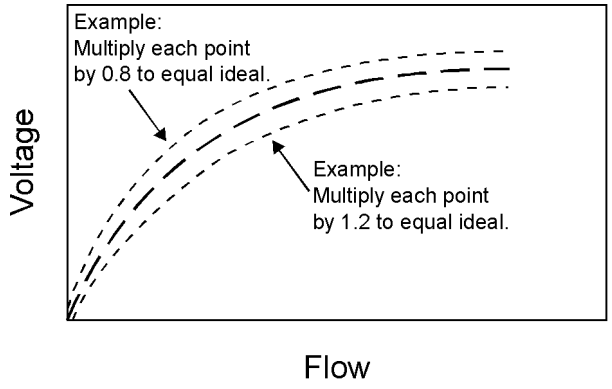


Figure 2-12 Output Voltage Gain Correction

Calibration

This chapter covers the calibration and verification of flow volume and calibration of plethysmograph pressure.

Note:

Calibrate the system at least once every testing day to ensure accurate test results.

Calibration Setup (Vmax and Autobox)

1. Select **1 Flow Sensor Calibration** on the Vmax Program Manager screen to access the Flow Volume Calibration screen.

Note:

For information on all the options accessible from the Flow Volume Calibration screen, refer to the reference manual.

2. Select **F1** on the Flow Volume Calibration screen.
   The Mass Flow Sensor Zero dialog box will be displayed.
3. Attach the calibration syringe to the Mass Flow Sensor using a cardboard mouthpiece and calibration hose or by using the calibration adapter. Stroke the syringe two times, and then select **Space Continue**.

> **CAUTION!** Do not use the FRC Adapter to connect the syringe for calibration. Use only the calibration hose or the flexible calibration adapter. Using the FRC Adapter will reduce the accuracy of the calibration.
>
> Do not unnecessarily move the mass flow sensor or the sensor cable. Excessive movement of these components may affect the accuracy and success of the calibration procedure.

A timer will count down to zero seconds before continuing to the zeroing routine.

Next, the Mass Flow Sensor will be automatically calibrated to zero gas flow. If the instrument fails the auto-flow sensor zero calibration, the following message will be displayed:

The Mass Flow Sensor Does Not Respond. Check the Sensor Cable or Substitute Another Sensor	Refer to the chapter "Maintenance and Troubleshooting."

When the zeroing routine is complete, the **Flow Volume Calibration** screen will be re-displayed.

Calibration Procedure (All Systems)

1. In the Vmax Program Manager, select **1 Flow Sensor Calibration**.
2. Select **F1** to open the Mass Flow Sensor Zero dialog box.
3. Connect the Mass Flow Sensor to the syringe, and do a room-air purge by performing two complete strokes.
4. Select **Spacebar to Continue**.

   The flow sensor automatically goes through a stabilizing and zeroing process. When this process is complete, the Calibration Bar Graph is displayed.
5. Perform inspiratory and expiratory strokes within the following target ranges:

   0 to 0.6 LPS

   0.9 to 1.6 LPS

   2.4 to 5.5 LPS

   7.0 to 12.0 LPS

These target ranges are shown on the graph in yellow. The bar graph segments on the right

turn to green when the mean flow rate of a stroke falls within the adjacent range.

If you complete 15 strokes, or the three-minute clock reaches zero, before you turn on the required number of green segments, the following message will be displayed:

Minimum Calibration Requirements have not been met. F1 to repeat calibration.	This message will be given if: • There are less than three green segments for the inspiratory strokes (in any combination). • There are less than three green segments for the expiratory strokes, and the second and third segments are not green. Select **F1** to repeat the calibration; select **Esc** to terminate the calibration and return to the Mass Flow Sensor Calibration screen.

If the required number of bar graph segments is turned to green before you complete the 15 strokes, or before the three-minute timer reaches zero, the **Calibration Bar Graph** screen is replaced by the **Calibration Verification** window. The following message will then be displayed:

Minimum Calibration Requirements have been met. F1 to repeat the calibration.	Select **F1** to repeat the calibration; select **F2** to accept the calibration.

This message is displayed either automatically or manually, as designated in the **Flow Volume Setup Calibration** dialog box. Refer to the *Vmax Reference Manual* for a description of this dialog box. You can now proceed to the next step.

6. In the **Verification** window, perform five full inspiratory and full expiratory strokes. Perform these strokes at the ATS (American Thoracic Society) recommended flow rates.

   Four of the five strokes are displayed and should appear as follows:

   - One stroke (inspiratory and expiratory) should reach the lowest dotted line (0.5 LPS).
   - One stroke (inspiratory and expiratory) should reach the highest dotted line (3.0 LPS).
   - One stroke should be halfway between the dotted lines (1.5 LPS).
   - One stroke (the fourth stroke) should represent a peak-flow rate near 12 LPS (8 LPS minimum). This stroke should be created without “banging” the piston at either end of the stroke.

Verification Procedure

CAUTION! Perform this procedure before testing each patient to prevent erroneous test results.

1. On the Flow Volume Calibration screen, select **F2**.
2. Perform five full inspiratory and full expiratory verification strokes of the syringe. Perform these strokes at the ATS (American Thoracic Society) recommended flow rates.

Note:

If a warning message box is displayed, it generally indicates that you need to perform a complete calibration procedure. You cannot proceed with patient testing until the system meets the verification criteria (a warning message is not displayed).

CAUTION! Do not proceed with patient testing if, after your repeated attempts to calibrate the instrument, the results fail to meet the verification criteria. Proceeding under this condition could cause erroneous test results. Refer to the chapter “Maintenance and Troubleshooting” on page 1.

Four of the six strokes are displayed and should appear as follows:

- One stroke (inspiratory and expiratory) should reach the lowest dotted line (0.5 LPS).
- One stroke (inspiratory and expiratory) should reach the highest dotted line (3.0 LPS).
- One stroke should be halfway between the dotted lines (1.5 LPS).
- One stroke (the fourth stroke) should include a peak-flow rate near 12 LPS (8 LPS minimum). This stroke should be created without “banging” the piston at either end of the stroke.

Plethysmograph Pressure Calibration Procedure

Note:

This procedure applies only to the Autobox.

CAUTION! Calibrate the pressure a least once every testing day to prevent erroneous test results.

Note:

Nobody should be inside the cabin during this procedure.

1. Select **F4** on the **Flow Volume Calibration** screen to access the Pressure Calibration window (Figure 2-13).

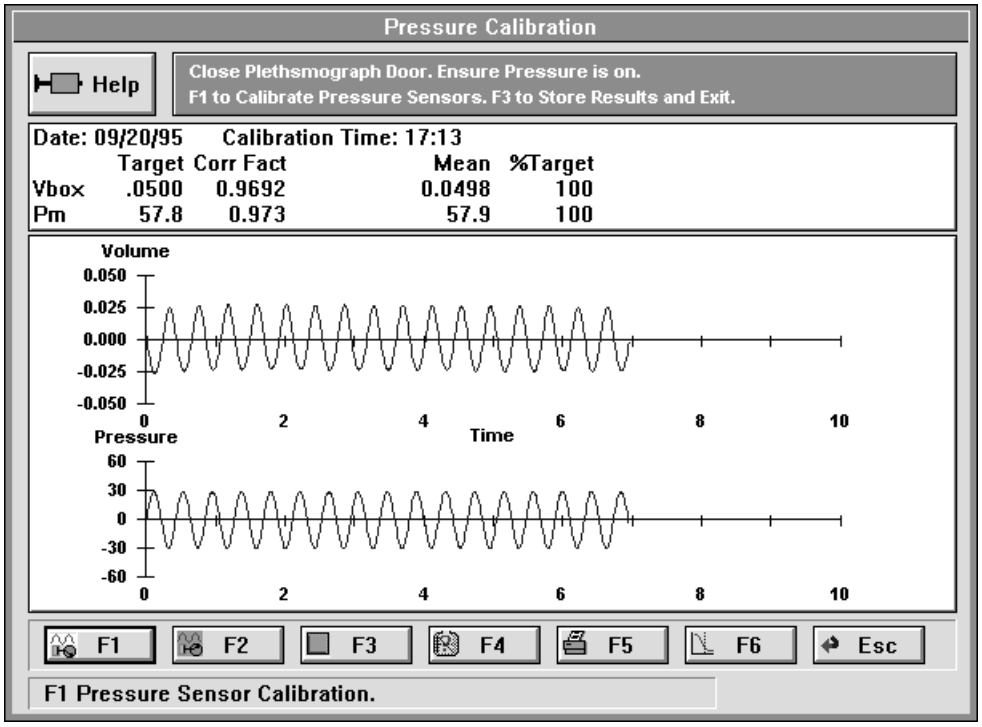


Figure 2-13 Pressure Calibration window

2. Close and latch the cabin door.
Make sure the gas cylinder is completely turned on and the secondary pressure gauge is set between 50 and 60 PSI (345–414 k Pa).

3. Select **F1** to begin the calibration procedure.

   The internal calibrator syringe will begin pumping 50 mL of air into and out of the cabin. The screen will display sixteen calibration strokes (red) followed by sixteen verification strokes (blue). When the procedure is complete, the Vbox and Pm values will be updated.

4. Verify that the %Target values for Vbox and Pm are within the range 97 to 103. If the values are not within this range, repeat the calibration.

CAUTION! Do not proceed with patient testing if, after your repeated attempts to calibrate the instrument, the results fail to meet the verification criteria. Proceeding under this condition could cause erroneous test results. Refer to the chapter “Maintenance and Troubleshooting” on page 1.

In addition to displaying the %Target values, the computer evaluates the correction factors calculated during the calibration procedure and displays a warning message if the factors are out of range.

CAUTION! Do not proceed with patient testing if the following warning message is displayed. Proceeding under this condition could cause erroneous test results.

The Calibration Factors are Out of Range. Ensure Gas Pressure is On and Door is Closed	This message means that one or both of the calculated calibration factors are out of range. The acceptable range for Vbox varies with the barometric pressure, but is approximately 0.7 to 1.3 at sea level. The acceptable range for Pm does not vary with barometric pressure and is always 0.7 to 1.3. Selecting **F1** restarts the calibration routine. This encourages you to do another calibration after failure of the Calibration Accuracy Standards. Selecting **Esc** allows you to ignore the warning message and displays the calibration verification results.

CAUTION! Do not proceed with patient testing if, after your repeated attempts to calibrate the instrument, the results fail to meet the verification criteria. Proceeding under this condition could cause erroneous test results. Refer to the chapter “Maintenance and Troubleshooting” on page 1.

Plethysmograph Pressure Verification Procedure

Note:

This procedure applies only to the Autobox.

Note:

Without performing another complete pressure calibration, you can perform a Pressure Verification Procedure to check the accuracy of the last calculated pressure-calibration factors.

Note:

Nobody should be inside the cabin during this procedure.

1. Select **F4** on the Flow Volume Calibration screen to access the Pressure Calibration window (Figure 2-13 on page 22).
2. Close and latch the cabin door.
   Make sure the gas cylinder is completely turned on and contains adequate pressure.
3. Select **F2** to begin the verification procedure.
   The internal calibrator syringe will begin pumping 50 mL of air into and out of the cabin. The screen will display 16 blue verification strokes. When the calibration is complete, the Vbox and Pm values will be updated.
4. Verify that the %Target values for Vbox and Pm are within the range 97 to 103.
   If the values are not within this range, perform a complete pressure calibration.

CAUTION! Do not proceed with patient testing if, after your repeated attempts to calibrate the instrument, the results fail to meet the verification criteria. Proceeding under this condition could cause erroneous test results. Refer to the chapter "Maintenance and Troubleshooting."

Verification

The 3-liter syringe may be operated a second time to determine that the gain adjustments were made properly. The verification should be utilized occasionally during the day to determine that atmospheric changes (temperature and pressure) have not changed sufficiently to cause an error in the reading.

BAROMETRIC PRESSURE CIRCUITRY

The barometric pressure transducer is comprised of a silicon chip with an integral sensing diaphragm and four piezoresistors encased in a plastic housing and mounted on the Mass Flow Sensor Board. Pressure applied to the diaphragm causing it to flex, changing the resistance, which results in a low level output voltage proportional to pressure. The sensing resistors are connected as a four-active-element bridge for linearity and sensitivity.

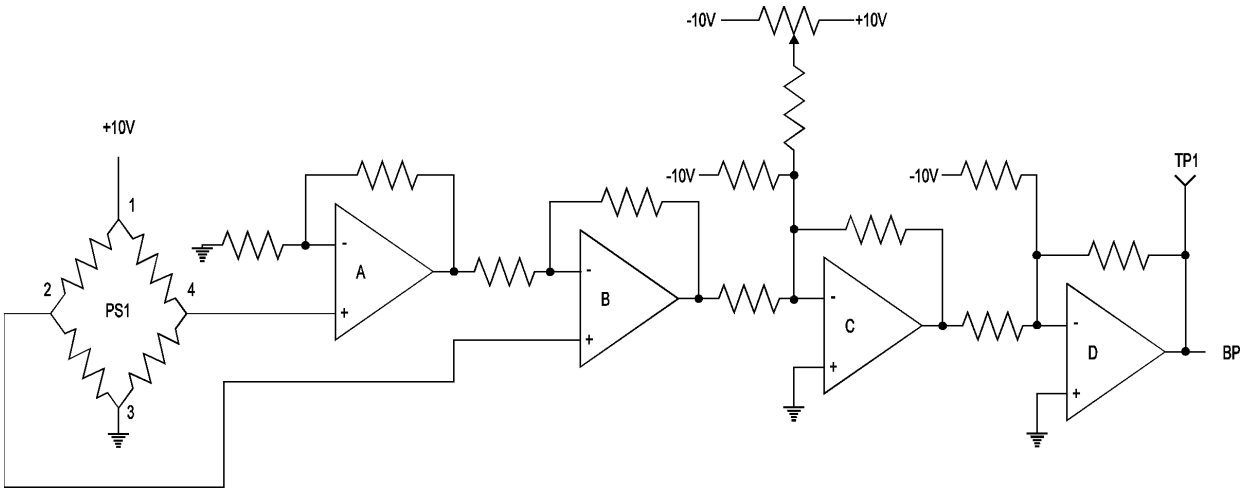


Figure 2-14 Barometric Pressure Signal Conditioning Circuitry

The barometric pressure transducer is a temperature compensated pressure sensor with a 0 - 15 PSI (0-776 mm Hg) sensing range. The supply voltage for the sensor is +10 V dc supplied by the reference voltage generator circuitry also on the Mass Flow Sensor Board. The maximum output voltage is –100 mV and the per-volt sensitivity is –6.67 mV.

The signal conditioning circuitry for the pressure sensor consists of 4 op-amps. The first two stages, U13-A and U13-B, are used as a null compensator for the sensor offset. The third stage, U13-C, is the offset amplifier used as an adjustment to match the output voltage to barometric pressure. The input of this stage is to the op-amp's negative input, inverting the output voltage. The forth stage, U13-D, is a gain amplifier. The output voltage at TP1 should be barometric pressure/10.

Example:
If the barometric pressure is 751 mm Hg, then the output voltage at TP1 should be +7.51 V dc.

ANALYZER CONTROLLER BOARD

The Analyzer Control Board is another main circuit board that carries out many functions. Its main function is to provide signal-conditioning circuits for all the system's analyzers and to provide source voltages for the CO_2 and Multi-gas analyzers. The functions of the Analyzer control Board are listed below.

- Provide signal conditioning circuitry for:
  - O_2 Sensor
  - CO_2 Analyzer
  - CH_4 signal from the Multi-gas Analyzer
  - CO signal from the Multi-gas Analyzer
- Provide Source voltages for the CO_2 and the Multi-gas Analyzers
- Provides switchable (off and on) +5 V dc to the sample pump
- Provides multiplexing of the following signals to the Mass Flow Sensor Board as EX1:
  - 8 analog inputs from External I/O pod
  - 3 ECG analog signals through the External I/O pod, from ECG pod
  - 4 analyzer output signals from item 1 above
- Provides 3 TTL control lines to the External I/O pod
- Provides 4 analog output signals to the External I/O pod
- Provides variable drive signal for the blower/fan in the Pneumatics Assembly
- Provides drive signals for solenoid valves in the Pneumatics Assembly on the Solenoid Board.
- Provides drive signal for the safety alarm in the Pneumatics Assembly on the blower/fan assembly.

PRESSURE BOARD

The Pressure Board is basically a mounting board for devices whose signals are processed on the Mass Flow Sensor Board. The functions of the Pressure Board are listed below.

- Houses the ambient temperature thermistor
- Houses the direction (DIR) pressure sensor
- Houses the mouth (PM) /sample pressure sensor
- Busses the remote start signal to the Mass Flow Sensor Board
- Houses solenoid 1 which acts as a solenoid shunt for the mouth (PM) or sample pressure transducer
- Houses solenoid 2, which switches between sampling gasses from the Breath-by-Breath (BxB) port or Sample In (SI) port
- Houses solenoid 3 which acts as a solenoid shunt for the direction (DIR) pressure transducer

SOLENOID BOARD

The Solenoid Board houses all the Pneumatics/Fan Assembly's solenoids and regulators for Cal 1 and Cal 2 gasses. It busses all the solenoid drive signals from the Analyzer Control Board. It also houses the. It busses drive signals for the Demand Valve Assembly. It also busses the variable drive signal for the blower/fan and the Alarm from the Analyzer Control Board. The functions of the solenoid valves are listed below.

- Sol 1 Not Used
- Sol 2 Not Used
- Sol 3 Switches between Cal gas and INSP port
- Sol 4 Switches from Cal gas/INSP (output of Sol 3) and DIL/MIX port (mixing chamber port on side of blower/fan)
- Sol 5 Switches between Hi and Low flow to the SO port
- Sol 6 Switches to evacuate the Gas port
- Sol 7 Provides drive gas to the Gas port balloon valve
- Sol 8 Provides drive gas to the Spir port balloon valve
- Sol 9 Provides drive gas to Sol 7 and Sol 8
- Sol 10 Provides Cal 2 gas to Sol 3, BxB port, and the Cal Overflow port
- Sol 11 Provides Cal 1 gas to Sol 3, BxB port, and the Cal Overflow port
- Sol 12 Provides DL/O_2 gas to Sol 3, BxB port, and the Cal Overflow port
- Sol 13 Switches to purge 3-Way Valve gas through the Test Mix port


Vmax
ENCORE

CHAPTER 3
MAINTENANCE AND TROUBLESHOOTING

MAINTENANCE

Install all items provided in the Annual Performance Check Kit (P/N 771635):

CLEANING

1. Remove all dust and dirt from all interior and exterior surfaces of the cart, console, or table.
2. Remove all dust and dirt from all surfaces of the computer, keyboard, and monitor.

COMPUTER

1. Ensure any adapter boards are secure.
2. Check for and remove any virus from the computer memory and hard-drive using “Anti-virus” software.

> **CAUTION!** If a virus is discovered, all software disks that may have come into contact with the computer must be “cleaned” or discarded. Make sure the customer is informed of the situation.

3. Note on the APC Record Form and FSR, the revision of Vmax Vision software being used.
4. Perform a Standard “SCANDISK” on the C drive, from the C:> of the computer.
5. Perform a Defrag on the C drive, from the C:> of the computer.

PRINTER

- Clean the interior and exterior surfaces.
- Perform a printer “self test” and ensure proper printing.

BATTERY/ALARM TEST

With the main power of the instrument turned OFF, turn ON the fan control switch that is located at the front of the Pneumatics/Fan Assembly. The alarm should activate within five seconds. Apply power to the system, the alarm should be silenced. Replace battery if necessary.

FRC SYRINGE VERIFY PROCEDURE

The FRC Syringe Verify Procedure can be used to check the accuracy and integrity of the entire Gas Dilution FRC test circuit.

- Perform a Mass Flow Sensor calibration and an analyzer calibration before proceeding with the FRC Syringe Verify Procedure.
- After the analyzer calibration, make sure the sample line is re-connected to the flow sensor port.
- The 100% Oxygen cylinder must be turned on completely and the secondary pressure gauge set between 50–60 PSI (345–414 k Pa).

1. Select **5 Pulmonary Function** on the Vmax Main menu. Next, select **A Lung Volumes** on the Pulmonary Function menu to display the Lung Volumes Test screen.
2. Select **Syringe Verify** from the Test menu. The FRC Verify Calibration Setup Box is displayed.
3. Enter the FRC Volume of the calibration syringe to be used in the FRC Syringe Volume Box. The FRC volume should be noted on the label of the syringe.

   Note:

   Do not adjust the FRC Factor at this time.

4. Select **F3** to store the syringe volume and return to the Lung Volumes Test Screen.
5. Select **F1** on the Lung Volumes Test Screen to begin the test procedure. The Oxygen Flush Dialog Box is displayed.
6. Select **Space** to flush the inspired test gas tubing with 100% oxygen.
7. Position the piston shaft at the etched line and connect the syringe to the Mass Flow Sensor using the FRC Adapter. (See Figure 3-1, “Calibration Syringe Adjustment/Attachment for FRC Verify.”)

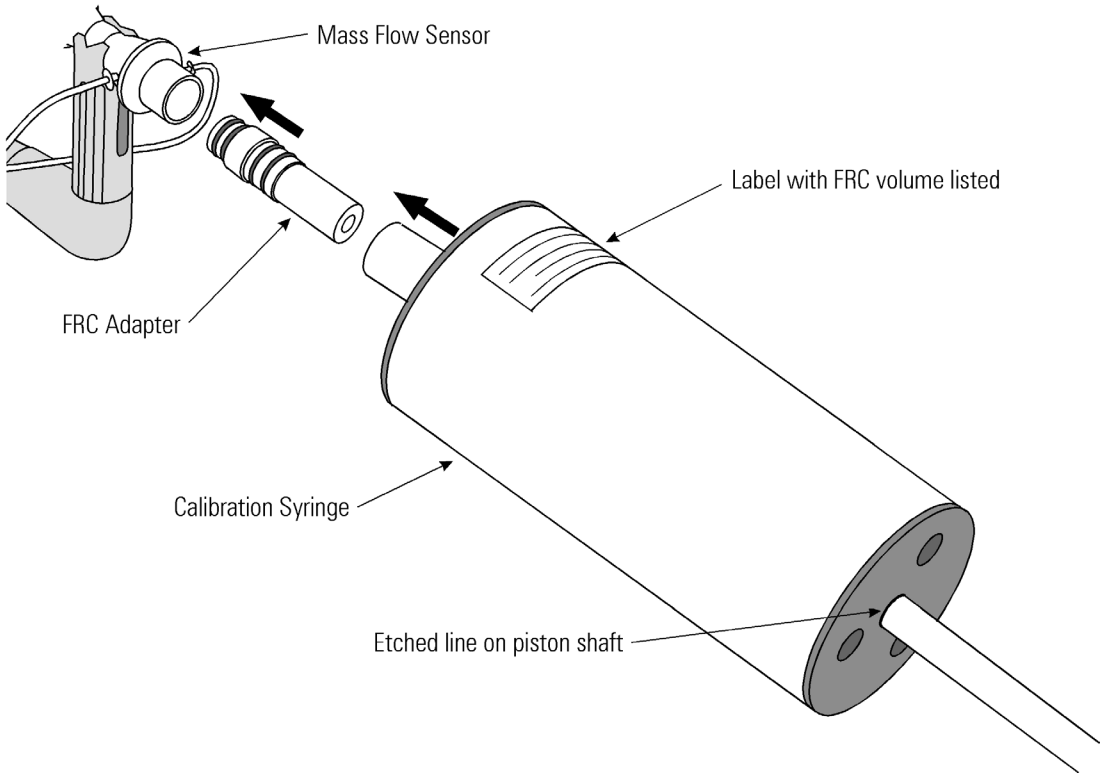


Figure 3-1 Calibration Syringe Adjustment/Attachment for FRC Verify

Note:

Do ***not*** use the flexible Calibration Adapter or any mixing chamber hose to connect the syringe to the Mass Flow Sensor; use the plastic FRC Adapter.

8. Stroke the syringe two times to fully flush the breathing valve with room air. ***Reposition the piston shaft at the etched line***.
9. Select **F1** to start the measurement procedure. Begin stroking the piston slowly, pulling the piston shaft all the way out, then pushing it back in to the etched line. This is the stroke volume for the FRC Verification (about 1/3 the full stroke volume). Try to be as accurate as possible, pulling the piston all the way out, then pushing it back in to the etched line.

Note:

During the FRC Verification procedure, the Lung Volumes Test screen is identical to screen displayed during a regular patient test, except for the Text Display at the top of the screen.

The Text Display shows the predicted FRC volume for the calibration syringe, the accumulating measured FRC volume, and the ratio of the measured volume to the predicted volume expressed as a percent.

10. Continue stroking the syringe until the message, "N_2 Stability Criteria Met" is displayed. Select **Space to End** and disconnect the syringe from the Mass Flow Sensor.

    The %Pred value displayed in the Text Box should be between 97–103. If it is not, you should check the breathing circuit and syringe attachment for poor connections or incorrect setup and then perform the procedure again.

    After multiple attempts, if the %Pred deviation is ***consistent*** and ***less than 8%***, you can select an FRC Correction Factor (range: –5% to +5%) in the FRC Verify Calibration Setup Box to compensate for the deviation. For example, if the measured syringe FRC was consistently 94% of predicted, you could set the FRC Factor to +5%, which should result in a consistent measured FRC of 99% of predicted.

    If the %Pred deviation is inconsistent, or greater than 8%, call technical support for assistance.

LUNG VOLUME STANDARD CALIBRATION

The Sensormedics Lung Volume Standard is the gold standard of isothermal volume control (IVC) devices. It is an optional quality assurance tool that can be used to verify the accuracy of V_{TG} measurement calibration. This self-contained unit is designed to be placed inside the cabin and controlled by an external foot switch. When activated, a precision four-liter flask will be compressed and decompressed by an internal piston at a typical panting frequency (2 Hz) and volume (90 mL). This enables the system to measure the flask volume as a V_{TG} and compare this to the known flask volume. The flask is filled with copper sponges to maintain an isothermal state.

Note:

The gas cylinder must be turned on completely and the secondary pressure gauge set between 50–60 PSI (345–414 k Pa).

1. Place the IVC box inside the cabin on the floor, and attach the power cables as shown in Figure 3-2, Lung volume standard setup components.

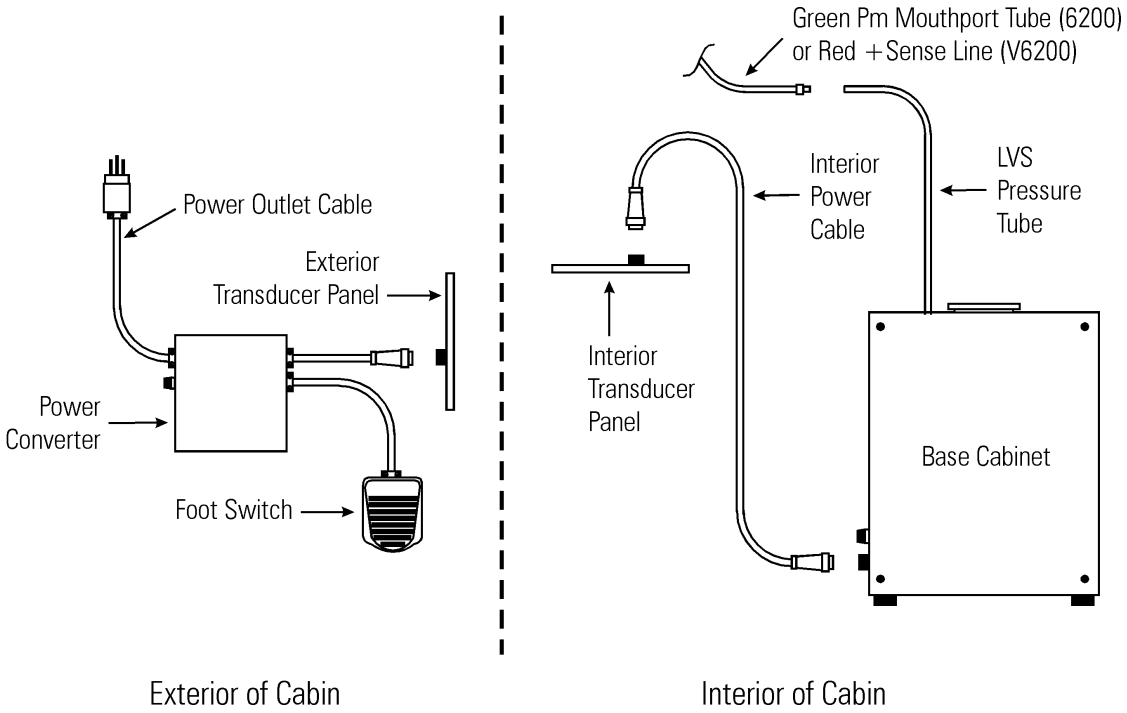


Figure 3-2 Lung volume standard setup components

2. Disconnect the pressure tubing from the patient mouth port and connect it to the clear plastic pressure tube on the top of the Lung Volume Standard.
3. Close and securely latch the cabin door.
4. Perform a Plethysmograph Pressure Calibration (with the Lung Volume Standard in the patient enclosure) as described in the plethysmograph-pressure calibration section of the Mass Flow Sensor calibration procedure.
5. Select **F4** from the Plethysmograph Pressure Calibration Menu to display the Isothermal Volume Control Verify screen (Figure 3-3).

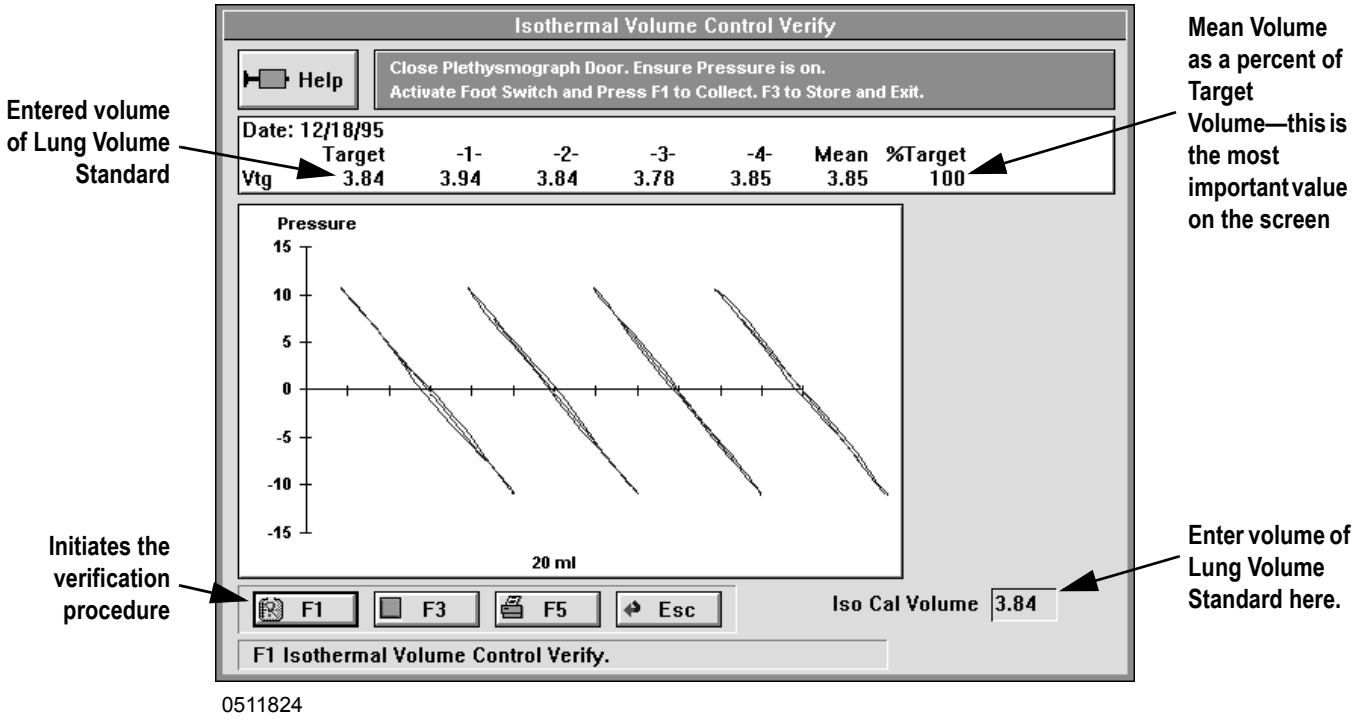


Figure 3-3 Isothermal Volume Control Verify screen

6. Enter the volume of the Lung Volume Standard (located on the serial number sticker) into the Iso Cal Volume Box. This will become the default volume and will be displayed in future calibrations.
7. Step on the foot switch to activate the Lung Volume Standard's internal piston.
8. Select **F1** to begin the VTG measurement procedure.

Note:

The test procedure ends automatically after approximately six seconds, and the last four collected loops are displayed.

9. Release the foot switch.

   The calculated VTG volume of the four displayed loops is shown in the data box at the top of the screen. The average of the four loops is displayed under "Mean." The mean value is compared to the target value and expressed as a percent under "%Target."
10. Verify that the %Target value is within the range of 97-103%. If the values are not within this range, repeat the procedure.

    To print a report of the test results, select F5.

Note:

The Lung Volume Standard Verification results are not permanently saved in the patient file and cannot be printed on the final report.

11. Select **F3** or **Esc** to exit and return to the Plethysmograph Pressure Calibration Menu.

ADJUSTMENTS

Before troubleshooting a problem with a pressure transducer, flow transducer, or gas analyzer, perform the procedures in this section to ensure that the transducers or analyzers have been properly aligned. It is not necessary to perform every alignment procedure; you only need perform the procedure(s) relevant to the situation. Before starting any of the procedures, however, do the following:

1. Before making any adjustments, allow system to warm up for at least 30 minutes.
2. Select Diagnostics from the Vmax main menu.
3. Reference the negative lead of voltmeter to TP8 (GND) for adjustments, unless otherwise noted.
4. Referencing the DIAGNOSTIC screen:

☐ =OFF ☒ =ON

Sample Pump Adjustment Procedure

1. Take a barometric pressure reading with a calibrated barometer.
2. Verify that the PBAR reading is +/- 0.5 from actual reading taken in the previous step.
3. If adjustment is necessary, connect the POSITIVE lead of the DVM to TP1 (Pbar) and adjust R17 for Barometric Pressure – mm Hg / 100 V dc, +/- .01 (that is 760 mm Hg / 100 = 7.6 V dc). Record the Pbar number.
4. Turn on the sample pump by putting a check mark in the white box, and then record the Pbar.
5. Calculate a percentage by dividing the number of the second reading by the number of the first reading and dividing the result by two. The percentage for Vmax systems is 84% to 85%; the percentage for body box systems is 83% to 84%.

Pneumatics Verification and Adjustment Procedures

Select Diagnostics from the main menu.

1. Oxygen Gas Supply Leak Test:
   a. Turn O2 supply gas ON and adjust regulator to 50 - 60 PSI.
   b. Turn O2 gas supply OFF. Pressure should not drop by more than 100 PSI, within 2 minutes. If so, locate source of leak and correct.
   c. Turn O2 gas supply ON when Leak Test is verified to be OK.
2. DLCO Supply Leak Test:
   a. Turn DLCO gas supply ON and adjust regulator to 70 - 80 PSI.

b. Select valve **L** (DLCO). Turn DLCO Supply OFF. Pressure should not drop by more than 100 PSI, within 2 minutes. If so, locate source of leak and correct.

c. Turn DLCO supply ON when Leak Test is verified to be OK.

3. Calibration Gas 1 & 2 Leak Test:

a. Turn Cal Gas 1 supply ON and adjust regulator to 50 PSI.

b. Turn Cal Gas 1 Supply OFF. Pressure should not drop by more than 100 PSI, within 2 minutes. If so, locate source of leak and correct.

c. Turn Cal Gas supply ON when Leak Test is verified to be OK.

d. Perform same operation for Cal Gas 2 supply.

MASS FLOW SENSOR BOARD ADJUSTMENT PROCEDURES

The test points and adjustment potentiometers for the procedures listed below are located on the Mass Flow Sensor Board. The voltages can be monitored with a voltmeter at the designated test points or by viewing the voltages on the Diagnostics Test screen.

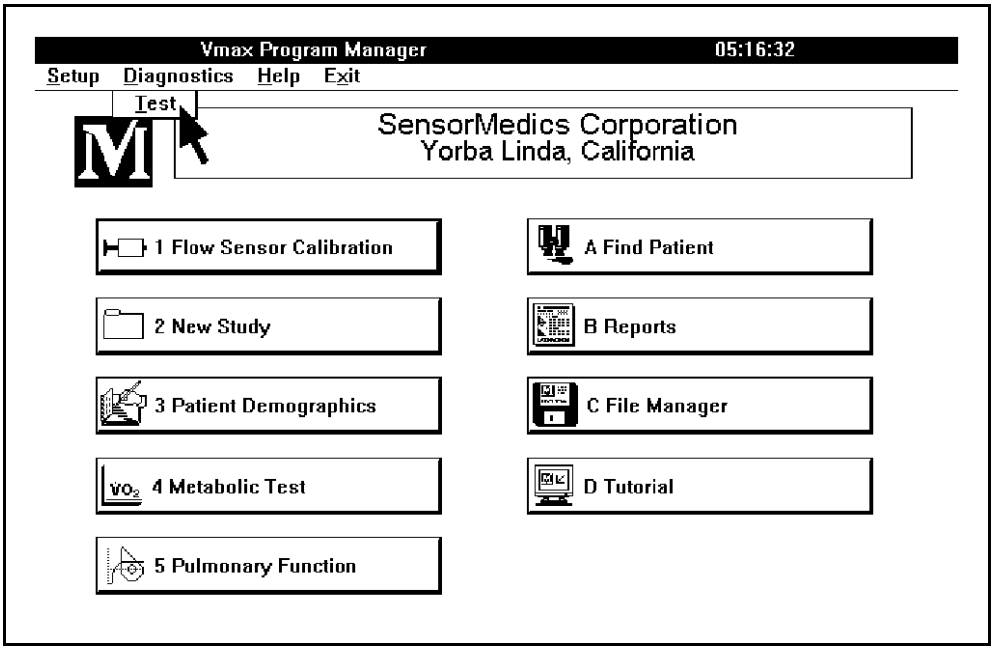


Figure 3-4 Vmax Program Manager Screen with Diagnostics selected

Access the Diagnostics Test Screen

To access the diagnostics test screen, from the Vmax Program Manager screen, select **Diagnostics** from the menu bar.

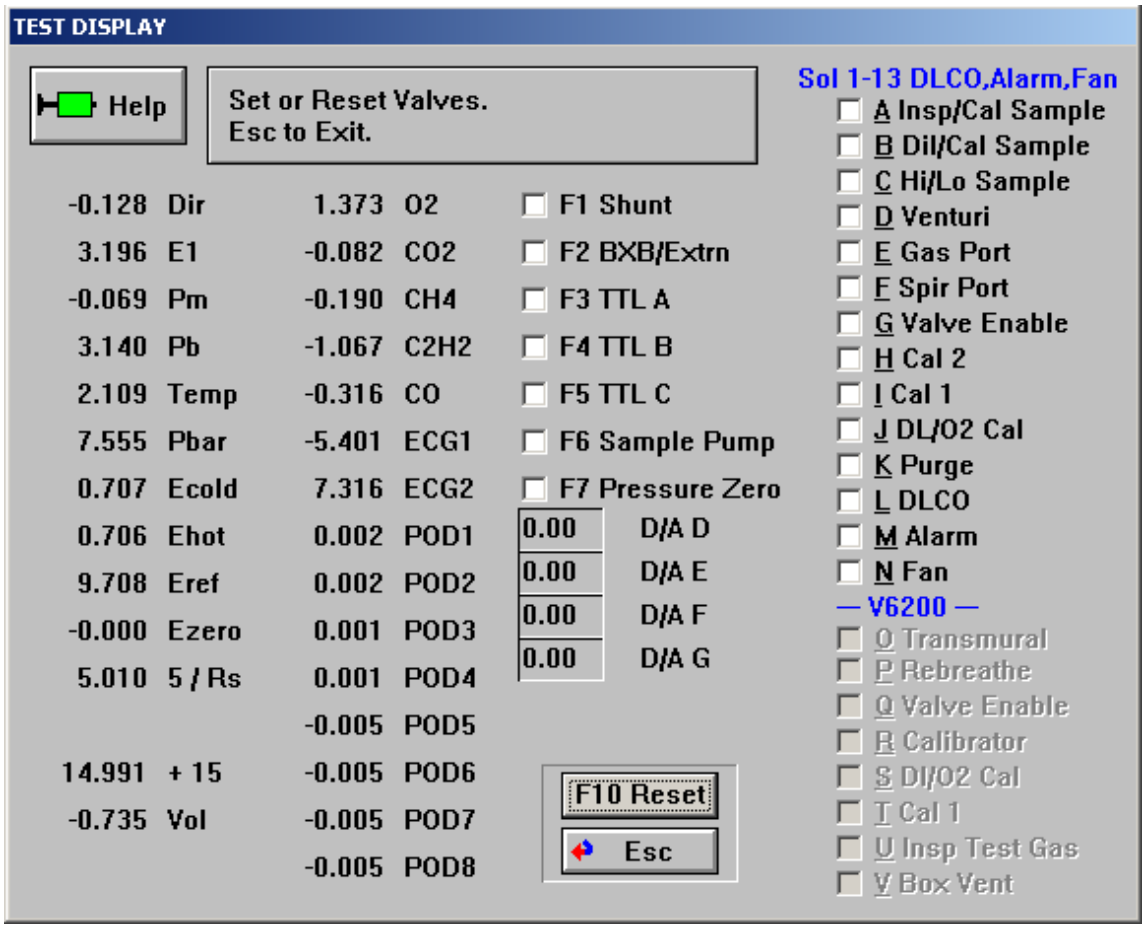


Figure 3-5 Vmax Diagnostics Test Screen

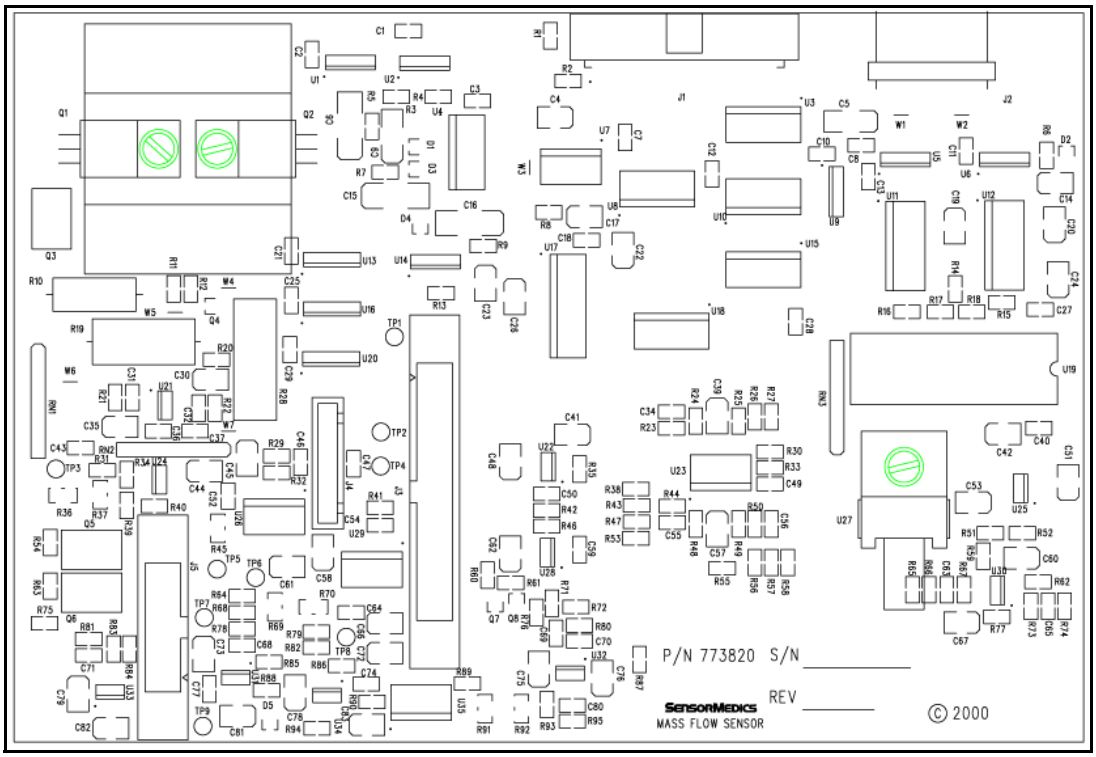


Figure 3-6 Mass Flow Sensor Board Component Layout

Temperature Transducer Adjustment

The temperature transducer must be adjusted to match the ambient temperature measured by a calibrated thermometer.

Note:

Make sure the unit is warmed up for 30 minutes before making adjustments.

1. On the Mass Flow Sensor board, connect the DVM positive lead to TP9 (Temp) and the negative lead to TP8 (analog ground).
2. With a calibrated thermometer, record the ambient (room) temperature in degrees Celsius.
3. Adjust R45 to (ambient temperature in degrees Celsius / 10) V dc ± 0.01 V dc.

   Example: If the ambient temperature is 23.5°C, adjust R57 to 2.35 V dc.

Barometric Pressure Transducer Adjustment

The barometric pressure transducer must be adjusted to match the ambient barometric pressure measured by a calibrated barometer.

1. On the Mass Flow Sensor board, connect the DVM positive lead to TP1 (Pbar) and the negative lead to TP8 (analog ground).
2. With a calibrated barometer, record the ambient (room) barometric pressure in mm Hg.

3. Adjust R92 to (ambient barometric pressure in mm Hg / 100) V dc ± 0.01 V dc.

   Example: If the ambient barometric pressure is 755 mm Hg, adjust R17 to 7.55 V dc.

Mouth Pressure Transducer Adjustment

The mouth pressure transducer must be calibrated for zero and span. Zero is adjusted with the transducer exposed to room air. Span is adjusted while the mouth pressure transducer is pressurized to a known pressure being monitored by a calibrated pressure manometer.

1. On the Mass Flow Sensor board, connect the DVM positive lead to TP3 (Pm) and the negative lead to TP8 (analog ground).
2. Ensure “F7 Pressure Zero” is off (blank box next to label).
   If “F7 Pressure Zero” is on (an “X” in the box next to the label), press **F7** to turn it off.
3. Adjust R70 to 0.00 V dc ± 0.01 V dc.
4. Press **F7 Pressure Zero** on (an “X” in the box next to the label).
5. Using a calibrated pressure manometer, inject 150 cm H_2O at the DIR+ connector (red port) in the rear of the Analyzer Assembly.
6. Adjust R69 to 3.5 V dc ± 0.05 V dc.
   The pressure should not decay by more than 3 cm H_2O after 1 minute. If it does, there is a leak that must be identified and corrected before this procedure can be completed.
7. Repeat steps 2 through 6 until no further adjustments are necessary.
8. Ensure “F7 Pressure Zero” is off (blank box next to label).

Direction Pressure Transducer Adjustment

The direction pressure transducer’s zero voltage must be adjusted to ensure proper direction sense.

1. On the Mass Flow Sensor board, connect the DVM positive lead to TP4 (Dir) and the negative lead to TP8 (analog ground).
2. Turn on the shunt solenoid by pressing “F1 Shunt” on (an “X” in the box next to the label).
   If “F1 Shunt” is off (a blank box next to the label), press F1 to turn it on.
3. Adjust R91 to 0.00 V dc ± 0.01 V dc.
4. Turn off the shunt solenoid by pressing “F1 Shunt” on (a blank box next to the label).

ANALYZER CONTROL BOARD ADJUSTMENT PROCEDURES

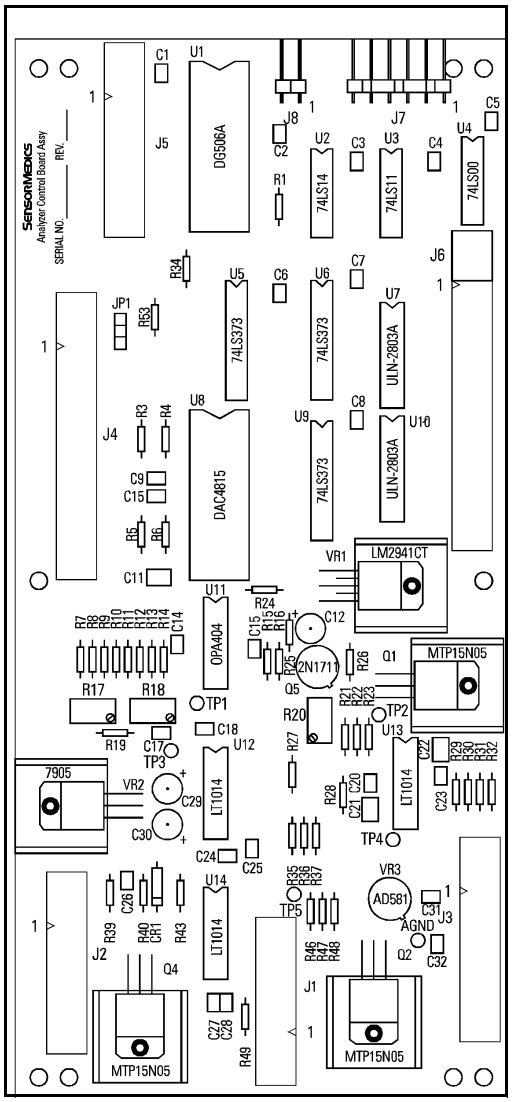


Figure 3-7 Analyzer Control Board Component Layout

As with the Mass Flow Sensor Board adjustments, the test points and adjustment potentiometers for the procedures listed below are located on the Analyzer Control Board. The voltages can be monitored with a voltmeter at the designated test points or by viewing the voltages on the Diagnostics Test screen.

CO_2 Analyzer Zero Adjustment

The CO_2 analyzer's zero voltage must be adjusted to ensure proper operation. The adjustment procedure is outlined below.

1. On the Analyzer Controller board, connect the DVM positive lead to TP3 (CO_2) and the negative lead to AGND (analog ground).
2. Turn on the sample pump by pressing "F6 Sample Pump" (an "X" in the box next to the label). Turn on valve H.
3. Adjust R17 to 0.00 V dc ± 0.50 V dc.
4. Turn off the sample pump by pressing "F6 Sample Pump" (a blank box next to the label). Turn off valve H.

Multi-gas Analyzer CO Zero

The Multi-gas analyzer's CO zero voltage must be adjusted to ensure proper operation. The adjustment procedure is outlined below.

1. On the Analyzer Controller board, connect the DVM positive lead to TP2 (CO_2) and the negative lead to AGND (analog ground).
2. Turn on the sample pump by pressing "F6 Sample Pump" (an "X" in the box next to the label).
3. Adjust R38 to 0.00 V dc ± 0.50 V dc.
4. Turn off the sample pump by pressing "F6 Sample Pump" (a blank box next to the label).

Multi-gas Analyzer CH_4 Zero

The Multi-gas analyzer's CH_4 zero voltage must be adjusted to ensure proper operation. The adjustment procedure is outlined below.

1. On the Analyzer Controller board, connect the DVM positive lead to TP4 (CH_4) and the negative lead to AGND (analog ground).
2. Turn on the sample pump by pressing "F6 Sample Pump" (an "X" in the box next to the label).
3. Adjust R20 to 0.00 V dc ± 0.50 V dc.
4. Turn off the sample pump by pressing "F6 Sample Pump" (a blank box next to the label).

O_2 Sensor Replacement

This procedure provides instructions for removing and replacing the O_2 sensor, which must be replaced annually.

WARNING! Turn off and unplug your system before removing the cover of the unit. Removing the cover without removing the power will expose a potential electrical-shock hazard that could result in serious injury or death.

CAUTION! During the course of servicing the equipment, wear eye and hand protection if you notice liquid on or around the O_2 sensor, and heed all safety notices that are included in the procedure. For important safety information about the O_2 sensor, and for first-aid instructions, refer to the section "O2 Sensor" on page 1–10.

To remove the old sensor:

1. Make sure that the power is turned off and that the power cord is disconnected.

CAUTION! Take precautions to prevent damage from electrostatic discharge (ESD). Removing the cover of the Vmax module exposes static-sensitive components that could be damaged by ESD.

2. Remove the cover retaining screws from the back of the Vmax module (Figure 3-8), and gently remove the cover.

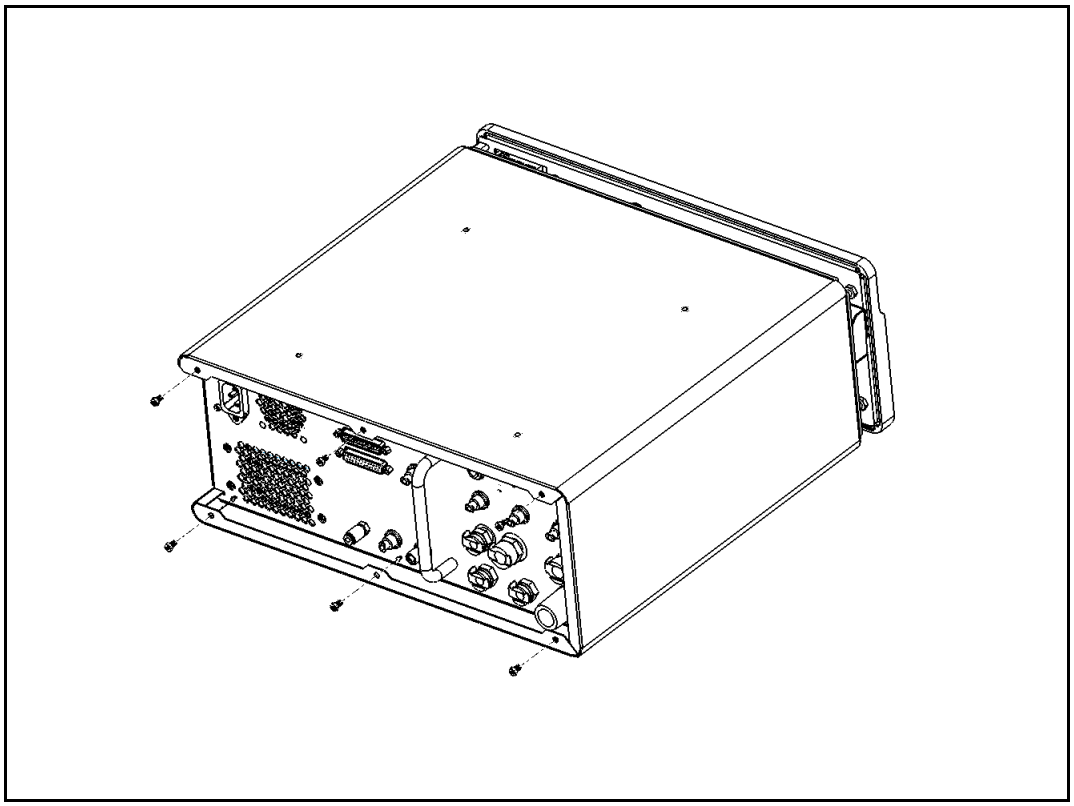


Figure 3-8 Cover Screws

3. Unfasten the strap that secures the O_2 sensor, which is at the front of the module (Figure 3-9).

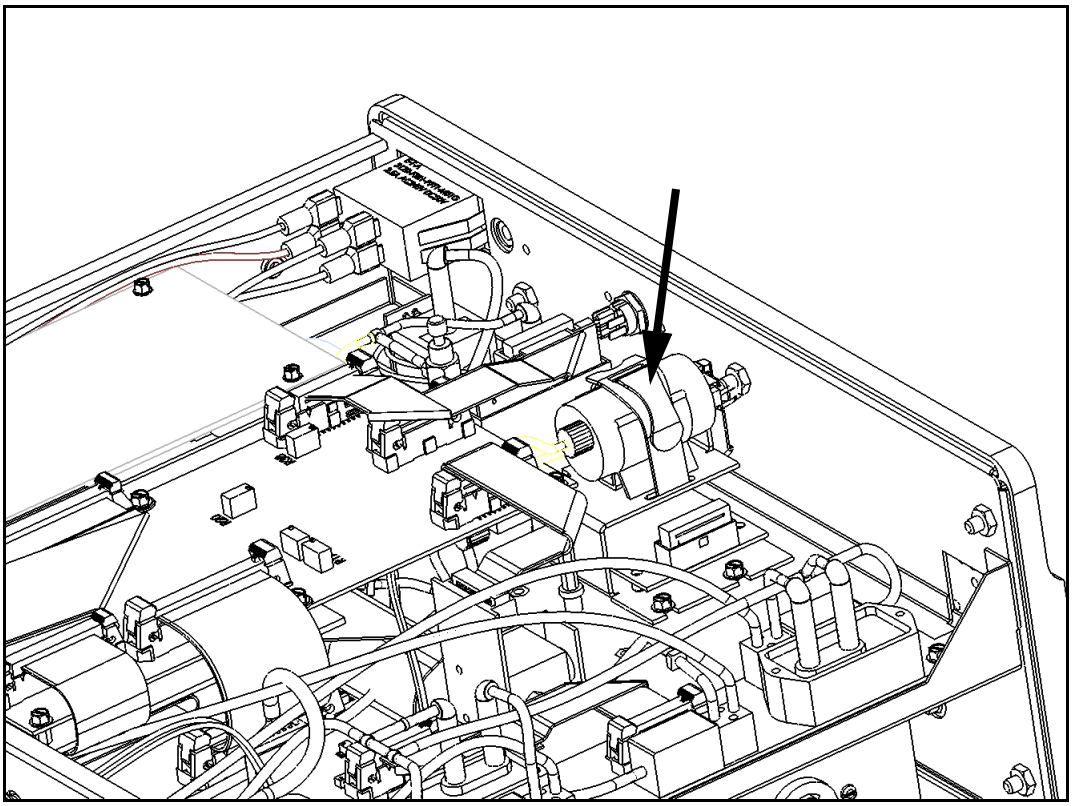


Figure 3-9 Sensor Retaining Strap

CAUTION! Do not twist or pull the ribbon cable up or down. Twisting or pulling the cable could damage the connector pins.

4. Disconnect the ribbon cable by carefully pushing outward on the two locking “ears” of the connector (Figure 3-10).

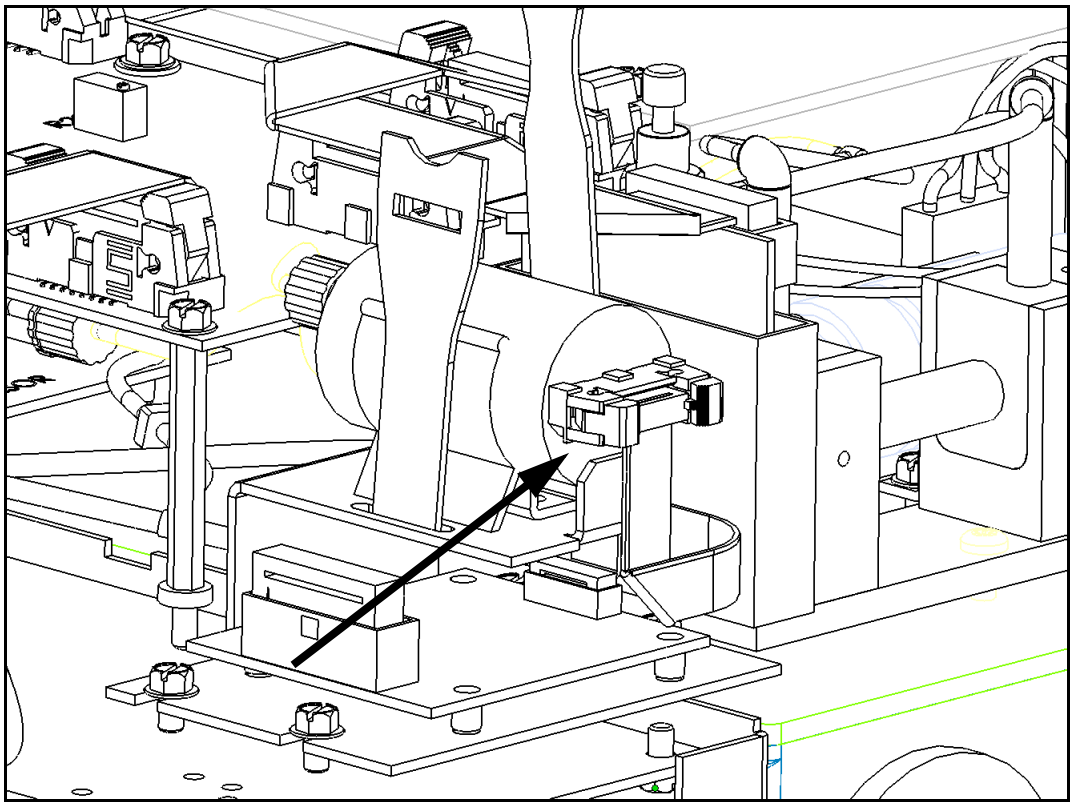


Figure 3-10 Ribbon Cable Connection

5. Disconnect the luer fittings (Figure 3-11).

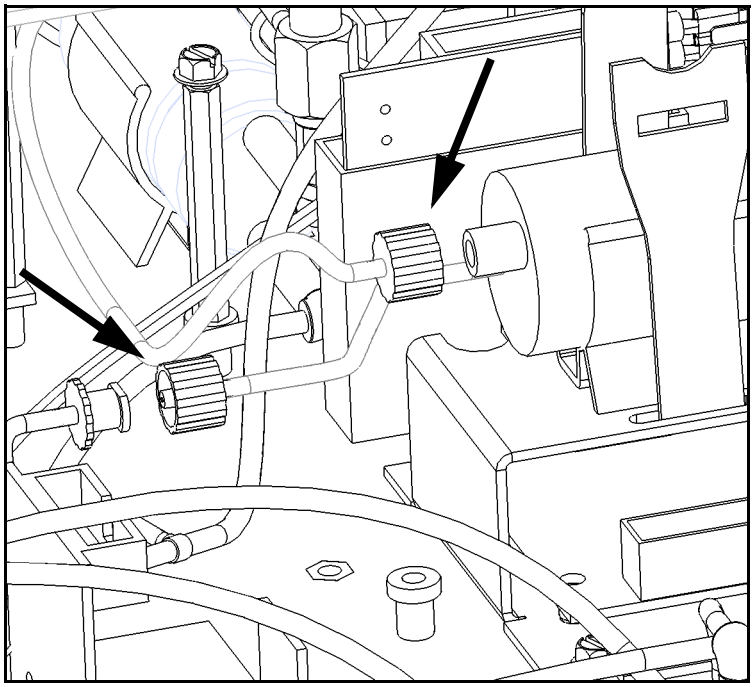


Figure 3-11 Luer Fittings

6. Carefully lift the old O_2 sensor out of the cradle and set the sensor aside.
7. Remove the new O_2 sensor from the packing tube, and inspect the sensor for damage. Put the old sensor into the packing tube and replace the lid.
8. On the new sensor, twist the white luer fitting to loosen it and disconnect it from the O_2 cell port.

Note:

Notice the slot on the bottom of the sensor connector (Figure 3-12). This slot must face downward as you seat the new O_2 cell into the cradle so that the cable connector attaches correctly.

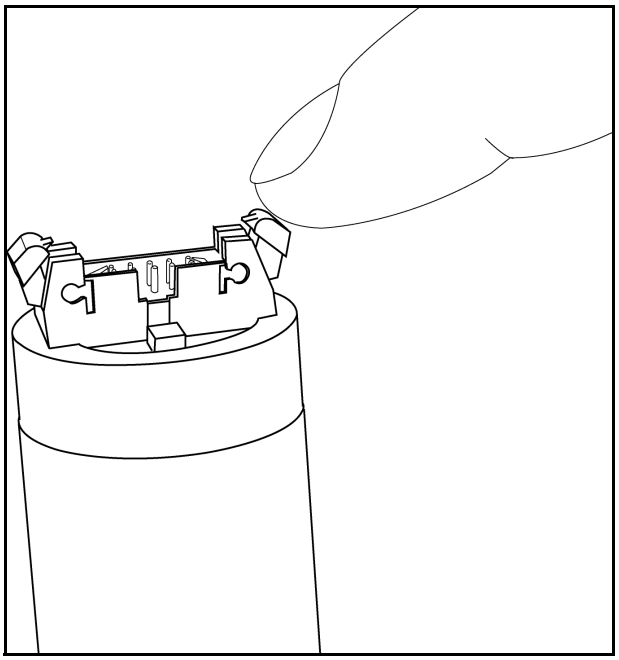


Figure 3-12 O_2 Sensor Connector

9. Position the O_2 Sensor in the cradle, and reconnect the luer fittings to the sensor.
10. Carefully connect the ribbon-cable to the O_2 sensor, close the locking ears to secure the connector, and refasten the strap.
11. Slide the cover of the unit back into place and tighten the cover retaining screws.
12. Dispose of the old O_2 cell according to the toxic-material handling procedures of your facility.

Analyzer Zero Adjustment Matrix

The table below is a quick reference to the adjustment potentiometers, voltmeter lead placements, voltages and tolerances for the Vmax Systems analyzer zero adjustments.

Table 3-1: Analyzer Zero Adjustments

Gas Signal	Adjustment	+ Lead	- Lead	Voltage	Tolerance
CH_4	R20	TP4	AGND	0.00	± 0.50
CO	R38	TP2	AGND	0.00	± 0.50
CO_2	R17	TP3	AGND	0.00	± 0.50

Note:

Perform Zero adjustments with the sample pump on.

Balloon Pressure Adjustment Procedure

1. Turn on valve L, and then turn on valves G and E.
2. Measure the pressure at the gas port of the two-lumen tube, and adjust the low-pressure regulator in the pneumatics assembly to 6.3 psi +0.2 psi.
3. Turn valve J on, and then off. The pressure reading should return to the set pressure within 0.2 psi. If it does not, re-adjust the low-pressure regulator to the set pressure, then turn valve J on and off again, and then re-check the pressure reading. Record the reading as “Reading 1.” After obtaining the set pressure, it should not rise over 7.0 psi.
4. When the reading settles, record the reading as “Reading 2.”
5. Turn off valve L. The pressure should not change by more than 0.6 psi. Record the reading.
6. Turn off Valve G. Measure and record the pressure after 30 seconds at the gas port of the two-lumen tube. The pressure may not decrease by more than 0.1 psi. Turn off valve E.
7. Turn on valves G and F. Measure and record the pressure at the spirometry port of the two-lumen tube.
8. Turn valve G off and record the pressure after 30 seconds. The pressure may not decrease by more than 0.1 psi.
9. Turn on valve K and listen for a rush of gas from the gas supply hose. Turn off valve K.
10. Turn on valves E and G, and wait for the gas port balloon to inflate. Turn valve E off.
11. Turn on valve D for approximately one second, and then turn it off.
12. Ensure that the gas-port balloon valve deflates completely and remains completely deflated for at least fifteen seconds, and then press **F10**.
13. Attach the gas supply hoses to the rear of the pneumatics assembly to be tested.
14. Open the gas supplies and adjust the secondary pressure of DLCO to 80 psi and O_2 to 60 psi. Adjust the secondary pressure of the two CAL gases to 50 psi.

15. From the main menu of the Vmax software, select **Diagnostics**. Connect a 3-liter syringe to the flow sensor then select valves G.

Body Box Calibration Procedure for V62/62J

1. Turn on the PC and, from the Main menu of the Vmax software, ensure that the button in the lower left of the screen reads “Autobox.” If it does not, press the **F1** key.
2. Select **2 – New Study**. For the Patient Name, enter the Autobox configuration being tested. For the ID Number, enter the serial number of the instrument. For the “Tested By” enter your name and stamp number. Enter all other relevant information, such as age, race, height, and weight. Store the information by pressing **F3**.
3. Click **Diagnostics** on the menu bar of the Vmax main menu, and proceed to the Test Display window. In the Test Display window, you can read any of the analog inputs, as well as enable or disable any of the control lines of the system. To enable a control line, enter the reference designator next to the description, or single click the box next to the designator or the descriptor. An X appears in the box when the line is enabled.

Adjustments and Verification of Analog Channels

Note:

The values on the Test Display screen can be used instead of the actual test points. The corresponding channel descriptor can be found in parenthesis next to the test point number in the step.

1. Ensure that the Autobox is in communication with the Vmax by reviewing the analog channel voltages and enabling all control lines. There should be an audible click for each of the solenoids. Press **F10** to reset all.
2. Connect the DVM positive lead to TP1 (Temp) on the Vmax MFB (Mass Flow Board) and verify that the ambient temperature in degrees Celsius/10 V dc ± 0.01 V dc, after measuring the ambient temperature with a calibrated thermometer. (Measure the ambient temperature as close as possible to TH1 on the Vmax Pressure Board.) If necessary, adjust R45 on the MFB.
3. Connect the DVM positive lead to TP4 (Pbar) on the Vmax MFB and verify the barometric pressure (mm Hg / 100) V dc ± 0.01 V dc, after measuring the barometric pressure with a calibrated barometer. If necessary, adjust R92 on the Vmax MFB.
4. Ensure that **F7 – Pressure Zero** is off, and connect the DVM positive lead to TP6 (Pm) on MFB. Verify that the reading is 0.00 V dc ± 0.01 V dc. If necessary, adjust R70 on MFB.
5. Press **F7 (ON)**, and then pressurize the red port on the pass through in the box to approximately 150 cm H_2O by using the digital pressure meter and a syringe. The reading should be (pressure setting / 30) V dc ± 0.05. The pressure should not decay by more than 3 cm H2O after one minute. If necessary, adjust R69 on the MFB.

   Repeat Steps 4 and 5 until no adjustment is necessary.

6. Select **F1 (Shunt)**, then inspire and expire using the 3-liter syringe connected to the mass flow meter inside the cabin. Observe the "Dir" signal on the Test Display. Inspiring generates a negative voltage; expiring generates a positive voltage. Press **F10** to re-set all valves.
7. Press **F6** to turn on the Sample Pump. Allow a 20-minute warm-up period with the cover installed.
8. Note the "Pb" (box pressure) reading on the screen and adjust the Autobox pressure board zero pot to 0.00 V dc ±0.010 V dc.
9. Select **F1 (Shunt)** and **O (Transmural)**. Using a pressure meter and syringe, inject 4 cm H2O into the Pb port on the pass through plate in the cabin. Adjust the Autobox pressure board span pot to 8.0 V dc ±0.05 V dc.
10. Remove the pressure and turn off the “Shunt”.

    Repeat steps 8 and 9 until both voltages are within tolerance.
11. Disconnect the green tubing (the negative side) from the ‘Pb’ plenum and pressurize the negative side of the Pb transducer to 4 cm H_2O. Pb should read -8.0 V dc ±0.075 V dc. This pressure should not drop by more than ½ cm H_2O in one minute.
12. Connect the pressure meter to the Pb port inside the cabin and pressurize to 5 cm H_2O. This pressure should not drop by more than ½ cm H_2O in one minute.

Volume Calibration and Verification Procedure

1. From the main menu, select **Flow Sensor Calibration** and then **F4 (Box Calibration)**. Connect the 3-liter syringe to the top port on the outside of the V6200 cabin. Close the door of the box, and close the leak stopcock by turning it clockwise.
2. Select **F6 (Box Leak Time Constant)**. Perform the box leak check by fully extending the syringe piston. The box leak should be 10 to 14 seconds for inspire. Repeat the test with a full stroke in the opposite direction, and the box leak should be 10 to14 seconds for expire.

   If the box-leak time constant is not 10 to 14 seconds, adjust the leak time constant by turning the stopcock counterclockwise. Repeat the box leak check to obtain a value of 10 to 14 seconds. The difference between inspire and expire is less than two seconds with the stopcock adjusted.
3. Print the results by selecting **F5**.
4. Select **F1, Pressure Sensor Calibration**. The Vbox correction factor must be 0.875 ±0.100 at 700 to 770 mm Hg for the V6200, 0.725 ±0.083 for the V62J, and 1.181 ±0.135 for the V62W. The Pm correction factor must be 0.980 to 1.020.

   If the Pm correction factor is outside these limits, remove one inch of the red tubing at a time, from the port on the calibrator shelf plenum and repeat the test until the correction factor is within limits. You must obtain three successive calibrations that are within limits before proceeding. Print each test by pressing **F5**.
5. Select **F4 (Isothermal Volume Control Verify)**. Enter the volume from the IVC into the Iso Cal Volume box. (See “Lung Volume Standard Calibration” on page 4).

6. Press and hold the foot switch, wait approximately two seconds, and select **F1**. If the loops are moving across the screen, press **F1** to restart the sampling, repeating until they are drawn over each other. The test automatically terminates.
7. Release the foot switch. Each loop must be within 3% of the predicted volume for the fixture. The “% Target” must be within ±2% of the predicted volume. If the “%Target” is greater than 102% repeat step 4.
8. Select **F1, Flow Sensor calibration**. Press the space bar to allow the sensor to zero after performing two purge strokes. Eight flow rate target zones must be met during the calibration routine (four inspire and four expire). The large yellow rectangles on the calibration screen represent the target zones. When the majority of a stroke volume is in a flow rate target, the smaller yellow rectangle to the right of the specific target zone turns green after 0.5L of volume in the opposite direction. A maximum of 15 strokes can be performed during the calibration routine. If a specific flow rate target cannot be met on the first try, keep trying until the target is met. The flow trace starts on the first full inspire after a complete expire, and subsequent strokes (red trace) count toward target goals.
9. The system automatically enters the verify portion of the calibration procedure after all flow rate target zones are met. The four verify strokes must be performed at approximately 0.5LPS, 1.5LPS, 4-6LPS, and a fourth stroke with peak flow greater than 10LPS, on both the inspire and expire portions of the piston stroke. Ensure that the strokes are smooth without “banging” the ends. The dotted lines on the display are positioned at 0.5LPS and 3LPS for reference.
10. Observe the display for a warning message. If there are no warning messages, and the results are within the acceptable range, proceed to step 14.

    Note:

    Warning messages may occur if any one individual value is outside the range +/-3% of predicted.

11. If a warning message appears because of a stroke being outside the 3% acceptable limit, repeat the verification procedure by pressing **F2** and starting the procedure at step 11.
12. If a system fails the calibration or verification two or more times, check (or consider changing) one of the test items used with the Vmax Encore to correct the problem. If, the problem persists, check and change the adjustments on the MFS board in the Vmax Encore module, and repeat the tests.
13. Ensure that the average of all strokes is within 2% of predicted for both inspire and expire. The predicted value is normally 3.00 liters. The acceptable limits for the average are 2.94–3.06. If the average is outside of this range, proceed to step 13. above.
14. Press **F5** to print the results of the calibration/verification. Return to the Flow meter Calibration program by exiting to the Encore main menu and pressing 1 for Calibration.

TROUBLESHOOTING

Troubleshooting a particular problem entails observing the symptoms and eliminating possible causes until the problem is found.

The best course of action is to first verify that only one device has a problem. If more than one device has a problem, check if those devices share common processors, voltages, A/D converters etc.

To troubleshoot a single device, check that device's signal path from start to finish.

ALL PRESSURE TRANSDUCERS

If all pressure transducers are not responding, check the signals that they all have in common:

+15.0 V dc

–15.0 V dc

+10.0 V dc

–10.0 V dc

BAROMETRIC PRESSURE TRANSDUCER

The barometric pressure transducer is mounted on the Mass Flow Sensor board. Four op-amp circuits that make up IC U13 condition the transducer signal.

To troubleshoot the barometric pressure transducer, check the op-amp outputs at U13 pins 1, 7, 8, and 14.

MOUTH PRESSURE TRANSDUCER

The mouth pressure transducer is mounted on the pressure board. The transducer signal is conditioned by one op-amp circuit part of IC U14 pins 12, 13, and 14.

To troubleshoot the mouth pressure transducer, check the op-amp outputs at U14 pin 14.

DIRECTION PRESSURE TRANSDUCER

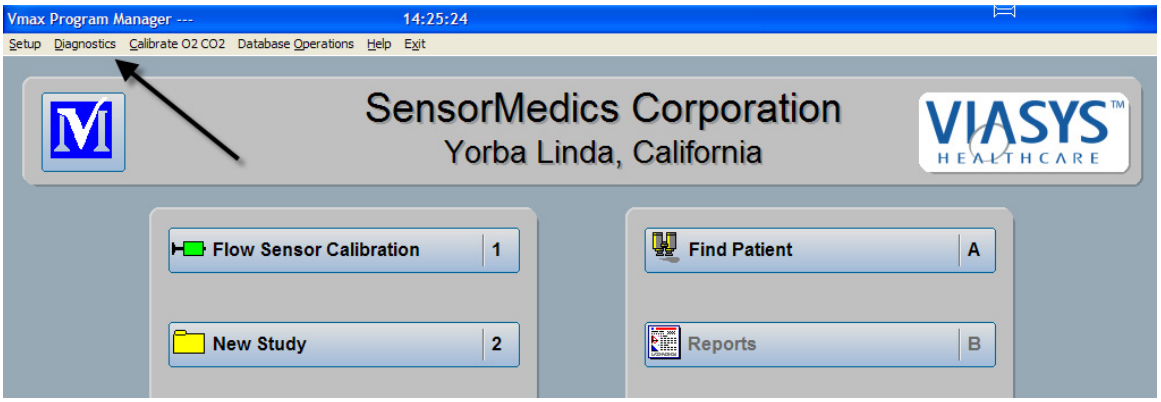
The direction pressure transducer is mounted on the pressure board. The transducer signal is conditioned by one op-amp circuit part of IC U14 pins 2, 3, and 1.

To troubleshoot the direction pressure transducer, check the op-amp outputs at U13 pins 1, 7, 8, and 14.

SYSTEM DIAGNOSTICS

The Diagnostics feature gives all operators the ability to help technical support personnel troubleshoot problems and the ability to verify specific functions. All diagnostic information is provided in one location: the Test Display window.

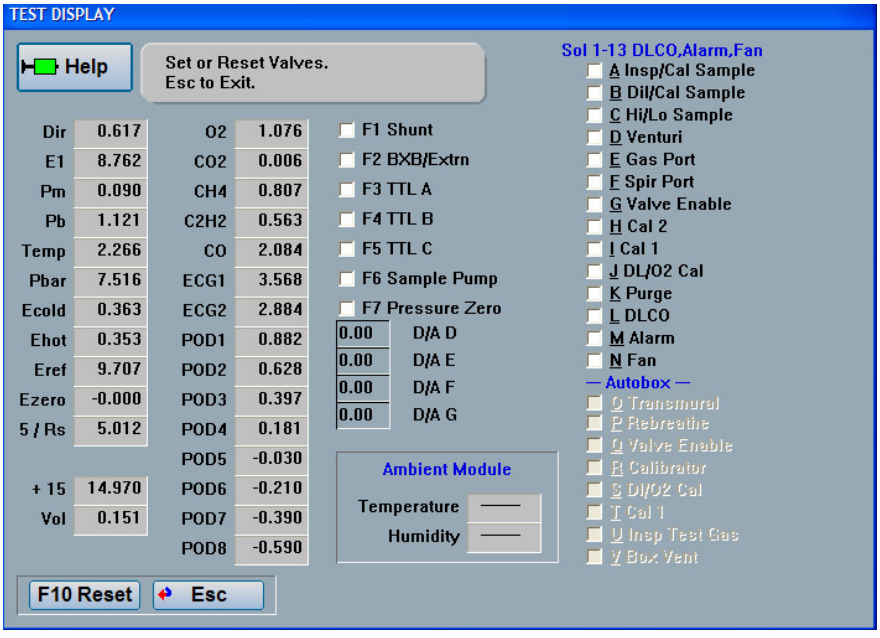
To open the Test Display window, click Diagnostics in the Program Manager window (Figure 3-13), or click Test in the Volume Calibration window.



0516001

Figure 3-13 Program Manager window

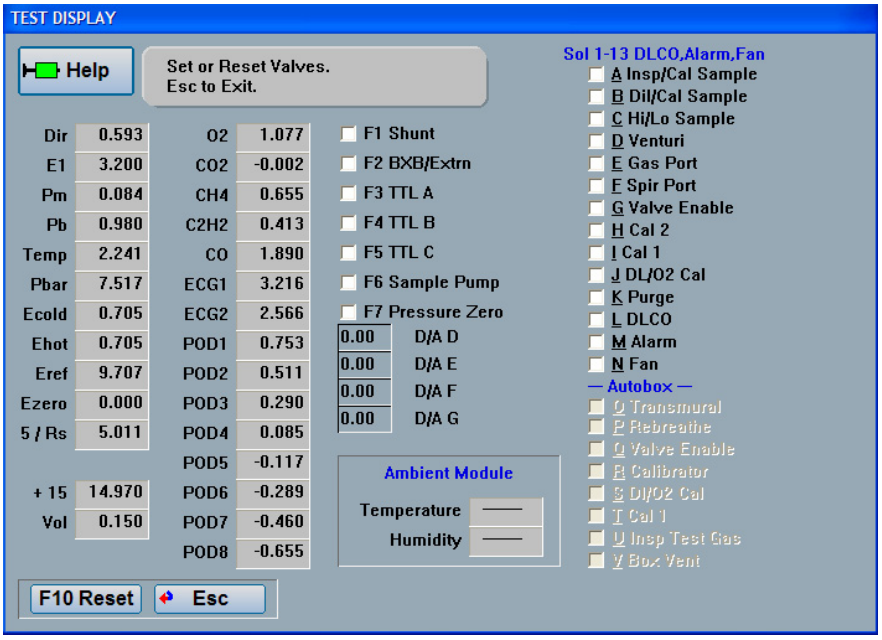
Examples of the Test Display window are given on the following pages. After the examples, the input and output signals are defined.



0516003

Figure 3-14 depicts a Test Display window of an Encore on an arm (non-Autobox) in an uncalibrated state (volume).

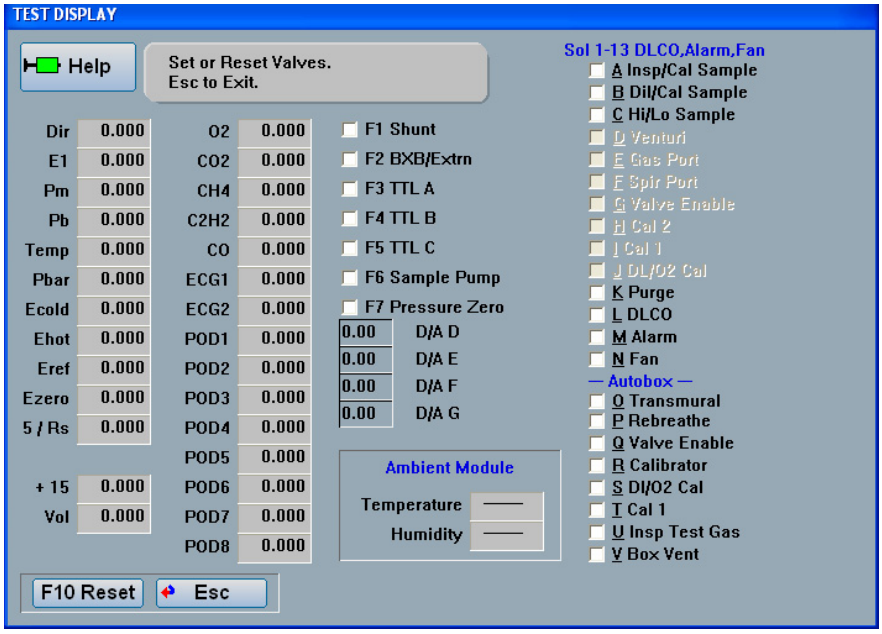
Figure 3-14 Test Display window—Encore on an arm (non-Autobox) in an uncalibrated state (volume)



0516002

Figure 3-15 depicts a Test Display window of an Encore on an arm (non-Autobox) in a calibrated state.

Figure 3-15 Test Display window—Encore on an arm (non-Autobox) in a calibrated state



0516004

Figure 3-16 depicts a Test Display window of an Encore connected to an Autobox.

Figure 3-16 Test Display window— Encore connected to an Autobox

Dir	Displays a voltage representing a pressure signal. The sign (positive/negative) of the zeroed pressure signal represents the direction of the flow
E1	Voltage representing the flow sensor. E1 of 3.2ish represents a valid calibration when no flow is present (Spectra or Encore)
Pm	Mouth Pressure transducer
Pb	Box Pressure transducer
Temp	Temperature. 2.266 represents 22.66 degrees Celsius
Pbar	Barometric Pressure. 7.516 represents 751.6 mmHg
Ecold	Created during development of Spectra— not currently used for troubleshooting
Ehot	Created during development of Spectra—not currently used for troubleshooting
Eref	Known voltage that is used to scale the A/D converter output.
Ezero	Known zero volt signal used to zero the A/D converter
5/Rs	Displays the status of the F1 remote start button. 5 volts represents button not pushed or activated. 0 volts represents activation
+15	Used to detect Vmax. If more than 14 volts isn't present, then problem with connection of Vmax
Vol	Used to analyze 922/1022 volume
O2	Oxygen sensor output
CO2	Carbon Dioxide sensor output
CH4	Methane sensor output
C2H2	Acetylene sensor output
CO	Carbon Monoxide sensor output
ECG1-2	Used to read the raw voltages from the SMC 3 lead
POD 1-8	Used to read the raw voltages from the analog pod box per channels 1-8
F1 Shunt	When checkmark present the pressure transducers reference the ambient conditions. When unchecked, both sides of the pressure transducers reference the mass flow sensors (used to zero the transducer)
F2 BXB/Extrn	When checked gas to the gas sensors comes from the Si/So line. When unchecked, gas comes from the BxB line.
F3 TTL A	Outputs a TTL logic level of on or off (1 or 0)
F4 TTL B	Outputs a TTL logic level of on or off (1 or 0)
F5 TTL C	Outputs a TTL logic level of on or off (1 or 0)

F6 Sample pump	When checked sample pump is turned on
F7 Pressure Zero	When checked, zeros all pressure transducers and checks the shunt box so that the system is referenced to ambient
F10 Reset	Clears all checkmarks
D/A D	Allows user to output a voltage through the pod box
D/A E	Allows user to output a voltage through the pod box
D/A F	Allows user to output a voltage through the pod box
D/A G	Allows user to output a voltage through the pod box
Ambient Module	
Temperature	Temperature Reading taken from the ambient module connected to an USB port on the Computer. This temperature overrides the module temperature
Humidity	Humidity Reading taken from the ambient module connected to an USB port on the Computer.
Sol 1-13 DLCO, Alarm, Fan	
A Insp/Cal Sample	Switches between inspire port on back of module (unchecked) and Calibration port on the front of the module (checked)
B Dil/Cal Sample	Switches between the mixing chamber (unchecked) and the calibration port on the front of the module (checked)
C Hi/Lo Sample	Used for calibration. Used to determine the pressure effects on the O2 sensor
D Venturi	Forces evacuation of the balloon valves
E Gas Port	Inflates the left balloon valve when checked
F Spir Port	Inflates the right balloon valve when checked
G Valve Enable	Allows for E and F to work, when balloons inflated and G is disabled the balloons should stay inflated
H Cal 2	Turns on cal 2 gas
I Cal 1	Turns on cal 1 gas
J DL/O2 Cal	If checked and DLCO (L) is checked, then DLCO gas will be sent through the calibration circuit. If checked and DLCO (L) is unchecked then O2 gas will be sent through the calibration circuit.
K Purge	Flushes the breathing hose (22 mm) with either O2 or DLCO gas (if L is checked)
L DLCO	Unchecked supplies oxygen as the test gas. Checked supplies DLCO as the test gas.
M Alarm	Turns on the mixing chamber alarm
N Fan	Turns on the mixing chamber fan

Autobox

O Transmural	Inflates the right balloon valve when checked
P Rebreathe	Inflates the left balloon valve when checked
Q Valve Enable	Allows O and P to work, when balloons inflated and Q is disabled the balloons should stay inflated
R Calibrator	Turns on the Autobox calibration piston
S DL/O2 Cal	If checked and DLCO (L) is checked, then DLCO gas will be sent through the calibration circuit. If checked and DLCO (L) is unchecked then O2 gas will be sent through the calibration circuit
T Cal 1	Turns on cal 1 gas
U Insp Test Gas	Allows test gas to be inspired in the Autobox
V Box Vent	Opens the box vent

REPLACEMENT PARTS

Vmax Encore 62J/62W Replacement Parts

Cable extension, Vmax to Autobox	775365
Cable, MFS, Autobox	775363-102
Hose, breathing 22mm 40”	774611-102
Hose, breathing 22mm 78”	774611-101
Hose, high pressure, Autobox	769527
Hose, white	35093
Mass Flow Sensor	775274
Pressure sense line, Autobox	769524-101
Sample line, Autobox	769525
Tube, 2 lumen, Autobox	769521-102
Tube, 4 lumen, Vmax to Autobox	769526
Valve, 3-way Autobox	775321

Part Description	Part No.
Adapter, 22mm x 30mm, canopy	775325
Adapter, FRC Plugs into Syringe and Mass Flow Sensor Mouth Port for FRC Piston Verifications	769296
Adapter, IEC Power; Cord set, HP Deskjet IEC M to US F, 6 In. Adapts HP Deskjet Power Transformer to plug into IEC Isolation Transformer	769299
Adapter, Max Pressure Fits into the Breath-by-Breath port of the Mass Flow Sensor. Used as a Calibrated leak for the Min Max Respiratory Pressures tests	769692
Arm assy. for console	775141
Cable assembly, external flow, Vmax Encore 62J/62W M	775365
Cable assembly, flow meter 12 pin to 9 Vmax Encore 62J/62W M	775363-102
Cable assembly, flow meter, 12 pin to 9 Vmax M	775363-101
Cable, Module Interface 37 Pin “D” M/F, Right Angle, 9.5 In. Molded. Connects Analyzer Assembly SOL OUT 1 to Pneumatics Assembly SOL IN	769800
Cable, PC Interface, Console/Table 25 Pin “D” M/M 6 Ft. Connects PC’s Printer Port to Vmax Encore Analyzer Assembly’s I/O Port (I/O 1, 2, or 3) when Configured as Vmax Encore Console or Table Top System	770796

Cable, PC Interface, LC Cart 25 Pin “D” M/M 16 In. Connects PC’s Printer Port to Vmax Encore Analyzer Assembly’s I/O Port (I/O 1, 2, or 3) when Configured as Vmax Encore LC Cart System	770795
Cable, Remote Start Pendant Switch to 1/4” Phone Plug, 2 Wire	464024
Cable, SatTrak Cable to Interface SatTrak Heart Rate and SAO2 Signals	770755
Cap diaphragm	775319
Clamp, W/Adh Grey stick-on clamp that acts as a rest/holder for the Remote Start Switch	12011
Cord set, Power IEC-320 SJT, Vmax Encore LC Cart/Console Components 39 In. Desktop PC, Desktop Monitor, Laptop PC, and Printer Power Cord when configured as Vmax Encore LC Cart or Console System. IEC connector on one end for Isolation Transformer	462321
Cord set, Power Locking Right Angle, Vmax Encore LC Cart 6 Ft. LC Cart Power Cord. Plugs into Vmax Encore LC Cart and Wall Outlet	769664
Cord set, Power Locking Straight, Vmax Encore Console 6 Ft. Console Power Cord. Plugs into Vmax Encore Console and Wall Outlet	769663
Cord set, Power Locking Straight, Vmax Encore Table Components 6 Ft. Desktop PC, Desktop Monitor, and Printer Power Cord when configured as Vmax Encore Table System. Connects PC, Monitor, and Printer to Table’s IEC Isolation Transformer.	769744
Coupler, Rubber For Mouthpiece Assembly, 2.50 Lg	42108
Drier tube assembly	769103
Filter, MicroGard Single Patient Bacterial Filter, Box Of 25	769204
Flow meter assy. w/o cable, Vmax Encore	775274
Gas, 0.3% CO, 0.3% CH_4, 21% O2, Bal N2 DLCO Gas, “E” Cylinder Tanks that Connect to “H” Regulators. Used for DLCO Tests	768093
Gas, 26% O2, Bal N2 CAL 2 Gas, Small 11” - “8D” Cylinder, Used to Calibrate Analyzers for Metabolic Tests	773868
Gas, 4% CO2, 16% O2, Bal N2 CAL 1 Gas, Small 11” - “8D” Cylinder, Used to Calibrate Analyzers for FRC and Metabolic Tests	773867
Head Set – Vmax Encore Light Weight, Adjustable Headset to hold Breathing Valve Assembly	769175
Hose Assembly - CAL 1, LC Cart/Console 1.13 Ft. Braided High Pressure Tubing with Blue Quick-Disconnect	769289
Hose Assembly - CAL 1, Table 4 Ft. Braided High Pressure Tubing with Blue Quick-Disconnect	769715
Hose Assembly - CAL 2, LC Cart/Console 1.13 Ft. Braided High Pressure Tubing with Orange Quick-Disconnect	769106

Hose Assembly - CAL 2, Table 6.5 Ft. Braided High Pressure Tubing with Orange Quick-Disconnect	769716
Hose Assembly - DLCO, Table 4 Ft. Braided High Pressure Tubing with Steel Quick-Disconnect	770215
Hose Assembly - Oxygen, LC Cart/Console and Table 10 Ft. Braided High Pressure Tubing with Green Quick-Disconnect	768748
Hose Assembly – White 1.25 OD W/Cuff, for connection to MicroGard	35093
Hose, Vmax to Vmax Encore 62J/62W	769527
Hose, breathing, 22mm flrd 40”LG Vmax Spec	774611-102
Hose, breathing, 22mm flrd 78”LG Vmax Spec	774611-101
Interface Assembly, Analog I/O Analog Interface Pod for interfacing external devices	769259
Luer Plug Assembly Fits into Breath by Breath and Mouth Pressure Ports of the Mass Flow Sensor when those ports are not being used.	770069
Mouthpiece, Cardboard Large Disp. (Box Of 150) Wax Coated Mouthpieces	42157
O_2 cell (yearly replacement)	466744
Regulator, Cal1/Cal2, 0–50 p.s.i. ED/8D Used on Cal1 and Cal2 tanks.	770063
Regulator, DLCO 0 - 80 PSI. Used with DLCO gas tanks	462690
Restrictor, gas	775324
Saliva trap	775309
Shipping LC Carton/Insert - Vmax Encore Used to ship Vmax Encore modules	769681
Syringe Assembly, 3 - Liter Calibrated hand piston. Used for volume calibrations	763722
Tube assembly direction sense	769288
Tube assembly, 2 lumen, balloon valve	769846
Tube assembly, S0S1	772551
Tube, 2 lumen, balloon (Vmax Encore 62J/62W)	769521
Tube, 4 lumen (Vmax Encore 62J/62W)	769526
Tube, direction sensor (Vmax Encore 62J/62W)	769524-101
Tube, sample	769525

Valve Assembly, One-Way Breathing Modified Hans Rudolph Valve Used for Metabolic Tests in Mixing Chamber Exercise and Indirect Calorimetry Modes	769704
Valve, 2-way	775323
Valve, 3-way	775321