FLUKE®

Biomedical

VT Plus HF

Gas Flow Analyzer

Operators Manual

PN 2137275
May 2008, Rev. 2, 4/09

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Fluke Biomedical warrants this instrument against defects in materials and workmanship for one year from the date of original purchase. During the warranty period, we will repair or at our option replace, at no charge, a product that proves to be defective, provided you return the product, shipping prepaid, to Fluke Biomedical. This warranty covers the original purchaser only and is not transferable. The warranty does not apply if the product has been damaged by accident or misuse or has been serviced or modified by anyone other than an authorized Fluke Biomedical service facility. NO OTHER WARRANTIES, SUCH AS FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSED OR IMPLIED. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

This warranty covers only serialized products and their accessory items that bear a distinct serial number tag. Recalibration of instruments is not covered under the warranty

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Technical Support

For application support or answers to technical questions, either email techservices@flukebiomedical.com or call 1-800- 850-4608 ext 2560 or 1-440-498-2560.

Claims

Our routine method of shipment is via common carrier, FOB origin. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim. If the instrument is delivered in good physical condition but does not operate within specifications, or if there are any other problems not caused by shipping damage, please contact Fluke Biomedical or your local sales representative.

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Use the original carton and packaging material for shipment. If they are not available, we recommend the following guide for repackaging:

- Use a double-walled carton of sufficient strength for the weight being shipped.
- Use heavy paper or cardboard to protect all instrument surfaces. Use nonabrasive material around all projecting parts.
- Use at least four inches of tightly packed, industry-approved, shock-absorbent material around the instrument.

Returns for partial refund/credit:

Every product returned for refund/credit must be accompanied by a Return Material Authorization (RMA) number, obtained from our Order Entry Group at 1-800- 850-4608 ext 2560 or 1-440-498-2560.

Repair and calibration:

To find the nearest service center, go to www.flukebiomedical.com/service, or

In the U.S.A.:
Cleveland Calibration Lab
Tel: 1-800-850-4606
Email: globalcal@flukebiomedical.com

Everett Calibration Lab
Tel: 1-888-993-5853
Email: service.status@fluke.com

In Europe, Middle East, and Africa:
Eindhoven Calibration Lab
Tel: +31-402-675300
Email: ServiceDesk@fluke.com

In Asia:
Everett Calibration Lab
Tel: +425-446-6945
Email: mailto:service.international@fluke.com

Certification

This instrument was thoroughly tested and inspected. It was found to meet Fluke Biomedical's manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Institute of Standards and Technology (NIST). Devices for which there are no NIST calibration standards are measured against in-house performance standards using accepted test procedures.

WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. Fluke Biomedical will not be responsible for any injuries sustained due to unauthorized equipment modifications.

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Manufacturing Location

The VT PLUS HF Gas Flow Analyzer is manufactured in Everett, Washington by Fluke Biomedical, 6920 Seaway Blvd., Everett, WA, U.S

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Introduction

The VT Plus HF Gas Flow Analyzer, referred to hereafter as the Analyzer, is a general-purpose, gas flow analyzer with special modes for testing mechanical patient ventilators. The Analyzer measures bidirectional flow in both high and low ranges, as well as high- and low-pressure ranges. Users control the unit using the command system or a special control mode that uses RT200-style commands. Multiple special-function tests allow efficient troubleshooting.

The Analyzer can measure either high- or low-flow and pressure, eliminating the need for gauges and flow meters. It measures 21 ventilator parameters and can display all of them on one screen. Results can be printed directly from the unit or from Windows-compatible software on a PC. The Analyzer also has onboard graphing capability and shows the minimum, maximum, average, and absolute measurement for all parameters.

This manual provides a description of the Analyzer and its applications. It should be used as a guide when using the instrument to analyze a ventilator and test lung.

Key Features

- Bi-directional flow, low- and high-pressure, volume, and oxygen concentration, and pressure measurements
- Very high-frequency measurement capability – up to 900 BPM (15 Hz)
- RS232 and printer ports
- Included Windows-compatible graphics software
- Minimum, maximum, average, absolute, and graph for all parameters
- All 21ventilator parameters displayed on one screen simultaneously
- Operation by user-friendly command mode or RT200 command mode
- Operation with a variety of precision test lungs available from Fluke Biomedical to complete a fully NIST-traceable ventilator test
- Tests the leak rate of a sealed vessel or test lung
- Tests whether a predetermined parameter deviates from limits set by the user
- Useful for pre-purchase evaluations of ventilators, incoming and routine performance verification, troubleshooting clinical problems, and teaching principles of mechanical ventilation

Unpacking and Inspection

Use the following checklist when unpacking the Analyzer. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it.

- Inspect the shipping carton for damage. If the shipping carton is damaged, carefully continue unpacking the instrument and note any dents and scratches on the Analyzer. Save the damaged shipping carton and packing material for the carrier's inspection.
- If there is no shipping damage, continue removing the Analyzer from the shipping case. Save the box and packing materials.

Note

This box contains specifically designed inserts to ensure safe shipment of the Analyzer. Please save these for return of the unit for service or calibration.

- Perform a visual inspection to ensure that the Analyzer is intact and if there is any physical damage, such as bent or broken parts, dents, or scratches. If the Analyzer has been damaged, call the Fluke Biomedical Service Center immediately. If the Analyzer be returned to Fluke for service, follow the procedure given under *Maintenance, Service, and Calibration: Packing Instructions*.
- After unpacking the Analyzer, check to see if all of the standard accessories listed under Accessories have been included with the Analyzer. If anything is missing, contact the Fluke Biomedical Service Center.

General Safety Considerations

Read the Users Manual before operating the Analyzer.

Symbols

Table 1-1 describes the symbols associated with the Analyzer.

Table 1-1. Symbols

Symbol	Description
⚠	Hazardous voltage
⚠	Important information; refer to manual
	Conforms to UL Std 3101-1; certified to Can/USA Std C22.2 No. 1010.1
CE	Conforms to European Union directives
	Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.
Hg	Contains mercury. Dispose properly.

Warnings and Cautions

A **Warning** identifies hazardous conditions and actions that could cause bodily harm or death.

A **Caution** identifies conditions and actions that could damage the Analyzer, the equipment under test, or cause permanent loss of data.

⚠⚠ Warning

To avoid possible electrical shock or personal injury, follow these guidelines:

- **Use this Analyzer only in the manner specified by the manufacturer.**
- **Do not use the product if it operates abnormally.**
- **Plug the main power cord only into a power outlet that has a protective earth contact to connect the chassis of the Analyzer to ground.**
- **Do not use extension cords without earth ground, or a hazardous condition may result.**
- **Turn off the Analyzer and disconnect its power cord before opening the case or performing any service procedures.**

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, follow these guidelines:

- **Do not expose the system to temperature extremes. Ambient temperatures should remain between 10 °C and 40 °C. System performance may be adversely affected if temperatures fluctuate above or below this range.**
- **Clean the Analyzer only by wiping it down with a clean, lint-free cloth dampened with a mild detergent solution. A solution of 70 % isopropyl alcohol may be used to remove stains and clean the system. No other solvents are recommended. Do not spray liquid directly on or immerse the unit.**

Instrument Familiarity

Figure 1-1 shows the top and right panels of the Analyzer.

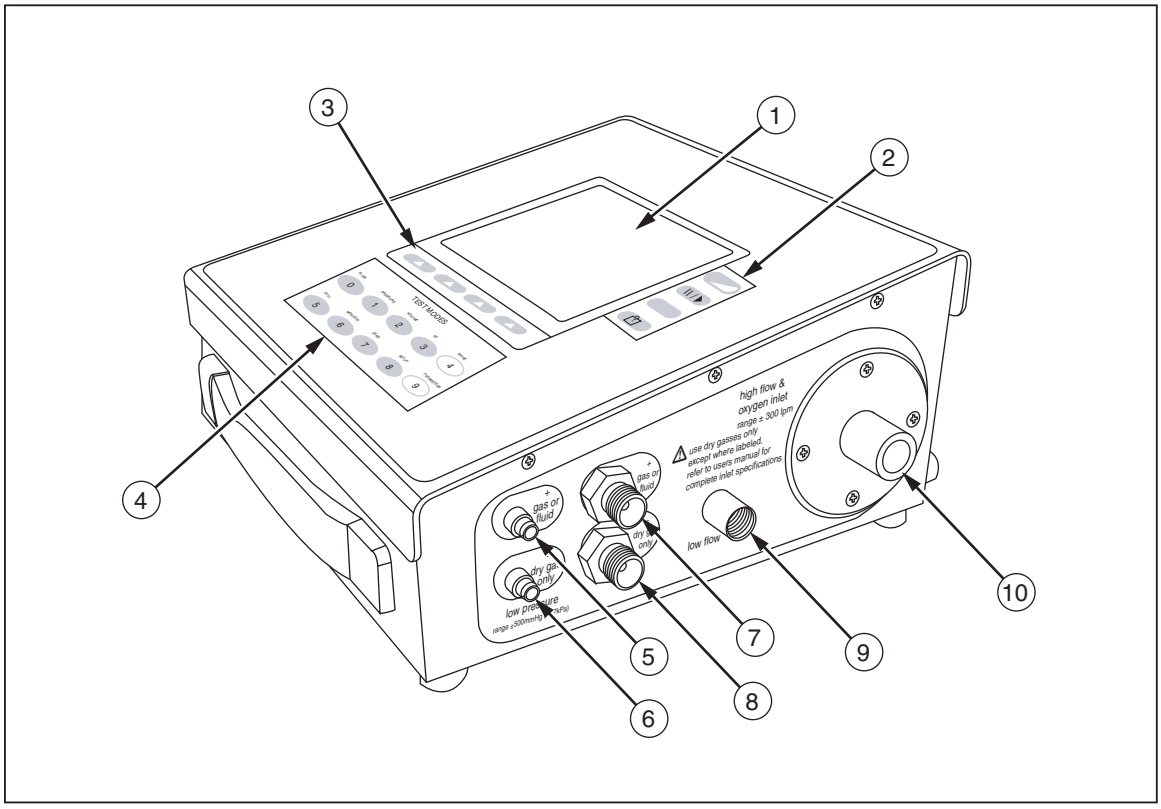

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Figure 1-1. Front and Right Analyzer Panels

Front Panel

The components of the front panel are listed in Table 1-2. See *Front Panel Details* for detailed descriptions of front panel components.

Table 1-2. Front Panel Components

Label	Description
①	LCD Display with CFL backlight
②	Contrast, Pause/resume, print, and help keys
③	Soft keys
④	Test Mode keys

Right Panel

The components of the right panel of the Analyzer are described in Table 1-3.

Table 1-3. Right Panel Components

Label	Description
⑤	Low Pressure (+) Gas Or Fluid Port
⑥	Low Pressure (-) Dry Gas Only Port
⑦	High Pressure (+) Gas Or Fluid Port
⑧	High Pressure (-) Dry Gas Only Port
⑨	Low Flow Inlet
⑩	High Flow And Oxygen Inlet

Figure 1-2 shows the rear and left panels of the Analyzer.

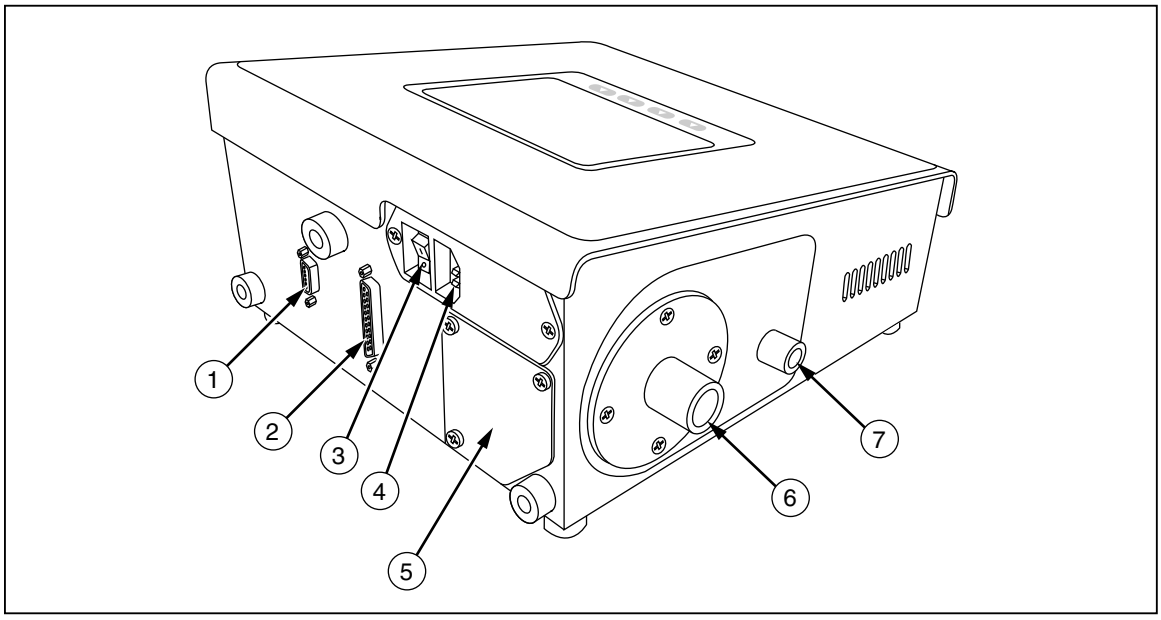

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Figure 1-2. Rear and Left Analyzer Panels

Rear Panel

The components of the back panel are listed in Table 1-4.

Table 1-4. Back Panel Components

Label	Description
①	RS232 Serial Port
②	Parallel Printer Port
③	Power Switch
④	Power Cord Input
⑤	Oxygen Sensor Access

Left Panel

The components of the left panel are listed in Table 1-5.

Table 1-5. Left Panel Components

Label	Description
⑥	High-Flow Exhaust Port
⑦	Low-Flow Exhaust Port

Front Panel Details

Figure 1-3 shows details of the Analyzer front panel, and Table 1-6 describes the various keys, their icons, and functions.

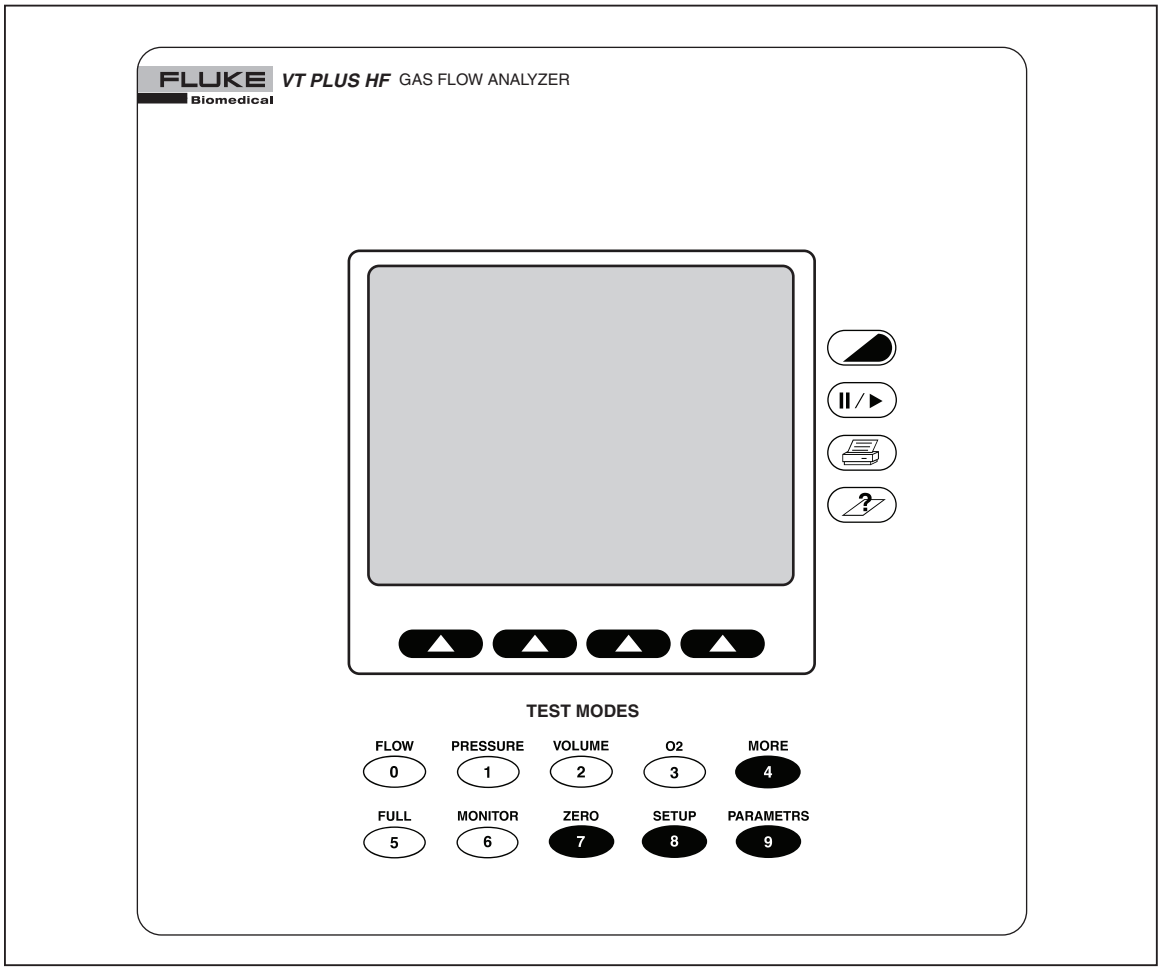

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Figure 1-3. Analyzer Front Panel

Table 1-6. Front Panel Functions

Icon	Name	Function
	Contrast Adjustment	This key adjusts the screen contrast to match the user's preference. Each time the key is pressed, the screen becomes lighter. When the minimum contrast is reached, the screen is set to the maximum contrast and the screen can be made lighter until the preferred setting is achieved.
⏸/▶	Pause/Resume	This key pauses the plots and numeric data on the screen to allow further examination of the data, or for transcription of the data by the user. After the screen has been paused, a second press of the Pause/Resume key resumes the plot. Note: The Analyzer stops sampling the transducers while in the Pause mode.

Table 1-6. Functions (cont.)

Icon	Name	Function
	Print	This key prints the current data to the printer. The mode and format of the printout is set using the printer options function selected under the setup menu.
	Help	This key displays help for any screen. A brief description of the screen and of the options available from that screen is provided when help is pressed.
	Soft Keys	These are four programmable keys located directly below the display. Each display mode has unique options assigned to its soft keys.
	FLOW/0 Key	This key selects the flow mode on the Analyzer. The flow mode displays signal, instantaneous numeric value and statistical data for the high or low flow signal. This key is also the 0 key for numeric data entry.
	PRESSURE/1 Key	This key selects the pressure mode. The pressure mode displays the signal, instantaneous numeric value, and statistical data for the high, low, or airway pressure signal. This key is also the 1 key for numeric data entry.
	VOLUME/2 Key	This key selects the volume mode. The volume mode displays the signal, instantaneous numeric value, and statistical data for the volume signal. This key is also the 2 key for numeric data entry.
	O2/3 Key	This key selects the oxygen mode. The oxygen mode displays the signal, instantaneous numeric value and statistical data for the oxygen signal. This key is also the 3 key for numeric data entry.
	MORE/4 Key	This key selects other tests such as the Leak test and the Trend test. This key is also the 4 key for numeric data entry.
	FULL/5 Key	This key selects the full breath parameters mode. The full mode displays all of the breath parameters calculated by the Analyzer following every breath. Note that one of the breath-detect settings must be enabled to observe volume signals or data. Refer to *System Setup* for breath detection settings. This key is also the 5 key for numeric data entry.
	MONITOR/6 Key	This key selects the monitor mode. The monitor mode displays the signal and instantaneous value for three of the signals measured by the Analyzer. Alternatively, the lower of the three plots may be replaced by selected breath parameters. The user can select the signals and/or parameters that are displayed. This key is also the 6 key for numeric data entry.

Table 1-6. Functions (cont.)

Icon	Name	Function
ZERO 7	ZERO/7 Key	This key initiates the zero function in the Analyzer. All of the pressure and differential pressure (flow) sensors in the Analyzer must be periodically zeroed or calibrated to a zero reference. When zero is selected, the device measures the zero value of the selected signal for flow measuring. The Analyzer can be set to periodically call of the zero function. Refer to *System Setup* for Zero Mode Descriptions. This key is also the 7 key for numeric data entry.
SETUP 8	SETUP/8 Key	This key accesses the Analyzer configuration and setup screens. When this key is pressed, a menu is displayed. The soft keys are used to navigate the menu. From this menu, other sub-menus are accessible to adjust the various configuration settings. The details of this menu and its sub-menus are described later. This key is also the 8 key for numeric data entry.
PARAMETRS 9	PARAMETERS/9 Key	This key selects which of the breath parameters are displayed in the various modes. Each mode screen has space to display 4 of the breath parameters. Using the parameters function, the four breath parameters can be selected. Note that if 4 parameters are already selected, then no more can be selected until one of the previously selected parameters is cleared. Also note that the parameters that are selected only apply to the screen that the Analyzer was in when the parameters key was pressed. This key is also the 9 key for numeric data entry.

Specifications

The following are general, performance, breath parameter accuracy specifications for the Analyzer.

General Specifications

Display ..... 320 x 240 LCD with CFL backlight

Viewing Area ..... 3 in x 4 in (10.1 cm x 8.2 cm) Blue on white background

Operational Modes ..... Manual mode for simple tests or troubleshooting; computer-control mode, using RS232 serial port for special applications; use of Analyzer with VT for Windows PC software for recording graphs and logging data to a computer

Output Ports ..... RS232 serial port and parallel-printer port

Operating Environmental Conditions

Temperature Range..... ..... 10 °C to 40 °C

Ambient Humidity..... ..... 0 - 80 % non-condensing to 31 °C, decreasing to 50 % at 40 °C

Barometric Pressure..... 8 to 18 psia

Vibration ..... Devices intended to be used on tabletop or other stable surface.

Storage Environmental Conditions

Temperature Range .....-25 to 50 °C

Humidity.....0 to 95 % non-condensing °C

Power Requirements

Maximum Over-voltage .....264 V ac

Input Voltage Range .....100 to 240 V ac

Input Frequency Range .....50/60 Hz

Power Consumption ..... <132 VA
Fuse Rating ..... 0.5 A, Slo-Blo

Performance Specifications

Low-Pressure Port

Maximum Applied Pressure..... 60 psi
Operating Pressure ..... (Differential) ±500 mmHg (±10 psi)
(Common-mode) 30 psi
Span Accuracy ..... ±0.80 % of reading or ±1.5 mmHg, whichever is greater
Frequency Response ..... >10 Hz
Resolution..... 0.1 mmHg
Sample Rate .....100 Hz

Note

Fluid pressure may be applied to the positive port; however, fluids should be kept from entering the pressure port by using a suitable length of connection tubing.

High-Pressure Port

Maximum Applied Pressure..... 150 psi
Operating Pressure ..... ±100 psi
Span Accuracy ..... ±1 % of reading or ±0.3 psig, whichever is greater
Frequency Response ..... >10 Hz
Resolution..... 0.1 psi
Sample Rate..... 100 Hz

Note

Fluid pressure may be applied to the positive port; however, fluids should be kept from entering the pressure port by using a suitable length of connection tubing.

Airway Pressure

Maximum Applied Pressure..... 20 psi
Operating Pressure ..... ±120 cmH_2O
Span Accuracy ..... ±0.75 % of reading or r 0.5 cmH_2O, whichever is greater
Frequency Response ..... >25 Hz or t10-90 <40 ms, whichever is greater
Resolution..... 0.1 cmH_2O
Sample rate ..... 100 Hz

Note

Airway pressure is internally tapped off the proximal flow sensor port, which is the port closest to the exhaust port on the Analyzer.

Continuous Flow

Low Flow ..... ±(2 % of reading and 1 % of range)

High Flow..... ±(2 % of reading and 1 % of range)

Volumetric Flow

High-Flow Port

Maximum Flow Rate..... (absolute value) 500 lpm
Operating Flow Range..... ±300 lpm
Accuracy..... ±2.0 % of range
Resolution..... 0.01 lpm

Frequency Response. ..... >25 Hz or t10-90 <40 ms, whichever is greater
Sample Rate..... 100 Hz
Dynamic Resistance..... <2.00 cmH_2O @ 60 lpm
Low-flow Dropout..... 25 lpm
Breath Detect Threshold.....(user settable) 2.0 lpm
Volume Range..... >±60 l

Notes

- *Tidal Volume Accuracy ±3 % of reading or ±10 ml, whichever is greater*
- *Volume Accuracy tested to 7 liters.*
- *Flow accuracy is specified for dry air or oxygen.*
- *Do not use with humidified gases.*

Low Flow Port

Maximum Flow Rate.....(absolute value) 50 lpm
Operating Flow Range..... ±25 lpm
Accuracy..... ±1.0 % of range
Resolution..... 0.01 lpm flow >1 lpm; 0.001 lpm flow <1 lpm
Frequency Response ..... >25 Hz or t10-90 <40 ms, whichever is greater
Sample Rate..... 100 Hz
Dynamic Resistance..... <2.5 cmH_2O @ 5 lpm
Low-flow Dropout..... 0.01 lpm
Breath Detect Threshold.....(user settable) 0.50 lpm
Volume Range ..... >±60 l

Note

- *Tidal Volume Accuracy ± 3 % of reading or ±5 ml, whichever is greater*
- *Volume Accuracy tested to 1 liter*
- *Flow accuracy is specified for dry air or oxygen.*
- *Do not use with humidified gases.*
- *Below 0.25 lpm, measurement accuracy is obtained by allowing the Analyzer to fully warm up, and manually zeroing before reading or documenting a measurement.*

Breath Parameter Accuracy Specifications

Breath parameter accuracy specifications are listed in Table 1-7.

Note

If a choice of readings is indicated by an "or", choose whichever is greater; for example, 3 % or 250 ml.

Table 1-7. Breath Parameter Accuracy Specifications

Parameter	Resolution	Range	Accuracy
Inspiratory and Expiratory Tidal Volume	0.1 ml	As specified in high/low-flow spec	As specified in high/low-flow spec
Minute Volume	0.001 lpm	0-60 l	3 %
Breath Rate	0.1 bpm	0.5 – 150 bpm	1 %
Inspiratory to Expiratory Time Ratio (I:E Ratio)	0.01	1:200 to 200:1	2 % or .1
Peak Inspiratory Pressure	0.1 cmH_2O	±120 cmH_2O	±3 % or 1 cmH_2O
Inspiratory Pause Pressure	0.1 cmH_2O	±120 cmH_2O	±3 % or 1 cmH_2O
Mean Airway Pressure	0.1 cmH_2O	±80 cmH_2O	±3 % or 0.5 cmH_2O
Positive End-expiratory Pressure (PEEP)	0.1 cmH_2O	-5 to 40 cmH_2O	±3 % or 0.5 cmH_2O
Lung Compliance[1]	0.1 ml/cmH_2O	0 - 150 ml/cmH_2O	±5 % or 5 ml/cmH_2O
Inspiratory Time	0.01 sec	0 - 60 sec	0.5 % or 0.02 sec
Inspiratory Hold Time	0.01 sec	0 - 60 sec	1 % or 0.1 sec
Expiratory Time	0.01 sec	0 - 90 sec	0.5 % or 0.01 sec
Expiratory Hold Time	0.01 sec	0 - 90 sec	1 % or 0.1 sec
Peak Expiratory Flow	0.01 lpm	0 - 300 lpm	3 % or 2 lpm
Peak Inspiratory Flow	0.01 lpm	0 - 300 lpm	3 % or 2 lpm
Flow Bias[2]	0.01 lpm	0 - 30 lpm	2 % or 0.5 lpm

[1] Inspiratory pause time >0.5 sec
[2] Expiratory pause time >0.5 sec

Accessories

Table 1-8 lists standard accessories provided with the Analyzer. Table 1-9 lists optional accessories.

Table 1-8. Standard Accessories

Item	Part Number
Operators manual	2137275
VT for Windows PC software	2392054
Standard bi-directional RS232 serial cable	2238659
Tilt stand	2133387
Power cable US Schuko UK Australia	 2238562 769422 2238570 658641
Accessory kit containing the following items:	2131367
One bacterial filter for external connection to the flow ports	2133712
One adapter, DISS O2 nut and nipple with ¼ in ID hose barb	2391777
4’ Tubing 1/8” ID clear w/blue stripe	2391848
Two 22 mm ID x 22 mm ID tubing adapters	2133305
Two 22 mm OD x 22 mm OD tubing adapters	2133291
Two tapered 15 mm OD x 22 mm OD tubing adapters	2133269
Two tapered 15 mm OD x 15 mm OD tubing adapters	2133278
Two tapered 15 mm ID x 15 mm ID tubing adapters	2133284
Two narrow bore tubing adapters	2133322
Two flexible 15 mm ID x 22 mm ID tubing adapters	2133310
Two 1/4" NPT male to 1/8" ID tubing barb fitting (Nylon)	2133240
Two 1/4" NPT male to 1/16" ID to bulkhead connection	2133202
Two luer to barb fittings	2213679
Two replacement fuses 0.5 A slow-blow	2133932
One DISS Handtight Nut/Nipple to 1/4” ID hose barb adapter	2216329
Certificate of Calibration – Data Sheet	NA

Table 1-9. Optional Accessories

Item	Part Number
Soft vinyl carrying case	2222822
Hard-sided protective carrying case	2248587
Soft-sided carrying case for ACCU-LUNG	2397628
Graphics Printer 110 V Citizen IDP3110 220 V Citizen IDP3110	 2248762 2719653
D25 male to Centronics parallel cable	2238072
ACCU-LUNG Lung Simulator with Soft-sided carrying case (2397628)	2387318

Chapter 2
Connection and Setup

Connecting the Analyzer

The Analyzer can be connected to a ventilator and a test load in either a bidirectional or unidirectional flow configuration.

Pneumatic Connections

The following is a description of various pneumatic connections on the Analyzer.

High Flow (Inlet and Exhaust)

The outer diameter of the high flow ports is a standard 22 mm fitting to allow connection using patient hoses. The inner diameter of the high flow ports is designed to accept a 15 mm male respiratory fitting such as endotracheal tubes, gas sampling adapters, etc.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, follow these guidelines:

- **Pressure inside the high flow port should not exceed ±120 cmH_2O.**
- **Measure only dry gases with the high flow port. Do not use this port to measure exhaled or artificially humidified gases.**

Low Flow (Inlet and Exhaust)

The outer diameter of the low-flow ports is a standard 15 mm to allow connection with standard respiratory fittings such as gas sampling Y-pieces and gas sampling adapters. The inner lumen of the low-flow ports are threaded to accept a standard ¼ in NPT fitting.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, follow these guidelines:

- **Pressure inside the low flow port should not exceed ±120 cmH_2O.**
- **Measure only dry gases with the low flow port. Do not use this port to measure exhaled or artificially humidified gases.**

High Pressure (+ and -)

The high-pressure ports are primarily designed for testing wall and tank pressurized gas sources. The connector mates to standard oxygen DISS fittings as used on oxygen supply hoses. Note that only the + side can be used to measure fluid pressure.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, follow these guidelines:

- **Applied differential pressure to either side of the high-pressure port should not exceed 100 psi.**
- **The negative (-) side of the high-pressure port cannot be used to measure fluid pressure.**

Low Pressure (+ and -)

The low-pressure ports connect using standard luer fittings. Note that only the + side can be used to measure fluid pressure.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, follow these guidelines:

- **Pressures applied to either side of the low-pressure port should not exceed ±500 mmHg.**
- **Negative (-) side of the low-pressure port cannot be used to measure fluid pressure.**

Test System Setup

High- or low-flow ranges can be used for ventilator testing. One test setup is measuring ventilator parameters using a test lung. Either a bi-directional flow mode, as shown in Figure 2-1 or a unidirectional flow mode, as shown in Figures 2-2 and 2-3, below can be chosen; however, the bi-directional mode is preferred.

Bi-directional Flow Mode

1. Connect the ventilator, using a Y-piece adapter, to the flow inlet port on the right of the Analyzer.
2. Connect the flow exhaust port on the left to the test lung using standard breathing hoses.

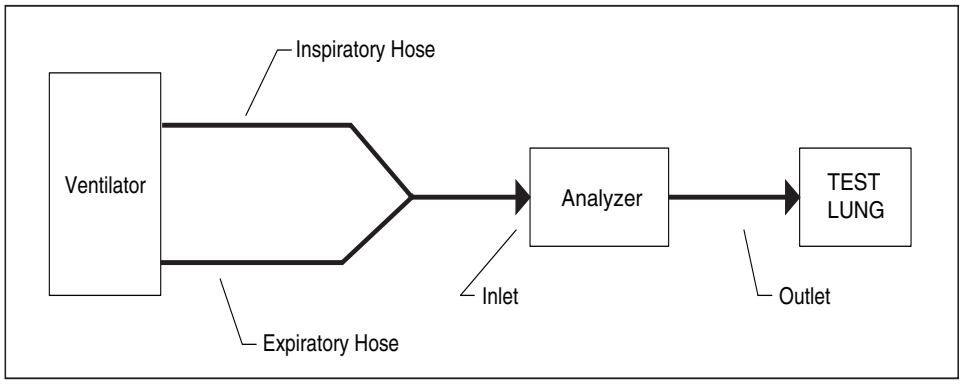

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Figure 2-1. Connecting the Analyzer in a Bi-Directional Flow Mode

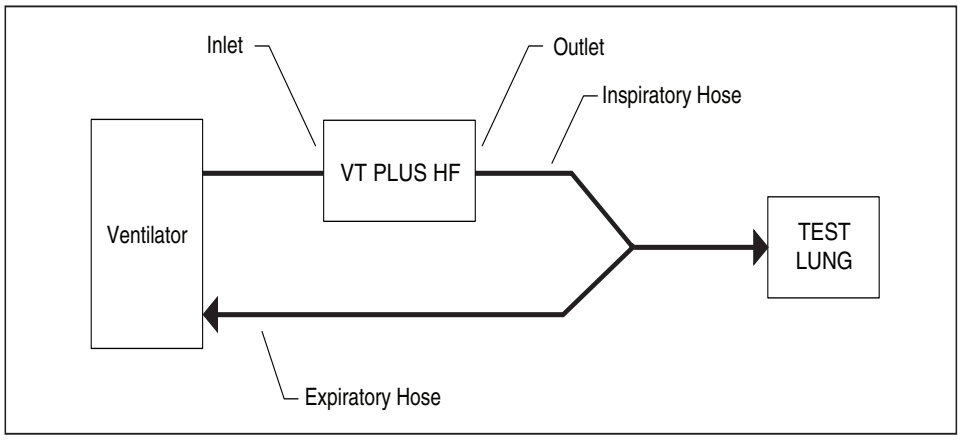
3. Ensure that the breath detection mode is set to bi-directional.
   a. Go into **Setup**.
   b. Choose **Settings**
   c. Choose **Breath Detect** and modify as needed

Unidirectional Flow Mode

Alternatively, the Analyzer can be used to measure only inspiratory or expiratory gas flow, as described below.

Inspiratory Testing

1. Connect the inspiratory hose to the flow port on the right of the Analyzer.
2. Connect the flow exhaust port on the left to the test lung using standard breathing hoses.



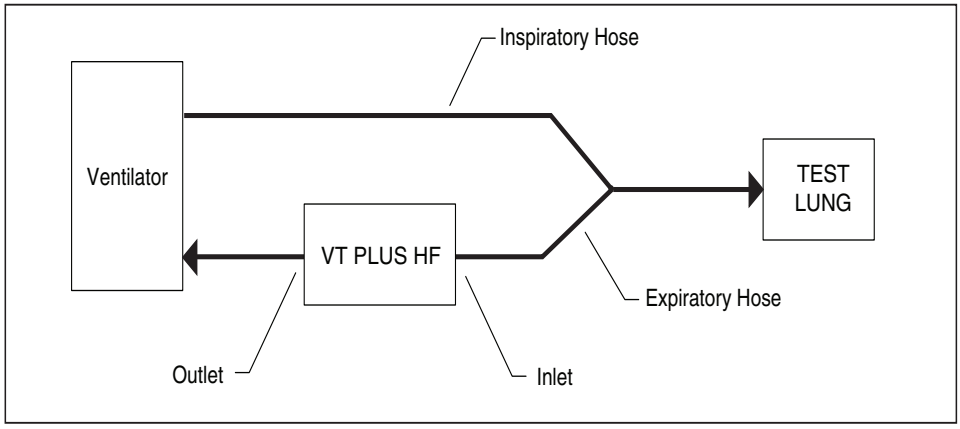
fec008.eps

Figure 2-2. Connecting the Analyzer to the Inspiratory Limb of the Breathing Circuit

3. Ensure that the breath detection mode is set to Unidirectional Inspiratory.
   a. Go into **Setup**
   b. Choose **Settings**
   c. Choose **Breath Detect** and modify as needed

Expiratory Testing

1. Connect the expiratory hose to the flow port on the right side of the Analyzer.
2. Connect the flow exhaust port on the left to the ventilator using standard breathing hoses.

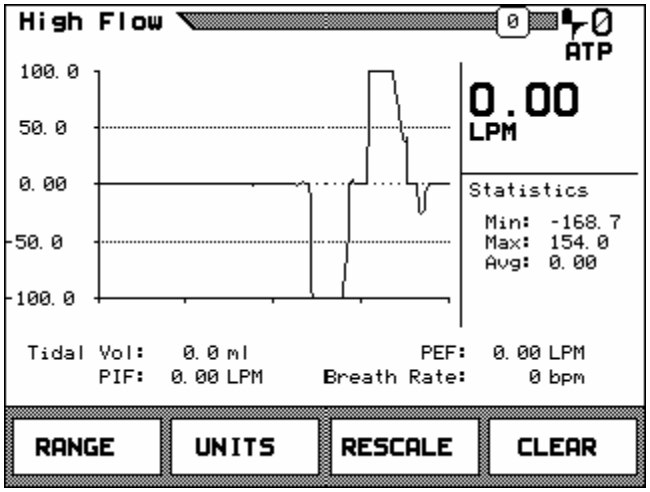


fec009.eps

Figure 2-3. Connecting the Analyzer to the Expiratory Limb of the Breathing Circuit

3. Ensure that the breath detection mode is set to Unidirectional Expiratory.
   a. Go into **Setup**
   b. Choose **Settings**
   c. Choose **Breath Detect** and modify as needed

The Analyzer displays a screen showing the flow of gas delivered by the ventilator:



fec049.bmp

The instantaneous flow rate displays in large numbers in the upper right portion of the screen. The flow statistics (min., max and average) are shown below in the center right portion of the screen. A subset of the breath parameters is shown below the flow plot.

The following adjustments can be made to the screen:

- Switch between the high- and low-flow ports – Press the **RANGE** soft key.
- Change the measurement units (LPM, CFM, LPS) – Press the **UNITS** soft key.
- Change the plot scaling – Press the **RESCALE** soft key. The new scaling is based on the minimum and maximum values shown in the statistics area.
- Erase the plot and re-initialize the statistics and breath parameters – Press the **CLEAR** soft key.
- See more information in any screen – Press the **HELP** key.
- Pause and resume the plot screen, respectfully – Press the **PAUSE/RESUME** key.

Printer Cable Attachment

The printer uses a D25 male to Centronics parallel cable for parallel printing. This cable is available from Fluke (part #2238072) or from most electronic supply outlets.

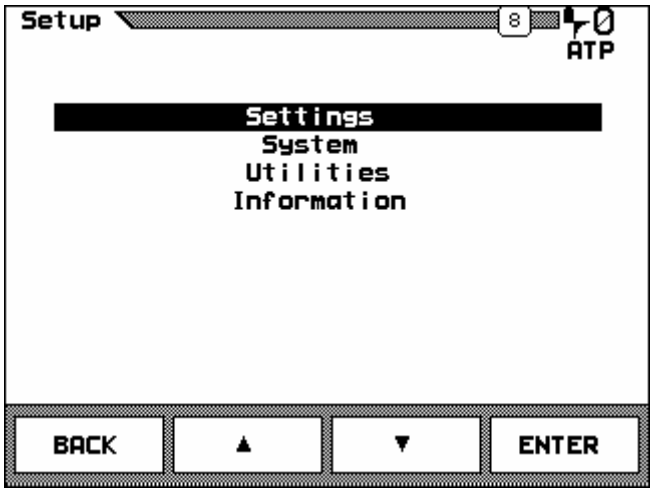
To attach the parallel cable:

1. Connect the 36-pin end for the Centronics type parallel cable to the printer's parallel input connector.
2. Attach the 25-pin male end of the parallel cable to the 25-pin connector on the back of the Analyzer.

Using the Setup Screen

To use the **Setup** screen:

1. Press the **SETUP/8** key. The **Setup** screen displays:



fec027.bmp

   The options are:

   - **Settings** – a menu for choosing options that affect flow and measurement on the Analyzer
   - **System** – a menu for choosing options that affect how information on the Analyzer is set up such as time and date
   - **Utility** – used for system service and calibration only
   - **Information** – product information about the Analyzer, such as serial number and copyright

2. Use the ▲ and ▼ soft keys to highlight an option.
3. Press the **ENTER** soft key to select the option.
4. Press the **BACK** soft key to return to the previous menu.

Setting Testing Parameters

To adjust the settings:

1. From the **Setup** screen, highlight **Settings** and press the **ENTER** soft key. The **Settings** menu displays.
2. Change settings to pre-selected options or to numeric values by highlighting the option and pressing the **MODIFY** soft key.

   For example, if one selects **Correction Mode** then presses **MODIFY**, he can scroll through the available Correction Mode options. If one selects an option that requires a numeric entry, such as **BD Threshold** and press **MODIFY**, the entered data is cleared, and the field can accept numeric input from the keypad until the **ENTER** key is pressed.

Note

The option displayed when exiting the settings screen is saved and used for future measurements.

The following is a description of each setting.

Gas Settings

This setting tells the Analyzer what type of gas is flowing through the high- and low-flow ports. The Analyzer uses this information to improve the accuracy of the flow calculations.

Note

Failure to enter the correct value causes the flow and volume calculations to be in error.

To modify the gas settings:

1. From the **Setup** menu, highlight **Settings** and press the **ENTER** soft key.
2. Highlight **Gas Settings** and press the **MODIFY** soft key.

   Depending on the option, a value can be pre-selected or input from the keypad. The following is a description of each of the options.

Gas Type

The possible values for **Gas Type** are shown in Table 2-1.

Table 2-1. Gas Type Values

Value	Description
Air	Standard room air
N2	100 % Nitrogen
N2O	100 % Nitrous Oxide
CO2	100 % Carbon Dioxide
O2	100 % Oxygen
Heliox	30 % Oxygen and 70 % Helium blend
N2O bal O2	Measured Oxygen balance Nitrous Oxide
He bal O2	Measured Oxygen balance Oxygen Helium
N2 bal O2	Measured Oxygen balance Nitrogen
User Defined	User selects custom gas mixture. This option requires the VT for Wondows PC software.

Note

*For **balance** gas settings, the oxygen concentration is measured using the Analyzer oxygen sensor located on the high-flow port. If the low-flow port is to be used, allow gas to flow through both high- and low-flow ports so that the oxygen can be measured.*

To modify the gas type:

1. From the **Gas Settings** menu, highlight **Gas Type**.
2. Press the **MODIFY** soft key until the desired value displays.
3. Press the **BACK** soft key to return to the **Settings** menu.

Gas Temperature

This setting is the temperature of the gas flowing through the high- or low-flow port. The Analyzer uses this information to improve the accuracy of the flow measurements. All temperatures are in °C.

To enter a gas temperature:

1. From the **Gas Settings** menu, highlight **Gas Temperature**.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad.

Note

The Analyzer accepts temperatures between 0 and 99 °C. No decimal values or fractions are allowed.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Ambient Temperature

This setting is the room temperature air flowing through the high-or low-flow ports.

To change ambient temperature:

1. From the **Gas Settings** menu, highlight **Ambient Temp**.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad.

Note

The Analyzer accepts temperatures between 0 and 99 °C. No decimal values or fractions are allowed.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Relative Humidity

This setting is the relative humidity in the air flowing through the high- and low-flow ports and is used only for STPD and BTPS corrections. The relative humidity is not used in calculating the effective viscosity on the Analyzer; however, the gas calculator in the VT Plus PC software does use relative humidity in determining the effective viscosity of user-defined gases.

To change relative humidity:

1. From the **Gas Settings** menu, highlight **Rel. Humidity**.
2. Press the **MODIFY** soft key to display the value field.

3. Input the desired value from the keypad.
4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Note

Use only dry gases with the Analyzer. Do not use with heated humidified gases; using humidified gases at room temperature may cause flow measurement errors of up to 1 % of reading for near-saturated, non-condensing gases.

Correction Mode

This setting calculates the flow volume of the air flowing through the high- or low-flow ports. This value should match the correction mode of the device under test (DUT).

To change correction mode:

1. From the **Gas Settings** menu, highlight **Correction Mode**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Barometric Pressure

The Analyzer constantly measures the barometric pressure and displays it on the **Full Test** screen. This setting allows the user to fine-tune the barometric pressure measurement. The difference between the value measured by the Analyzer and the entered value is applied to future Analyzer measurements as a offset correction factor. The correction factor is stored in nonvolatile memory and is remembered when the Analyzer is turned off and on.

Setting Barometric Pressure Units

These settings represent the various units available to measure barometric pressure such as mmHg.

To change the barometric pressure units:

1. From the **Gas Settings** menu, highlight **Baro Press Units**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Entering a Barometric Pressure Value

To enter a barometric pressure value:

1. From the **Gas Settings** menu, highlight **Barometric Press**.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad.

Note

The Analyzer accepts barometric pressure values between 0 and 999 mmHg. No decimal values or fractions are allowed.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Breath Detection

The Analyzer can be used to measure parameters on a breath-to-breath basis. To measure breath parameters, the mode of breath detection must be set. The breath detection options are shown in Table 2-2 .

Table 2-2. Breath Detection Options

Option	Description
	Bi-directional breath detection – Use this breath detection mode when analyzing both inspired and expired breath data or when the Analyzer is connected between the load (lung simulator) and the Y-piece in the breathing circuit.
	Unidirectional inspired only – Use this breath detection mode when the Analyzer is analyzing only inspired breaths or when the Analyzer is connected in the inspired limb of the ventilator breathing circuit.
	Unidirectional expired only – Use this breath detection mode when the Analyzer is analyzing only expired breaths or when the Analyzer is connected in the expired limb of the ventilator breathing circuit.
Off	Use this mode to measure continuous flow and volume without attempting to detect breaths. Use this mode to integrate a flow over a long period of time.

Setting Breath Detection Mode

To select the breath-detection mode:

1. From the **Gas Settings** menu, highlight **Breath Detect**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Setting Breath Detect Threshold

The Analyzer breath detection algorithm uses a flow rate threshold that the flow must cross to trigger a change in the breath phase. Higher flow rate thresholds yield less sensitive breath detection. Lower thresholds yield more sensitive breath detection.

To enter the breath detect threshold:

1. From the **Gas Settings** menu, highlight **LF Threshold** to adjust the low-flow threshold or **BD Threshold** to adjust the high-flow threshold.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Inspiratory/Expiratory Tidal Volumes

The Analyzer measures tidal volume when performing ventilator measurements. This option allows the user to choose between the expiratory or the inspiratory tidal volume. The default setting is inspiratory.

Note

This setting applies only when the bi-directional breath-detection mode is selected.

To change between inspiratory and expiratory tidal volume:

1. From the **Gas Settings** menu, highlight **Bi-Dir Tidal Vol**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Zero Mode

All pressure and differential pressure (flow) sensors in the Analyzer must be periodically zeroed or calibrated to a zero reference. This zero function can be set to occur automatically at pre-determined intervals or only when the user requests the function by pressing the key labeled **ZERO/7**. When a zero occurs, valves inside the device open the sensors to ambient pressure and measure the zero value to be subtracted from future measurements.

Note

Because no breath parameters are calculated for any breath in which a zero occurs, it may be desirable to turn off automatic zeroing for a short while during a critical test.

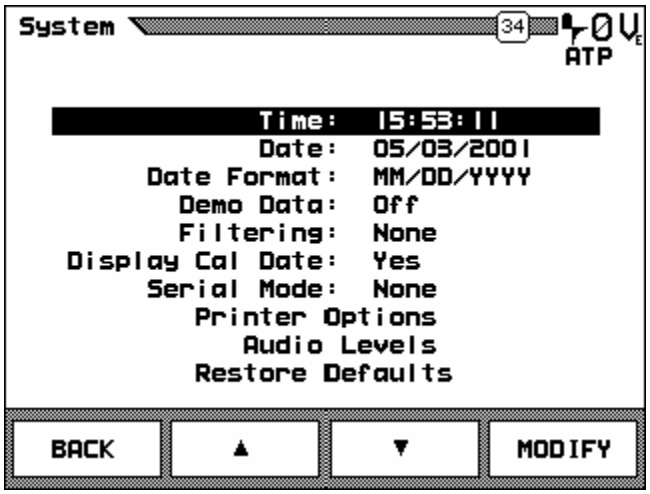
To turn automatic zeroing on or off:

1. From the **Gas Settings** menu, highlight **Zero Mode**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Setting Analyzer Operating Parameters

To adjust system information:

1. From the **Setup** screen, highlight **System** and press the **ENTER** soft key. The **System** menu displays:



fec032.bmp

2. Change settings to pre-selected options or to numeric values by highlighting the option and pressing the **MODIFY** soft key.

   For example, if one selects **Filtering**, then presses **MODIFY**, he can scroll through the available Filtering options. If one selects an option that requires a numeric entry, such as **Time**, and presses **MODIFY**, the entered data is cleared, and the field can accept numeric input from the keypad until the **ENTER** key is pressed.

Note

The option displayed when exiting the settings screen is saved and used for future measurements.

The following is a description of how to change each system setting. All of these options are accessed from the **System** menu of the **Setup** screen.

Time

The Analyzer displays hours, minutes, and seconds on the display. However, the user can set only hours and minutes.

To set the time:

1. Highlight **Time**.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad. Enter time in the HHMM format where HH is the hours in 25-hour format (0 to 23) and MM is the minutes, a number between 0 and 59.

Note

For hour and minute values less than 10, enter a leading zero. For example, if the time is 9:05, enter 0905.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Note

For hour and minute values less than 10, enter a leading zero. For example, if the time is 9:05, enter 0905.

Date

The Analyzer displays the date with MM as the month, DD as the date, and YYYY as the year.

To enter the date:

1. Highlight **Date**.
2. Press the **MODIFY** soft key to display the value field.
3. Input the desired value from the keypad. Enter the date with MM the number between 1 and 12, corresponding to the month; DD the number between 1 and 31, corresponding to the day of the month; and YYYY the year. See *Date Format*, below.

Note

For values of month and date less than 10, enter a leading zero. For example, if the month is February, enter 02.

4. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
5. Press the **BACK** soft key to return to the **Settings** menu.

Date Format

The Analyzer has two date formats as shown below: MM/DD/YYYY and DD/MM/YYYY

To change the format:

1. Highlight **Date Format**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Demo Data

This setting allows the user to show recorded data on screen without needing to connect the Analyzer to a ventilator or do any measurements. The word DEMO appears on the menu bar when this mode is engaged. The recorded data is for demonstration purposes.

To select the demo data function:

1. Highlight **Demo Data**.
2. Press the **MODIFY** soft key to toggle to the desired value.

3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Filtering

This setting is used to adjust the transition of signals on the flow meters. The filter has four levels: **Soft**, **Medium**, **Hard**, and **None**.

Note

When filtering is on, full test parameters are invalid.

To change the filtering level:

1. Highlight **Filtering**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Display Calibration Date on Startup Screen

Use this option to control whether the calibration due date appears on the startup screen.

To select whether the calibration due date is shown on the startup screen:

1. Highlight **Display Cal Date**.
2. Press the **MODIFY** soft key to toggle between **YES** and **NO**.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Serial Mode

Use this option to control what data is available through the Analyzer serial port. The possible options are shown in Table 2-3.

Table 2-3. Serial Port Options

Option	Description
Comp Ctrl	Computer Control – specialized serial communications used by the VT for Windows PC Software; contact your sales representative for the protocol if needed.
RT200	A serial mode that emulates the Allied RT200 serial communications
None	No serial communications

To select the serial mode options follow these steps:

1. Highlight **Serial Mode**.
2. Press the **MODIFY** soft key to toggle to the desired value.
3. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
4. Press the **BACK** soft key to return to the **Settings** menu.

Printer Options

This setting allows selection of the print format for information. The Analyzer can be connected to various printers, and the following printer languages are supported:

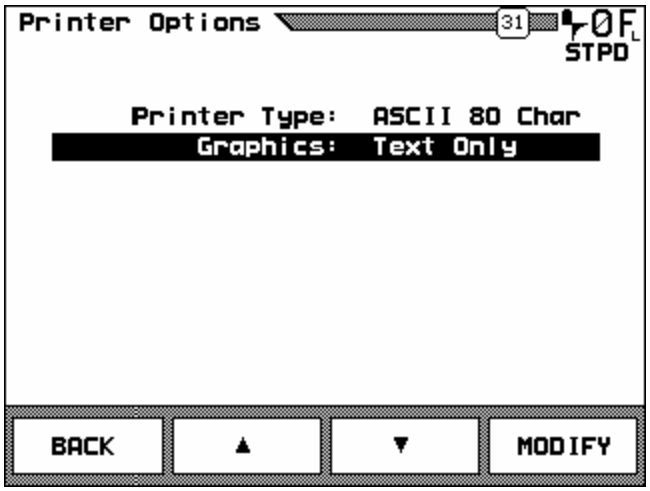
- HP PCL/3 (graphics/text or text only)
- Epson P1 (graphics/text or text only)
- ASCII printers in both 40 and 80 characters per line (text only).

Read the printer user manual to determine if it is compatible with these printer languages.

Note

A printer may require a special dip-switch setting to support a given language.

To select the printer options, highlight **Printer Options**. The **Printer Options** screen appears:



fec033.bmp

Printer Type

To choose a printer:

1. Highlight **Printer Type** and press the **MODIFY** soft key to toggle to the desired printer type.
2. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
3. Press the **BACK** soft key to return to the **Settings** menu.

Graphics

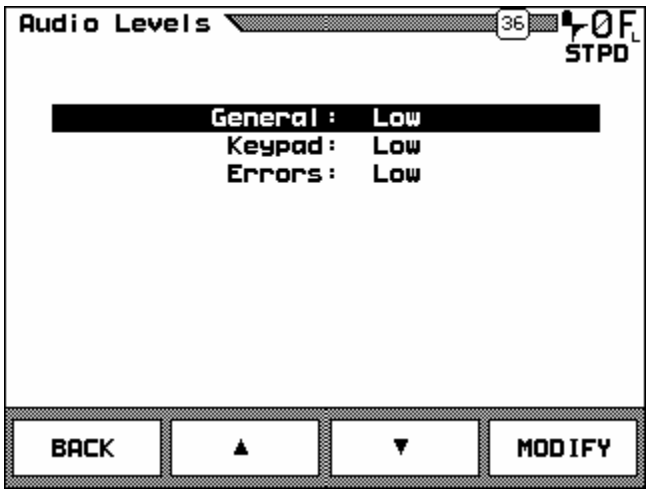
To choose the format of reports shown:

1. Highlight **Graphics** and press the **MODIFY** soft key to toggle between **Graphics** or **Text Only**.
2. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
3. Press the **BACK** soft key to return to the **Settings** menu.

Audio Levels

This setting adjusts the level of sound for the functions of the Analyzer.

To adjust the sound, highlight **Audio Levels**. The **Audio Levels** screen appears:



fec034.bmp

General

To adjust the general audio level:

1. Highlight **General** and press the **MODIFY** soft key to toggle between **Low** , **High**, or **Off**.
2. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
3. Press the **BACK** soft key to return to the **Settings** menu.

Keypad

When keypad buttons are pushed, a beep signals this action. This option adjusts the sound level of that beep.

To adjust the sound level of the keypad:

1. Highlight **Keypad** and press the **MODIFY** soft key to toggle between **Low** , **High**, or **Off**.
2. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
3. Press the **BACK** soft key to return to the **Settings** menu.

Errors

When an error is made, the Analyzer signals it with a beep. This option adjusts the sound level of that beep.

To adjust the sound level of errors:

1. Highlight **Errors** and press the **MODIFY** soft key to toggle between **Low** , **High**, or **Off**.
2. Press the **ENTER** soft key to save the change or the **ESCAPE** soft key to cancel the change.
3. Press the **BACK** soft key to return to the **Settings** menu.

Restore Defaults

This option returns all values to the factory defaults listed below, but does not change the device calibration.

To restore defaults:

From the **System** menu, highlight **Restore Defaults**. The Analyzer restores system values to the default, displays a *Restoring to defaults. Please wait* message.

After a few seconds, a beep indicates defaults are restored, and the display returns to the **System** menu. Factory defaults are shown in Table 2-4.

Table 2-4. Factory Defaults

System	
Date Format	MM/DD/YYYY
Demo Data	Off
Filtering	None
Display Cal Date	Yes
Serial Mode	None
Printer Options	
Printer Type	None
Graphics	Text Only
Audio Levels	
General	Low
Keypad	Low
Errors	Low
Settings	
Gas Settings	
Gas Type	Air
Gas Temperature	22 °C
Ambient Temperature	22 °C

Table 2-4. Factory Defaults (cont.)

Settings (cont.)	
Rel. Humidity	33 °C
Correction Mode	ATP
Baro Press Units	mmHg
Barometric Pressure	Actual ambient pressure
Breath Detect	Bidirectional
LF BD Threshold	0.50 lpm
HF BD Threshold	2.00 lpm
Bi-Dir Tidal Vol	Inspiratory
Zero Mode	Auto
Displays	
Flow	
Range	High Flow
Units	LPM Air
Scale	-100.00 to +100.00
Pressure	
Range	Airway
Units	cmH20
Scale	-100.00 to +100.00
Volume:	
Units	L Air
Scale	0.000 to 3.00
O2	
Units	% O2
Scale	0.0 to 100.0
Monitor:	
Top Zone	High Flow
Units	lpm Air
Middle Zone	Airway [Pressure]
Units	cmH20
Bottom Zone	Volume
Units	L Air
Parameters	
Tidal Vol, Base Flow, O2, Gas selected (checked) All others de-selected (un-checked)	

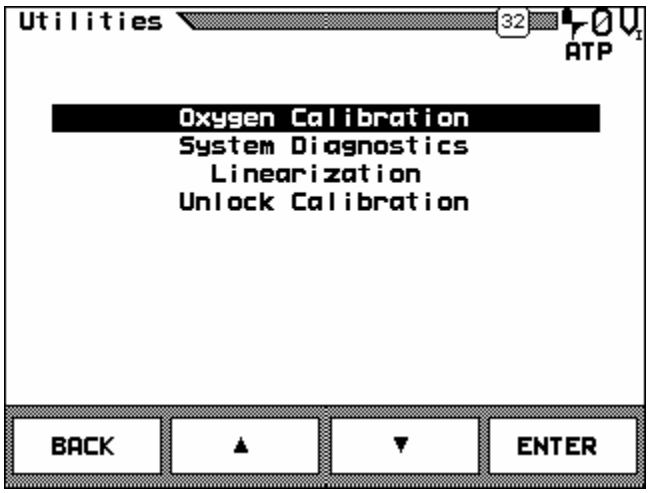
Utilities

Note

These settings are required by service technicians in servicing the Analyzer.

To access the utility functions:

1. From the **Setup** screen, highlight **Utilities** and press the **ENTER** soft key. The **Utilities** menu displays:



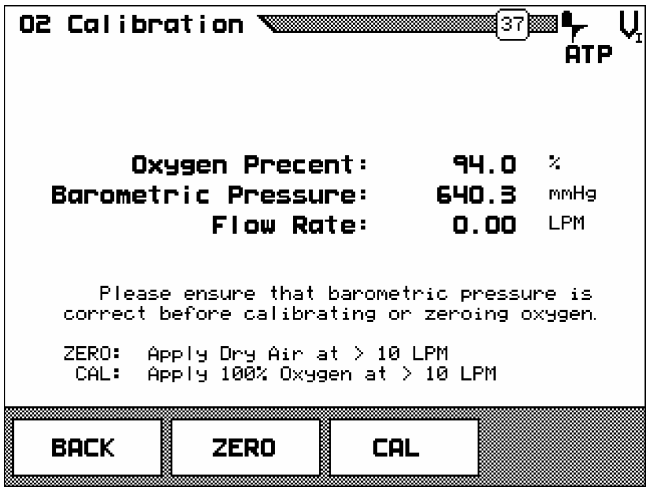
fec035.bmp

Oxygen Sensor Calibration

Recalibrate the oxygen sensor with 100 % oxygen and dry air at the beginning of any day in which oxygen concentrations are to be measured.

To calibrate the oxygen sensor:

1. Apply 10 lpm of dry air to the high-flow inlet or exhaust.
2. Use the ▲ and ▼ soft keys to highlight **Oxygen Calibration**.
3. Press the **ENTER** soft key. The **O2 Calibration** screen displays.



fec075.bmp

4. Press the **ZERO** soft key.
5. Press **OK** to start 21 % O_2 calibration. Allow the full 2-minute period. Do not press **SKIP**.
6. Verify that the O2 reading is 20.9 ±0.1 %.
7. Press the **CAL** soft key.
8. Apply 10 lpm of dry 100 % oxygen to the high-flow inlet or exhaust.
9. Press **OK** to start 100 % O2 calibration. Allow the full 2-minute period. Do not press **SKIP**.
10. Verify that the O_2 reading is 100 ±0.1 %.
11. Press the **BACK** soft key to return to the **Utilities** menu.

Note

If the oxygen sensor cannot be calibrated, it may need to be replaced. Refer to Maintenance, Service, and Calibration: Oxygen Sensor Replacement.

System Diagnostics

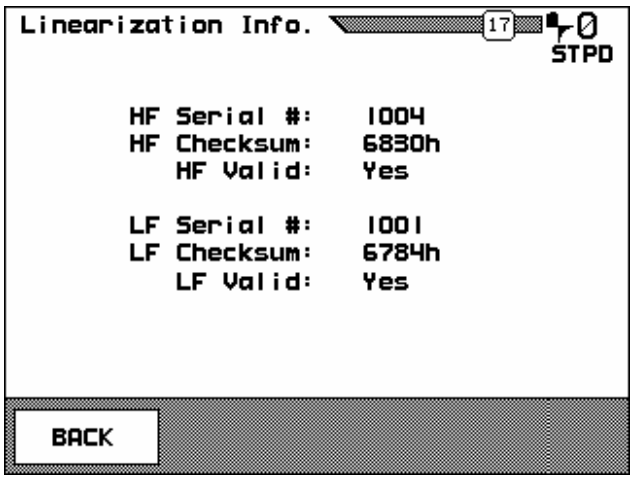
These functions are for the technical service personnel to use while repairing the Analyzer. They include **Zero All**, **AD Diagnostics**, and **Signal Diagnostics**.

Linearization

This option is most useful to technical service personnel repairing the Analyzer. There is no input, but the calibration data for each sensor is stored and displayed, so a checksum test can be performed to make sure the sensor data is still valid.

To check linearization data:

1. From the **Utilities** menu, highlight **Linearization**. The **Linearizaion Info** screen displays:



fec036.bmp

2. Press the **BACK** soft key to return to the **Utilities** menu.

Unlock Calibration

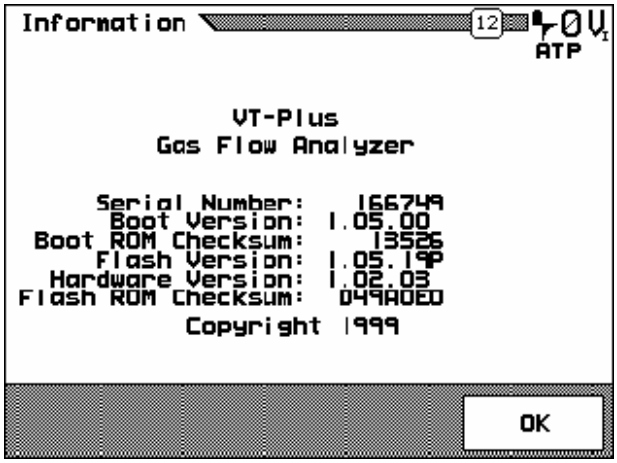
This function is for technical service personnel to use while repairing the Analyzer. When the **Unlock Calibration** is highlighted and the **ENTER** soft key is pressed, calibration is unlocked, and the display returns to the **Utilities** menu.

Information

This setting shows Analyzer product information, such as serial number and copyright.

To read system information:

1. From the **Setup** screen, highlight **Information** and press the **ENTER** soft key. The **Information** screen displays:



fec037.bmp

2. Press **OK** to return to the **Setup** screen.

Chapter 3
Operation

Measured Signals

The Analyzer measures the following signals:

- High flow
- Low flow
- Airway pressure
- Low pressure
- Barometric pressure
- High Pressure
- Oxygen concentration
- Calculated breath parameters

High Flow

The Analyzer has a high-flow (±300 LPM), bi-directional flow measurement. Flow measurements can be either static flows (no breath variations) or ventilator waveforms (i.e., both an expiratory and an inspiratory phase). The flow measurement is made using a differential pressure drop across a resistive screen mesh. This flow measurement can be used for pediatric/adult ventilators or for determining the performance of many types of flow meters. Valves switch between the low-flow and the high-flow measurements depending on the range selected in the display flow screens.

Low Flow

The Analyzer has a low-flow (±25 LPM), bi-directional flow measurement. The flow measurements can be either static (no breath variations) or ventilator waveforms (i.e., both an expiratory and an inspiratory phase). Flow measurements are made using a differential pressure drop across a resistive screen mesh. The low-flow signal can be used for infant/neonatal ventilators or for determining the performance of many other types of flow meter. Valves switch between the low-flow and the high-flow measurements depending on the range selected in the display flow screens.

Airway Pressure

The airway pressure is measured from a tap off of the proximal (near the exhaust port) of the flow sensor housings. This tap is connected to a ±120 cmH_2O pressure sensor that generates the airway pressure signal. Valves switch between the low-flow and the high-flow measurements. When the low-flow port is selected, the airway pressure is measured off the low-flow port. Likewise, when the high-flow port is selected the airway pressure is measured off the high-flow port. Use the **RANGE** soft key from any of the flow screens to select which flow port (high or low) airway pressure is measured from.

Low Pressure

This is a dual-port connection consisting of a (+) positive and a (-) negative pressure port. The differential pressure range is ±500 mmHg. This pressure measurement can be used for any pressure differential or gauge pressure in the given range. The transducer is capable of measuring fluid pressure on the (+) positive port as indicated on the label.

Barometric Pressure

A barometric pressure measurement is provided by the Analyzer. The barometer can read absolute pressures from 8 to 18 PSIA. The barometer is also used in the automatic ATP, BTPS, and STPD conversions for flow and volume measurements. The barometric pressure signal can be fine tuned using the procedure described in *System Setup*.

High-Pressure Measurement

The high-pressure measurement is made from a dual-port connection consisting of a (+) positive and a (-) negative pressure port. The differential pressure range is ±100 psi. This pressure measurement can be used for any pressure differential or gauge pressure in the given range. The transducer is capable of measuring fluid pressure on the (+) positive port as indicated on the label.

Oxygen Concentration

Oxygen concentration is measured through the high-flow port of the system on the rear panel bulkhead fitting. An integrated sensor measures the oxygen percent of the gas in the high flow channel of the Analyzer. The range for this sensor is 0 % to 100 %. The oxygen cell is mounted inside the enclosure on the rear bulkhead for the high-flow circuit. The fuel cell must be replaced approximately once a year. Oxygen readings are compensated for airway pressure.

Calculated Breath Parameters

From the primary flow and pressure measurements, the Analyzer is designed to calculate breath rate, % leak, and base flow. A breath detection algorithm determines the various phases of a ventilator breath and calculates the parameters listed in Table 3-1.

Table 3-1. Parameters Calculated by the Analyzer

Parameter	Abbreviation	How Calculated
Inspiratory Time	In Time	Time of the inspiratory period including the inspiratory hold time
Expiratory Time	Ex Time	Time of the expiratory period including the expiratory hold time
Inspiratory Hold Time	In Hold	Time of the End Inspiratory State
Expiratory Hold Time	Ex Hold	Time of the End Expiratory State
Inspiratory to Expiratory Time	Ratio I:E	Ratio of the inspiratory time to the Expiratory Time
Inspiratory Hold Pressure	IPP	Average pressure during the End Inspiratory State
Positive End-Expiratory Pressure	PEEP	Average pressure during the End Expiratory State
Mean Airway Pressure	MAP	Mean pressure over the entire breath
Peak Inspiratory Pressure	PIP	Maximum pressure during the Inspiratory Time
Tidal Volume	Tidal Vol	Total volume accumulated over the Inspiratory Time
Minute Volume	Minute Vol	Expiratory Tidal Volume times the respiratory rate in breaths per minute; reported as an eight-breath average
Peak Inspiratory Flow Rate	PIF	Maximum of the absolute value of the Flow Rate measured during the Inspiratory Time
Peak Expiratory Flow Rate	PEF	Maximum of the absolute value of the Flow Rate measured during the Expiratory Time
Compliance	N/A	Expiratory Tidal Volume divided by the difference of the Inspiratory Hold Pressure and PEEP

Screen Objects

Classes of information shown on the Analyzer display are a title bar, various breath detection icons, statistics, data plots, instantaneous numeric value of plotted data, and selected breath parameters, as shown in Figure 3-1 and listed in Table 3-2.

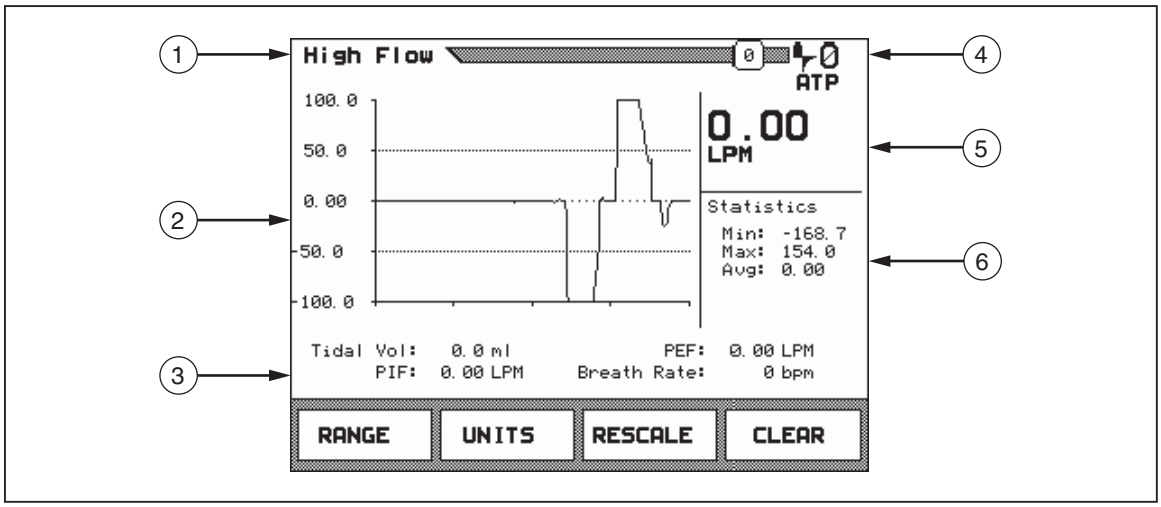


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Figure 3-1. Information Shown on Analyzer Display

Table 3-2. Display Components

Label	Description
①	Title bar
②	Data plots
③	Parameters
④	Icons
⑤	Instantaneous numeric data
⑥	Statistics

These screen options are described below.

Title Bar

Each screen includes a title bar that shows the screen or mode name on the left. A number indicating the screen number is shown in a small box on the right of the title bar:

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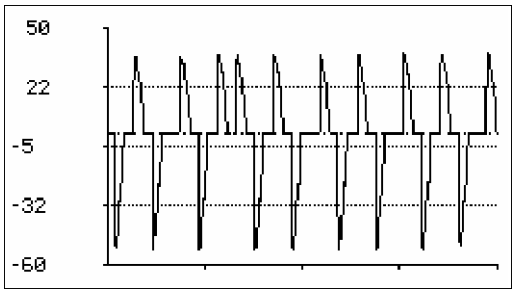
9 Indicates the screen number

Data Plots

Except the **FULL** screen, each screen includes a data plot that shows a measured signal (flow, pressure volume, or O_2) vs. time:



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New data is added to the plot starting on the left and progressing to the right. When the plot has progressed to the right edge, the plot restarts on the left side of the plot. One line of data from the previous plot is removed ahead of the new plot.

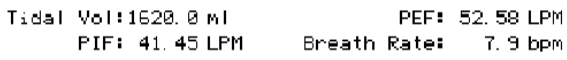
When a new screen is selected, the plot is displayed using a default plot range. Pressing the **CLEAR** soft key restarts the plot and clears all previously plotted data and calculated statistics. Pressing the **RESCALE** key changes the window of the data plot to a more appropriate range based on the minimum and maximum values in the *Statistics* area.

Note

*After pressing **CLEAR**, allow one full cycle to pass before pressing **RESCALE**.*

Breath Parameters

Every screen can display up to four breath parameters:



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These parameters are displayed only when breath detection is enabled. See *Special Functions* for instructions on how to enable breath detection. Parameters are updated following every breath. Units of measure for breath parameters are fixed. See *Introduction*: *Specifications* for a listing of breath parameters and units. See *Selecting Breath Parameters* for instructions on selecting which parameters are displayed for each of the modes.

Breath Detection Icons

The breath-detection icon is located on the right side of the title bar. Various icons and their meanings are listed in Table 3-3.

Table 3-3. Breath Detection Icons

Icon	Meaning
0	A large number 0 to the right of the title bar indicates that automatic sensor-zeroing mode has been selected.
	Bi-directional breath detection: Use this breath-detection mode when analyzing both inspired and expired breath data or when the Analyzer is connected between the load (lung simulator) and the Y-piece in the breathing circuit.
	Unidirectional expired only: Use this breath-detection mode when the Analyzer is analyzing only expired breaths or when the Analyzer is connected in the expired limb of the ventilator breathing circuit.
	Unidirectional inspired only: Use this breath-detection mode when the Analyzer is analyzing only inspired breaths or when the Analyzer is connected in the inspired limb of the ventilator breathing circuit.
ATP	ATP: This indicates the conversion of gas flow and volume to ambient temperature and pressure.
BTPS	BTPS: This indicates the conversion of gas flow and volume to body temperature of 37 °C with 100 % relative humidity.
STPD0	STPD0,: This indicates the conversion of gas flow and volume to a standard temperature of 0 °C and a standard barometric pressure of 760 mmHg.
STPD21	STPD21: This indicates the conversion of gas flow and volume to a standard temperature of 21 °C and a standard barometric pressure of 760 mmHg.
V_I	Inspiratory Tidal Volumes: This indicates that the reported tidal volumes are measured over the inspiratory phase of the breath. This only applies to the bidirectional breath-detect mode.
V_E	Expiratory Tidal Volumes: This indicates that the reported tidal volumes are measured over the expiratory phase of the breath. This only applies to the bidirectional breath-detect mode.
F_L	Light (Soft) Filtering: This indicates that the filtering option is turned on and the filter is set to light or soft filtering. In this mode, all of the signals (flow and pressure) have a Digital Signal Processing (DSP) low-pass filter applied. This is used when measuring very noisy signals. None of the ventilator parameters are valid when the filtering is turned on.
F_M	Medium Filtering: This indicates that the filtering option is turned on and the filter is set to medium filtering. In this mode, all of the signals (flow and pressure) have a Digital Signal Processing (DSP) low-pass filter applied. This is used when measuring very noisy signals. None of the ventilator parameters are valid when the filtering is turned on.
F_H	Hard Filtering: This indicates that the filtering option is turned on and the filter is set to hard filtering. In this mode, all of the signals (flow and pressure) have a Digital Signal Processing (DSP) low-pass filter applied. This is used when measuring very noisy signals. None of the ventilator parameters are valid when the filtering is turned on.

Instantaneous Numeric Data

The digital value of the plotted signal is displayed to the right of each plot:

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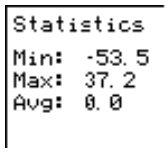
This value is updated approximately twice a second. This value is the average of the signal over the previous 500 milliseconds.

The Analyzer allows the user to select the desired units for each of the measured signals. For example, pressures can be displayed in mmHg, kPa, bar, mbar, atm, inH2O, inHg, cmH2O or mmHg. Pressing the **UNITS** soft key changes the unit of measurement for the displayed signal value. Pressing the **UNITS** soft key repeatedly causes the instrument to cycle through the various possible units. The selected units of measure remain in memory even if the mode has been changed or if the Analyzer has been turned off. The selected gas type appears in the area below the **UNITS** soft key.

Statistics

On each of the screens, except Full Breath Parameters and Monitor, the minimum, maximum, and average values of the plot are displayed to the right of the plot, as shown below:



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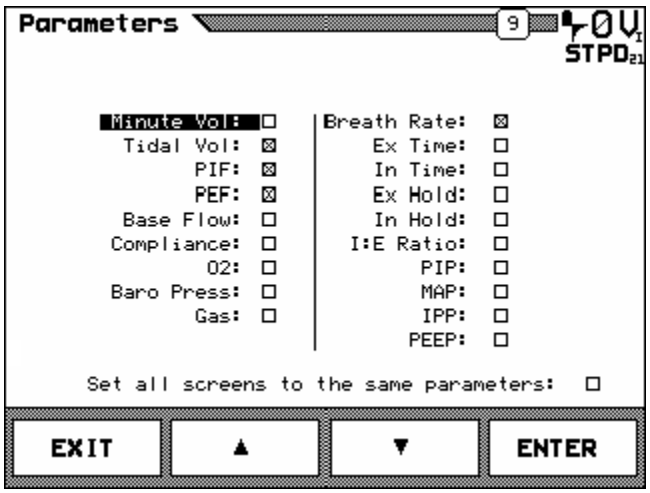
These values are calculated continually until a new screen is selected or until the **CLEAR** soft key is pressed.

Selecting Breath Parameters

The Analyzer calculates 17 breath parameters for every breath:



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The user can select up to four of these parameters to be displayed with each of the screens.

To select parameters for display on a specific screen:

1. Select the screen for which the parameters are to be added. For example, to select parameters for addition to the **Flow** screen, press the **FLOW/0** key.
2. Press the **PARAMETERS/9** key to display all possible parameters. An **X** in the small box adjacent to a parameter name indicates that the parameter is to be added. An empty box indicates that the parameter is not to be added.
3. Use the soft keys labeled ▲and ▼ to highlight parameters.
4. Press the **ENTER** soft key to select (add) or deselect (not add) a parameter. Only four parameters can be viewed on a screen; therefore, an existing parameter must be deselected from the list before a new parameter can be selected.
5. Repeat steps 3 and 4 above for each additional parameter to be changed. Selecting the **Set all screens to the same parameters** option in the parameters screen displays the currently selected parameters on all screens. If this option is deselected after having been in effect, previous parameter selections for each screen must be reselected.
6. Press the **EXIT** soft key to return to the previous screen.

Note

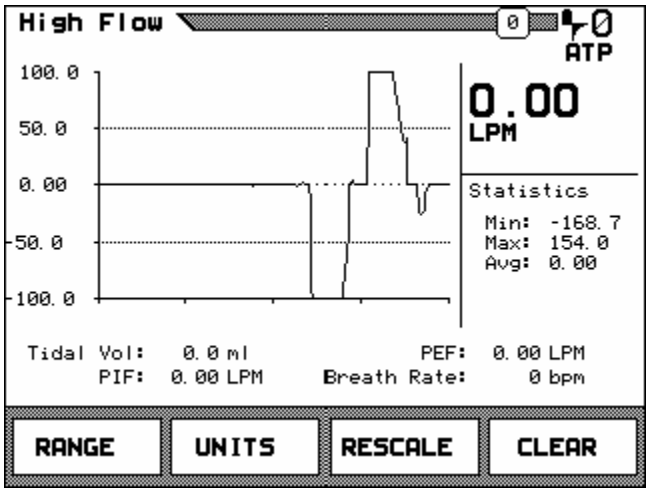
Parameter selections are retained even after the Analyzer has been powered off.

Flow Screens

There are two types of flow screen, high-flow and low-flow, based on which Analyzer flow port is used.

High-Flow Screen

The High-Flow screen displays the signal and statistics for flow in the high-flow port of the Analyzer.



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Range — Press the **RANGE** soft key to change from a low-flow screen to a high-flow screen or back again.

Units — Press the **UNITS** soft key to change the units of measure for the high-flow screen. Possible units of measure for this screen include:

LPM	Liters per minute
CFM	Cubic feet per minute
LPS	Liters per second
ml/min	Milliliters per minute
ml/sec	Milliliters per second

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

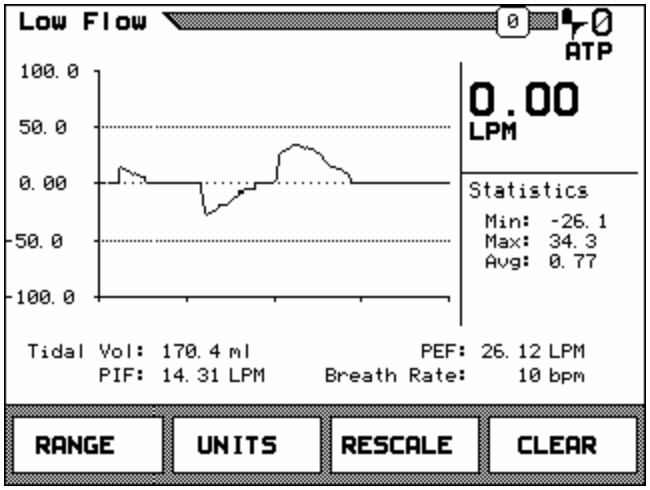
RESCALE *uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot. Allow one full waveform cycle to plot before pressing **RESCALE**.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*.

Low-Flow Screen

The Low-Flow screen displays the signal and statistics for the flow in the low-flow port of the Analyzer.



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Range — Press the **RANGE** soft key to change from a high-flow screen to a low-flow screen or back again.

Units — Press the **UNITS** soft key to change the units of measure for the low-flow screen. Possible units of measure for this screen include:

LPM	Liters per minute
CFM	Cubic feet per minute
LPS	Liters per second
ml/min	Milliliters per minute
ml/sec	Milliliters per second

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

RESCALE *uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

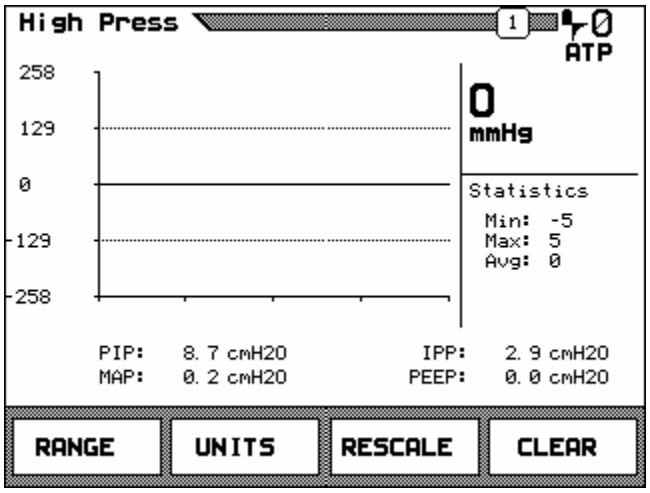
The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*.

Pressure Screens

There are two types of pressure screen, high-pressure and low-pressure, based on which Analyzer pressure port is used.

High-Pressure Screen

The High-Pressure screen displays the signal and statistics for the pressure signal from the high-pressure ports of the Analyzer.



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Range — Press the **RANGE** soft key to change between low pressure, airway pressure, and high-pressure screens.

Units — Press the **UNITS** soft key to change the units of measure for the high-pressure screen. Possible units of measure for this screen include:

mbar	millibar = .001 Bar
bar	14.7 PSIG (Barometric)
mmHg	millimeters of mercury
inHg	inches of mercury
cmH_2O	centimeters of water
inH_2O	inches of water
PSIG	pounds per square inch
atm	atmospheres
kPa	kilopascals

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

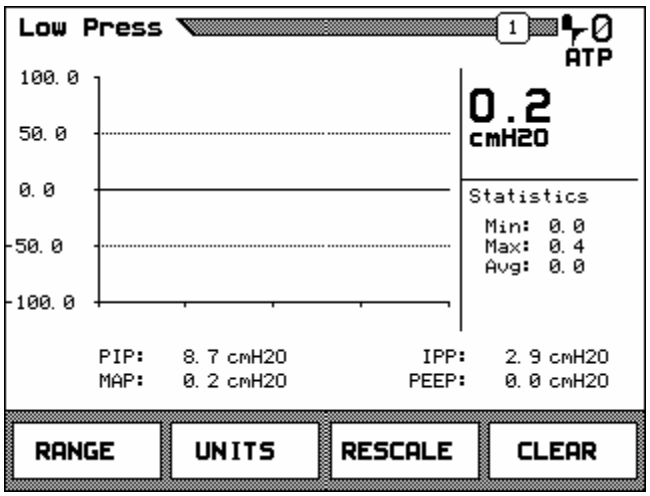
***RESCALE** uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*.

Low Pressure Screen

The Low-Pressure screen displays the signal and statistics for the pressure signal from the low-pressure ports of the Analyzer.



fec052.bmp

Range — Press the **RANGE** soft key to change between low pressure, airway pressure, and high-pressure screens.

Units — Press the **UNITS** soft key to change the units of measure for the low-pressure screen. Possible units of measure for this screen include:

mbar	millibar = .001 Bar
bar	14.7 PSIG (Barometric)
mmHg	millimeters of mercury
inHg	inches of mercury
cmH_2O	centimeters of water
inH_2O	inches of water
PSIG	pounds per square inch
atm	atmospheres
kPa	kilopascals

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

RESCALE *uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*.

Airway Pressure Screen

The Airway Pressure screen displays the signal and statistics for whichever range is currently selected in either the high- or low-flow ports of the Analyzer. This screen measures the pressure in a ventilated test lung. The airway pressure displayed is that for the selected high- or low-flow port.

Range — Press the **RANGE** soft key to change between low pressure, airway pressure, and high-pressure screens.

Units — Press the **UNITS** soft key to change the units of measure for the airway-pressure screen. Possible units of measure for this screen include:

mbar	millibar = .001 Bar
bar	14.7 PSIG (Barometric)
mmHg	millimeters of mercury
inHg	inches of mercury
cmH_2O	centimeters of water
inH_2O	inches of water
PSIG	pounds per square inch
atm	atmospheres
kPa	kilopascals

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

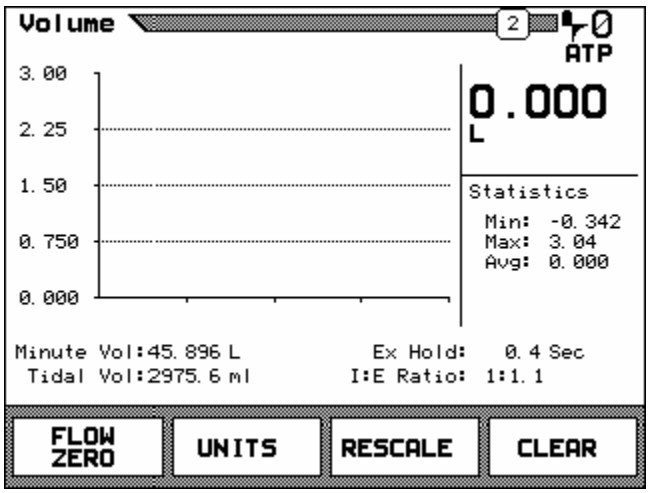
***RESCALE** uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*.

Volume Screen

The Volume screen displays the signal and statistics for the volume signal.



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The volume signal is the integral of the flow signal measured in either the high or low flow ports. The flow port that is integrated is selected by selecting the high- or low-flow range from within the flow screen.

Flow Zero — Press the **FLOW ZERO** soft key to zero the flow reading.

Units — Press the **UNITS** soft key to change the units of measure for the volume screen. Possible units of measure for this screen include:

l	Liters
ml	Milliliters
CF	Cubic Feet

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

***RESCALE** uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Parameters*.

Note

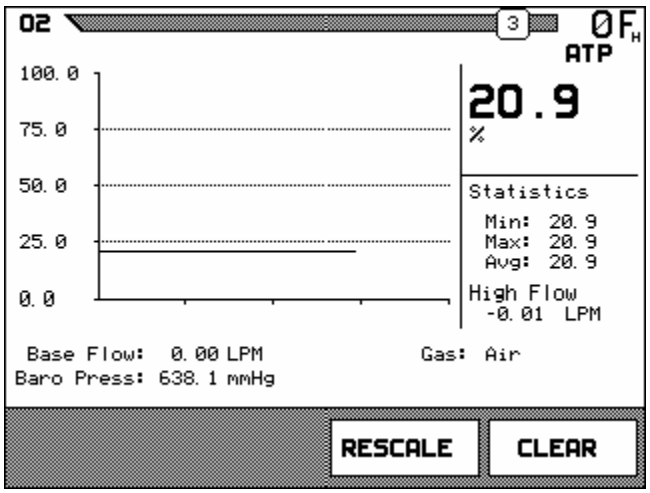
The volume signal is integrated from either the high- or low-flow signals.

To select which flow signal is used to calculate volume:

1. Press the **FLOW/0** key.
2. Press the **RANGE** soft key until the screen corresponding to the desired flow signal (high or low) displays.

Oxygen Screen

The Oxygen screen displays the signal and statistics for the oxygen sensor.



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The Analyzer measures oxygen in the high-flow port. If oxygen in the low-flow port is to be measured, the flow of gas must be passed through the high-flow port also to measure oxygen.

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Note

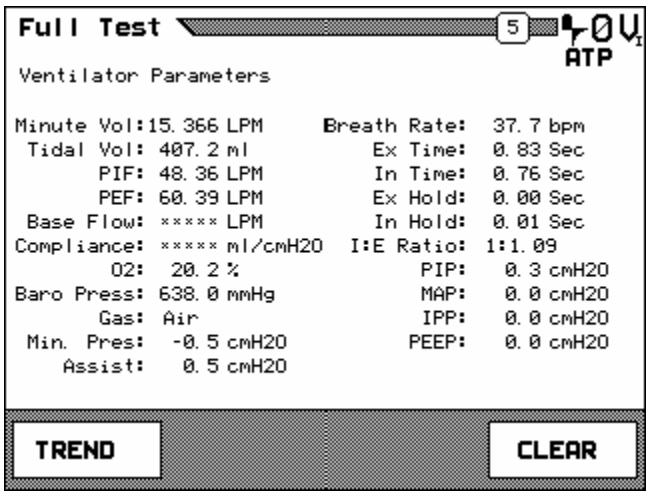
RESCALE *uses the current min/max values to determine plot limits.*

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

The user can select the breath parameters displayed on this screen by following the instructions under *Selecting Breath Parameters*. Refer to *Connection and Setup*: *Utilities: Oxygen Sensor Calibration* for instructions.

Full Breath Parameters Test Screen

The Full Test screen displays all of the breath parameters calculated by the Analyzer.



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Note

Breath detection must be enabled for breath parameters to be calculated. See System Setup for instructions on enabling breath detection.

Trend — Press the **TREND** soft key to print the trend of a single parameter. See *Special Functions* for a more description of the trend function

Clear — Press the **CLEAR** soft key to reset the statistics and re-start the plot.

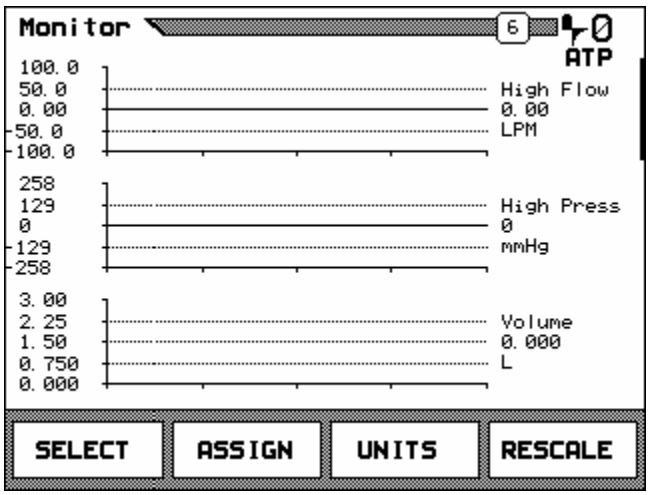
If asterisks appear for a parameter value, the parameter is either invalid for the current breath detect mode or the system does not have sufficient information to accurately calculate the parameter. For example, Base Flow is invalid during bi-directional breath detection mode because the base flow is seen only in the inspiratory and expiratory limbs of the ventilator circuit. In another example, it would be impossible to measure the inspiratory hold pressure during the expiratory-only mode.

Note

The Assist Pressure (Assist) and the Minimum Pressure (Min Pres) are not available for trending and cannot be added to other screens using the parameter selection. Refer to Special Functions for instructions on Assist Mode testing.

Monitor Screen

The Monitor screen shows three signals and their corresponding values.



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Alternatively, the lower signal can be replaced by a set of four breath parameters. The user can select which signals are displayed on the monitor screen.

Select — Press the **SELECT** soft key to change the position of the plot that can be altered using the **ASSIGN** and **UNITS** soft keys. The vertical cursor bar on the right side of the display moves, indicating the plot area selected.

Assign — Press the **ASSIGN** soft key to change which signal is plotted in the selected position. Four breath parameters can be displayed in place of a signal plot in the lowest position. The user can select the parameters displayed in this screen.

Units — Press the **UNITS** soft key to change the units of the signal and the units of the instantaneous value for the plot in the selected position. The possible units for each of the various signals are the same as the units that can be displayed in the screens that display that signal exclusively.

Re-scale — Press the **RESCALE** soft key to change the scale on the plot of data to a more appropriate window of values.

Units of Measure

The Analyzer has the capability to display the above signals and parameters in the following units of measure shown in Table 3-4 .

Table 3-4. Available Units of Measure

Unit	Description
Flow	
lpm	Liters per minute
f^3/min	Cubic feet per minute
l/sec	Liters per second
ml/min	Milliliters per minute
ml/sec	Milliliters per second
Low/High/Barometric/Airway Pressure	
PSIG	Pounds per square inch gauge
kPa	Kilopascals
bar	14.7 PSIG
mbar	millibar = .001 Bar
atm	Atmosphere
inH_20	Inches of water
inHg	Inches of mercury
cmH_20	Centimeters of water
mmHg	Millimeters of mercury
Volume	
l	Liters
F^3	Cubic Feet
ml	Milliliters

The Analyzer has conversion factors for gas, volume, and flow measurements, as shown in Table 3-5.

Table 3-5. Available Conversion Factors

Conversion Factor	Description
ATP	Conversion for gas flow and volume to ambient temperature and pressure
STPD0	Conversion for gas flow and volume to a standard temperature of 0 °C and a standard barometric pressure of 760 mmHg
STPD21	Conversion for gas flow and volume to a standard temperature of 21 °C and a standard barometric pressure of 760 mmHg
BTPS	Conversion for gas flow and volume to body temperature of 37 °C with 100 % relative humidity

Special Functions

Trend Test

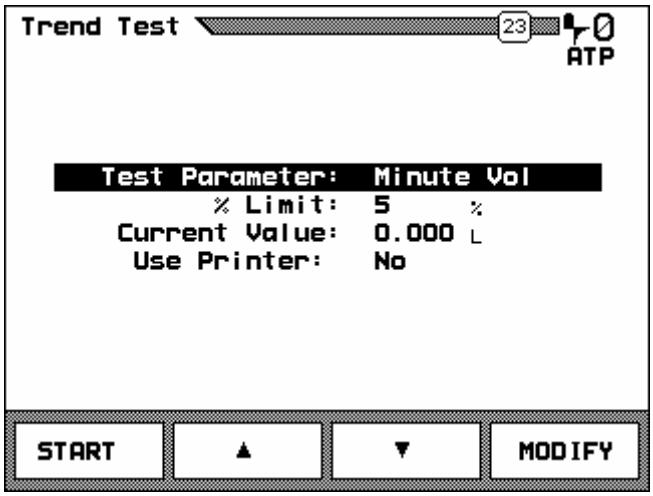
The Analyzer provides an automated Trend test that checks a single breath parameter over an extended period of time to see if it deviates from limits set by the user. The limits are set as a percent variation from the initial measured value.

To access the Trend test screen, use either of the following procedures:

1. Press the **FULL/5** key to display the breath parameters.
2. Press the soft key **TREND** soft key.

Or

1. Press the **MORE/4** key.
2. Use the ▲ and ▼ soft keys to highlight **Trend Test**.
3. Press the soft key **ENTER** soft key**.** The **Trend Test Setup** screen displays.



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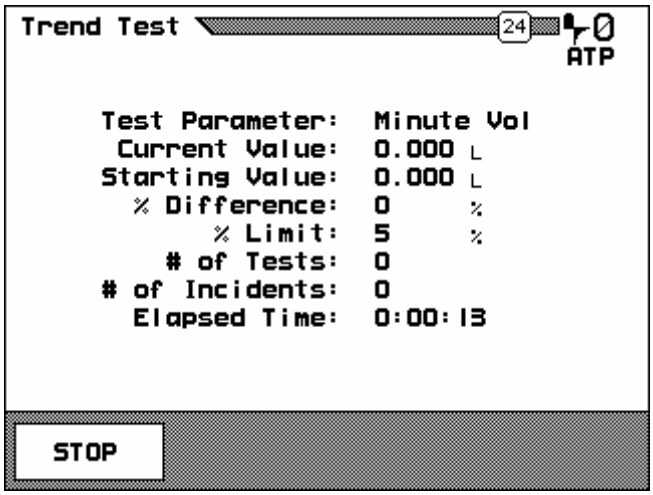
To set test parameters:

1. Use the ▲ and ▼ soft keys to highlight **Test Parameter**.
2. Press the **MODIFY** soft key until the desired breath parameter displays. The most recent measurement of the selected parameter is displayed as the **Current Value**.
3. Use the ▲ and ▼ soft keys to highlight **% Limit**.
4. Press the **MODIFY** soft key, then use the keypad to enter the percent change representing a deviation from acceptable limits. Percent values range from 1 to 99. Remember to enter leading zeros for values less than 10. For example, 5 % is entered as 05 %.
5. Press the **ENTER** soft key.
6. Use the ▲ and ▼ soft keys to highlight **Use Printer**.
7. Press the **MODIFY** soft key. If **Yes** is selected, a report is printed that list all breath parameters with a time/date stamp every time an incident occurs.

To run the test:

1. Ensure that the ventilator is on and that steady-state conditions are reached. Monitor the **Current Value** displayed to ensure that the breath parameter is as expected.

   Press the **START** soft key to begin testing. While the test is in progress, the Trend Test screen displays the parameter being tested, the current and starting values, and the % difference between the two values. The allowable % deviation limit, the number of tests taken, and the number of breaths (incidents) in which the limit has been exceeded is also displayed.



fec059.bmp

2. To terminate the test, press the **STOP** soft key. A sample Trend Test report is shown below.

TREND TEST REPORT

6/13/2000 10:45 VT PLUS HF S/N: 4294967295

Control #: _____ S/N: _____

Tech: _____

Incident Report

Test Parameter:	Minute Vol	Elapsed Time:	0:00:05
Current Value:	40.333 L	Starting Value:	28.686 L
% Difference:	41 %	% Limit:	5 %
# of Tests:	1	# of Incidents:	1

Parameters:

Minute Vol:	40.333 L	Breath Rate:	29 bpm
Tidal Vol:	1384.8 ml	Ex Time:	0.9 sec
PIP:	109.42 LPM	In Time:	1.1 sec
PEP:	113.91 LPM	Ex Hold:	0.0 sec
Base Flow:	***** LPM	In Hold:	0.0 sec
Compliance:	***** ml/cmH2O	I:E Ratio:	1.2:1
O2:	18.5 %	PIP:	1.9 cmH2O
Baro Press:	645.1 mmHg	MAP:	0.0 cmH2O
Gas:	Air	IPP:	0.0 cmH2O
		PEEP:	0.0 cmH2O

Final Report

Test Parameter:	Minute Vol	Starting Value:	28.686 L
Starting Time:	10:45:30	Ending Time:	10:45:37
Elapsed Time:	0:00:07	% Limit:	5 %
# of Incidents:	1	# of Tests:	1

Leak Test

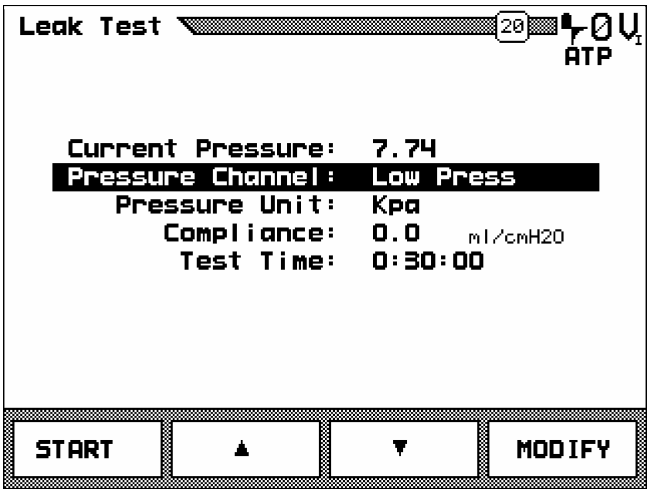
The Analyzer allows the user to test the leak rate of a sealed vessel or test lung. A Leak test can be done using the high pressure, low pressure, or airway pressure signals to measure the leak rate of a sealed vessel or test lung.

⚠ Caution

To avoid damage to the Analyzer, be sure that maximum pressure ratings are not exceeded when performing a Leak test. See Specifications for absolute maximum pressure ratings for each pressure port.

To access the Leak test screen:

1. Press the **MORE/4** key.
2. Use the ▲ and ▼ soft keys to highlight **Leak Test**.
3. Press the **ENTER** soft key**.** The **Leak Test Setup** screen displays.



fec061.bmp

To set test parameters:

1. On the **Leak Test Setup** screen, press the ▲ and ▼ soft keys to highlight **Pressure Channel**.
2. Press the **MODIFY** soft key until the desired pressure channel is selected.

Note

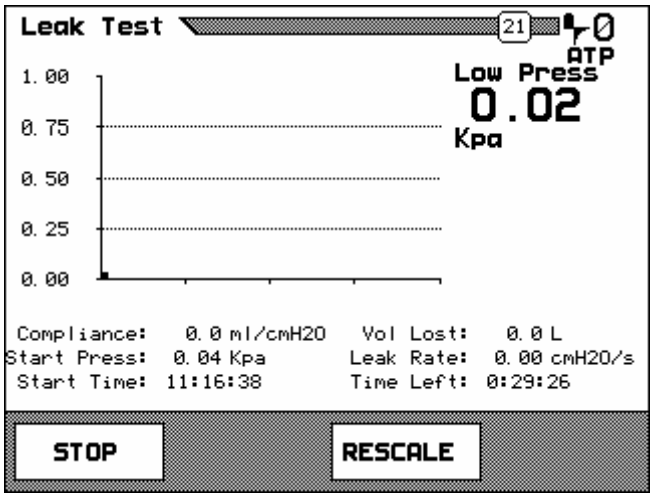
*If **Airway** is selected, the airway transducer is connected to the currently selected flow channel. Both flow channels can be tested; however, the appropriate channel must be selected using the **RANGE** function in the **Flow Mode** screen.*

3. To enter the compliance of the test chamber (test lung) press the ▲ and ▼ soft keys to highlight **Compliance**.
4. Press the **MODIFY** soft key. Use the keypad to enter the compliance in l/cmH_2O. Be sure to use leading zeros so that a number is entered for all five digits.
5. To enter the duration of the test, press the ▲ and ▼ soft keys to highlight **Test Time**.
6. Press the **MODIFY** soft key.

7. Use the keypad to enter the duration of the Leak test in hours, minutes, and seconds. Six digits must be entered to set the test time. The time is entered in the following format: HHMMSS (HH is the hours (0-99), MM is the minutes (0-59) and SS is the seconds (0-59). Be sure to use leading zeros to enter values less than 10. For example, to enter a time of 1:09:05, press the following sequence of keys: 0, 1, 0, 9, 0, 5).

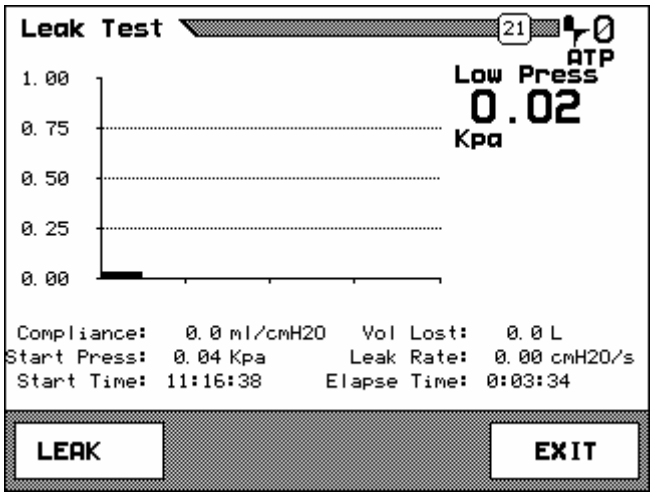
To run the test:

1. After all of the test parameters are set, pressurize the test chamber (test lung).
2. Press the **START** soft key to begin testing. A screen similar to the one shown is displayed.



fec062.bmp

3. The display shows a pressure plot and instantaneous pressure value to the right of the plot. Parameters below the pressure plot show the entered compliance, the time of day that the test was started, and the calculated test results.
4. Press the **STOP** soft key to terminate the test or let the test time elapse. In either case, a Leak test result displays.



fec063.bmp

A sample Leak Test Report is shown below.

```
                    Fluke Biomedical Corporation




1/2/2000             3:05                       VT PLUS HF S/N: 166752

 Control #: _____________________        S/N: _____________________
      Tech: _____________________


Leak Test:

Low Press            0.02 Kpa

 Compliance:           0.00 ml/cmH2O
Start Press:           0.00 Kpa
 Start Time:          03:05:13
   Vol Lost:             0.0 ml
  Leak Rate:           0.07 cmH2O/s
Elapse Time:          00:00:03


Parameters:

 Minute Vol:          0.000 L              Breath Rate:       0 bpm
  Tidal Vol:            0.0 ml                 Ex Time:     0.0 sec
        PIP:           0.00 LPM                In Time:     0.0 sec
        PEP:           0.00 LPM                Ex Hold:     0.0 sec
  Base Flow:           0.00 LPM                In Hold:     0.0 sec
 Compliance:            0.0 ml/cmH2O         I:E Ratio:   *****
         O2:            20.6 %                     PIP:     0.0 cmH2O
 Baro Press:           766.6 mmHg                  MAP:     0.0 cmH2O
        Gas:           Air                         IPP:     0.0 cmH2O
                                                  PEEP:     0.0 cmH2O
```

Stacked Volume Test

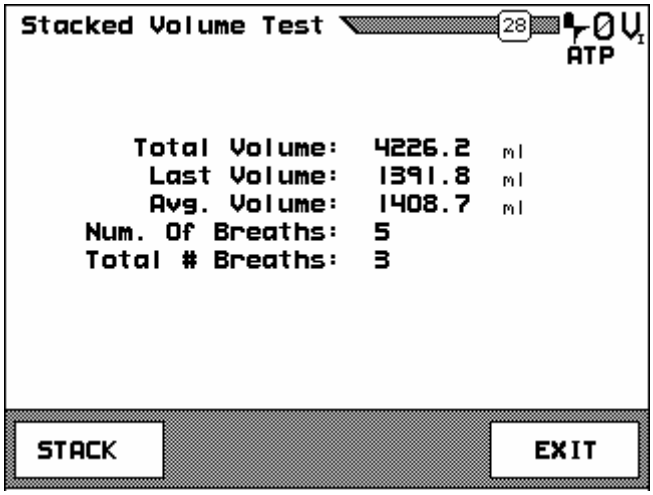
The Stacked Volume test measures the volume of multiple breaths to determine the accuracy of the ventilator in accumulating volume.

To access the Stacked Volume test:

1. Press the **MORE/4** key.
2. Use the ▲ and ▼ soft keys to highlight **Stacked Volume Test**.
3. Press the **ENTER** soft key.
4. Press the **MODIFY** soft key.
5. Use the keypad to enter the number of breaths for the test and press the **ENTER** soft key.

To run the test:

1. Press the **START** or **AUTO** soft key to begin the test. The display changes to show the progress of the test:



fec067.bmp

The values shown are described below:

Total Volume – The total volume of all breaths together

Last Volume – The volume of the last breath taken

Avg. Volume – The average volume of all breaths taken

Num. Of Breaths – The total number of breaths taken

Total # Breaths – The total number of breaths to be taken

Note

*If a stacked volume test is started with the **START** soft key, the test accumulates the requested number of breaths and ends. If the test is started using the **AUTO** soft key, the test automatically restarts after the requested number of breaths have accumulated.*

2. When the test is complete, press the **STACK** soft key to start a new stacked volume test or press the **EXIT** soft key to exit.

RT200 Emulation Mode

The Analyzer can emulate RT200 serial port communications. This mode is used for some ventilator automated test procedures.

To set the RT200 emulation mode:

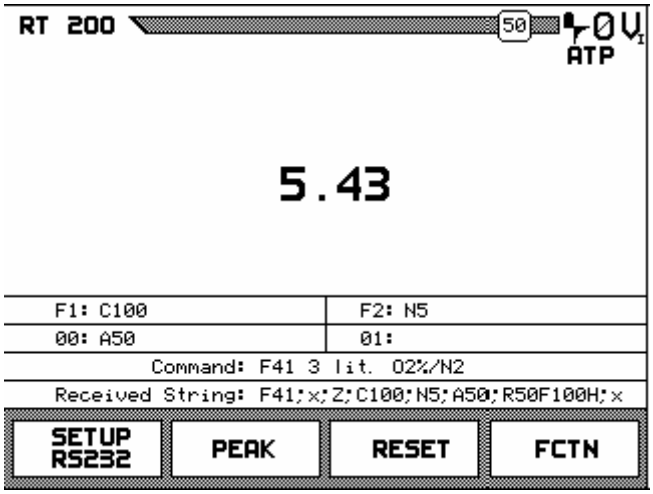
1. From the **Setup** screen, select **System**.
2. Use the ▲ and ▼ soft keys to highlight **Serial Mode**.
3. Press the **MODIFY** soft key to change **Serial Mode** to **RT200**.

To access the RT200 Emulation mode use either of the following procedures:

1. Press the **MORE/4** key.
2. Use the ▲ and ▼ soft keys to highlight **RT200 Emulation Mode**.
3. Press the **ENTER** soft key.

Or

1. Press the **SETUP/8** key.
2. Use the ▲ and ▼ soft keys to highlight **SYSTEM**.
3. Press the **ENTER** soft key.
4. Use the ▲ and ▼ soft keys to highlight **Serial Mode**.
5. Press the **MODIFY** soft key until **RT200** displays.
6. Press the **BACK** soft key to return to the **Setup** screen.
7. Press the **BACK** soft key again to exit the **Setup** screen and display the **RT200** screen.



fec069.bmp

In the emulation mode, serial (RS232) commands can be sent to the Analyzer in the format of the communication protocol used by the RT200.

The status of the RT200 special functions are displayed in the boxes: **00**, **01**, **F1**, **F2**. The meaning of the special functions can vary depending on the active function. Refer to the *RT200 Calibration Analyzer – Operation Manua*l from Allied Healthcare Products, Inc.

The **Command** box displays the active command and the units of the command, (F41 3 lit. O2%/N2). If the peak mode is active, the **Command** box displays peak at the end of

the command string. When a command is received, it is displayed in the box named **Received String**. Refer to Serial Interface for the *RT200 Calibration Analyzer System – Operation Manual* from Allied Healthcare Products, Inc. for the format of serial commands.

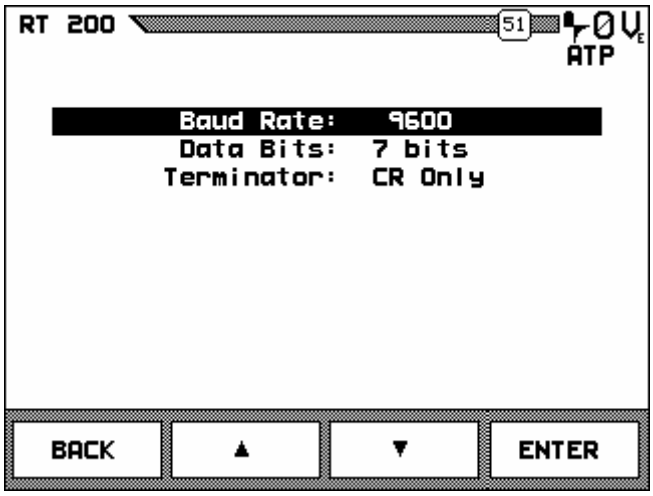
The RT200 Functions supported by the Analyzer are listed in Table 3-6.

Table 3-6. Supported RT200 Functions

Command	Description
F09	Reset
F11	Low Pressure Measurement – (20 cmH_2O)
F12	Low Pressure Measurement – (250 cmH_2O)
F13	Low Pressure Measurement – (185 mmHg)
F21	High Pressure Measurement – (20 psi)
F22	High Pressure Measurement – (100 psi)
F23	High Pressure Measurement – (5170 mmHg)
F31	Low Flow Measurement – (O_2% / N_2)
F32	Low Flow Measurement – (Air)
F33	Low Flow Measurement – (O_2% / N_2O)
F35	High Flow Measurement – (O_2% / N_2)
F36	High Flow Measurement – (Air)
F37	High Flow Measurement – (O_2% / N_2O)
F41	Tidal Volume – (O_2% / N_2)
F42	Tidal Volume – (Air)
F43	Minute Volume – (O_2% / N_2)
F45	Respiratory Rate
F46	$T_{inspiratory}$
F47	$T_{expiratory}$
F48	I:E Ratio

The soft keys for the RT200 screen are:

SETUP RS232 – displays a screen for setting the baud rate, number of data bits, and the terminator character:



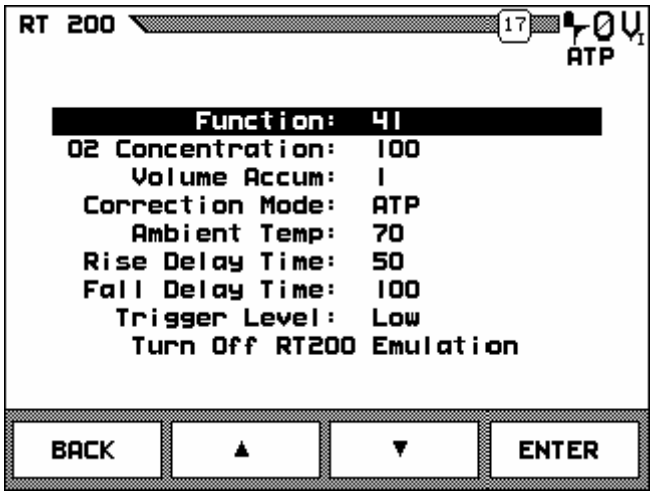
fec071.bmp

These settings affect only the RT200 emulation mode and not the other serial communication modes. The default settings are 9600 baud, 7 bits, and a termination character of carriage return only.

PEAK – toggles the RT200 peak-detect mode on and off, for flow and pressure signals; when in peak-detect mode, the peak of the current signal (flow or pressure) is shown for each breath

RESET – resets the RT200 mode, turning off any active functions, and resetting the special functions

FCTN – displays a menu that allows the user to start a RT200 function and enter the special function values associated with that RT200 function. The menu is function sensitive, and the options in the menu correlate to the RT200 special functions 00, 01, F1, and F2. The values set in this menu include those shown below:



fec070.bmp

Assist Test

The Assist test determines the sensitivity of the ventilator in patient assist mode and helps to calibrate the full range of assist pressures under which the ventilator can operate. During an assisted breath, the airway pressure drops during the inspiration due to the spontaneous breath. The assist is triggered by a negative pressure (relative to the end-expiratory pressure) during the expiratory hold period. See Figure 3-2.

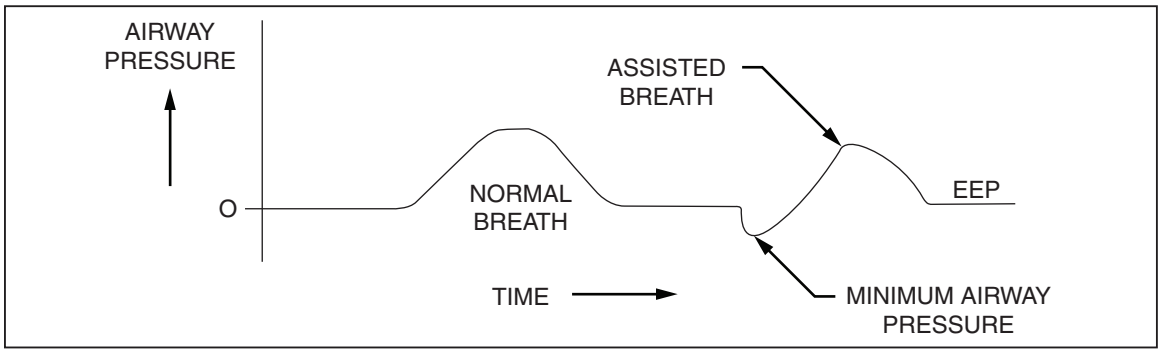


Figure 3-2. The Assist Test

To perform an Assist test:

1. Press the **FULL/5** key. The **Full Test** screen displays.
2. Connect the ventilator breathing circuit to the Analyzer in the bidirectional measurement configuration as shown in Figure 3-3.

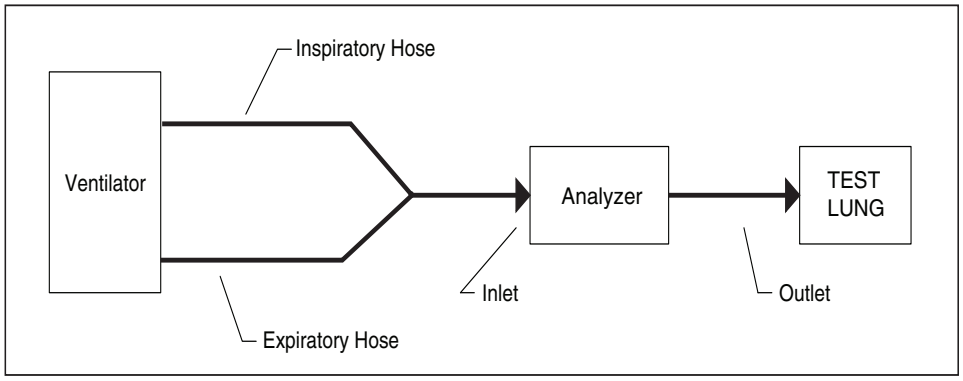


Figure 3-3. Ventilator Breathing Circuit Setup for Bi-Directional Measurements

3. Adjust the ventilator controls so that the ventilator is triggered by an effort (negative pressure) at the lung during the expiration hold period of the ventilator's breath cycle.

Note

Use the Synchronized Intermittent Mandatory Ventilation (SIMV) mode or Intermittent Demand Ventilation (IDV) mode if the ventilator provides it.

4. Check the control setting by applying upward force at the back of the test lung and observing if the ventilator triggers as desired.
5. Set a low breath rate to allow the distinction to be made between a triggered assist breath and a mandatory breath.

4. Ensure that the ventilator is delivering breaths in a steady manner.
5. Gently lift the back of the test lung top plate during the expiratory hold period in a smooth, steady pull to create negative pressure.
6. Repeat several times using different forces to approximate the minimum patient effort required to trigger the ventilator.

Note

To carry out a more repeatable performance study, such as the determination of the work of breathing, attach an external, motor-driven cam system or a pneumatic actuator to the top plate of the test lung.

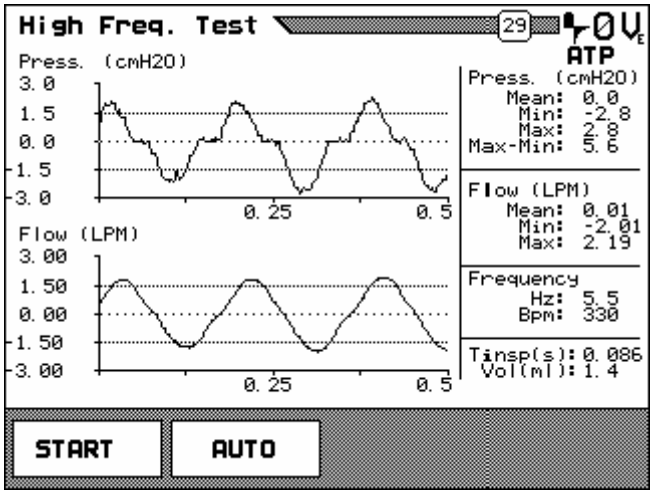
The **Full Test** screen shows all of the ventilator parameters. The minimum pressure and the assist pressure are displayed on the lower left column.

High Frequency Oscillator Mode

The Analyzer can test high-frequency flow and airway pressure.

To access the High-Frequency Oscillator mode:

1. Press the **MORE/4** key.
2. Use the ▲ and ▼ soft keys to highlight **High Frequency Oscillator**.
3. Press the **ENTER** soft key. The **High Freq. Test** screen displays:



fec074.bmp

The high-frequency oscillator (HFO) mode samples flow and airway pressure at a much faster rate (5x) than the Analyzer does in normal operation. It is useful for monitoring the function of extremely high-frequency breath rates, up to 800 bpm. In HFO mode, the Analyzer collects two seconds worth of data at a time. After the data is collected, it is processed to calculate parameters, and the first half-second of data is plotted on the display.

The mean, min, and max values are calculated for both pressure and flow signals. These values apply to the entire two seconds of data, not just the half-second that is plotted. The breath rate is calculated and displayed in both breaths per minute and Hz. The inspiratory time and tidal volume are also calculated.

To run the HFO test:

1. Press the **START** or **AUTO** soft key to begin the test. The **START** soft key runs the test once, while the **AUTO** soft key starts the HFO test in automatic mode. In automatic mode the HFO test is run every 15 seconds.
2. If in automatic mode, press the **STOP** soft key to end the test.

Chapter 4
Remote Operation

Title **Page**

Getting Started

The Analyzer can be run by the VT for Windows PC software from a PC that meets the minimum requirements listed below. The two must be connected properly, and the VT for Windows PC software installed as described. Then, the PC must establish communications with the Analyzer.

System Requirements

The following are minimum requirements for PC:

- Microsoft Windows 98/NT/2000/XP.
- 8 MB of RAM required, 32 MB of RAM recommended.
- 100 MHz Pentium system required, 200 MHz Pentium II system recommended.

On slower computers, the Analyzer software may not be able to display the real-time waveform data. If using a slower computer than recommended and a problem occurs, select **Parameters Only** from the **Communications** menu.

Connecting to the Analyzer

To make connection between the Analyzer and a PC, plug a standard 9-pin serial cable into the RS232 port on the back of the Analyzer and into an unused serial (com) port on the PC.

Note

When the VT for Windows PC software is launched, the Analyzer is automatically placed into the computer control mode. No graphics are available on the Analyzer screen while serial communications are active. A screen displays on the Analyzer, indicating that serial communications are enabled.

Installing the Software

To install the VT for Windows PC software on the PC:

1. Insert the VT for Windows PC software disk into a 3.25 in disk drive on the PC.
2. Select **Run** from the start menu under Microsoft Windows 95/98/NT.
3. When the **Run** dialog box appears, type “a:\setup.exe”. If the disk drive is not “a”, substitute the correct drive letter for “a”.
4. Click **OK**.

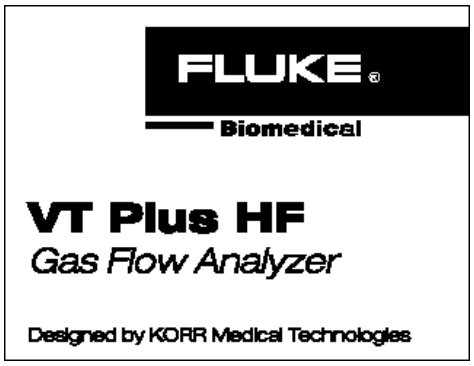
The installation program for VT for Windows PC software asks several questions before installing the program:

- The user is given the option to specify where to install the program on the computer.
- If installing over a previous version of this software, the user is asked where to back up old copies of the files.
- Also, the user is asked where to put the icons for the VT for Windows PC software program. Simply follow the instructions given by the installation program. If no changes are made to the default installation options, VT for Windows PC software is installed to “C:\Program Files\VTPlus”, and the shortcuts to the program are in the VT Plus group.

Starting the Software

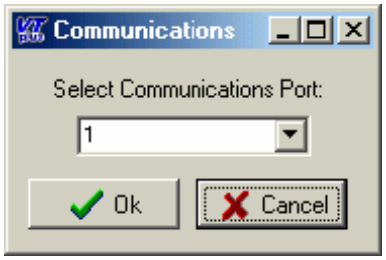
The software application is ready to start when the software has been installed and the Analyzer connected.

The first time the software is used, the application attempts to establish communications with the Analyzer and displays the following:



fec109.bmp

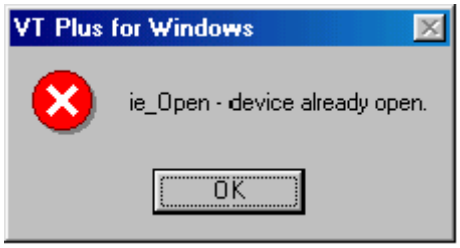
The software checks the serial communication ports (also called Comm Ports) listed in the Windows Registry. If the software cannot find the Analyzer, the following screen appears, allowing the Analyzer communication port to be designated:



fec079.bmp

Once the software has established communication with the Analyzer, an initialization file is created that is read by the software during future use. The software uses the information in the initialization file to know where to check for the Analyzer.

An error can occur if the communication port is in use by another device and/or software application. If the communication port is already open, the following error is shown:



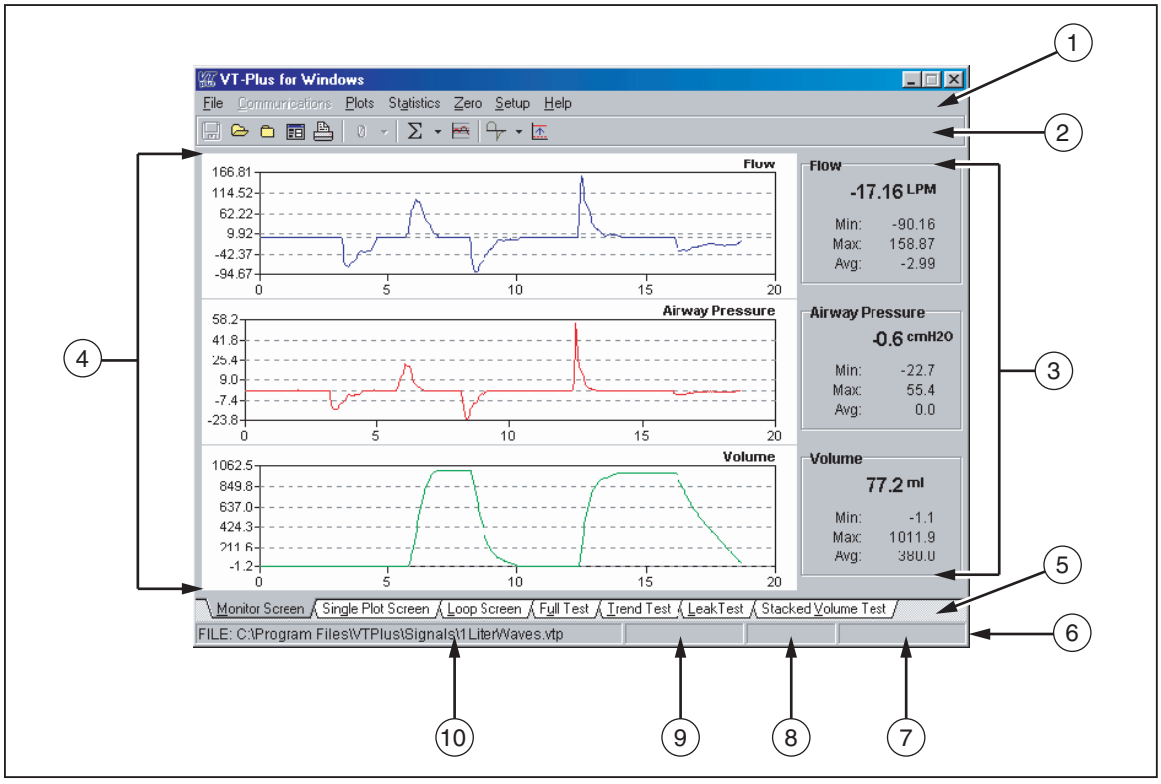
fec080.bmp

To solve this error, simply close the application that is using the desired communication port. It should be noted that opening the VT for Windows PC software multiple times would also cause the same error message.

Finally, if the communication port for the Analyzer must be manually set or changed, start VT for Windows PC software and select **Communications** > **Comm Port** from the pull down menu. Select the appropriate communication port. Communications are established when the software displays waveforms and the displayed values for flow and pressure are changing.

Overview of VT for Windows PC Software

VT for Windows PC software provides a simple interface for recording and playing back data calculated by the Analyzer. The software provides most Analyzer functions on a simple interface for recording and playing back data calculated by the Analyzer. Figure 4-1 shows the VT for Windows PC software interface, and Table 4-1 identifies its essential elements.



fec086.eps

Figure 4-1. VT for Windows PC software Interface

Table 4-1. Elements of the VT for Windows Interface

Label	Element
①	Menu
②	Tool Bar
③	Statistics Area
④	Plot Area
⑤	Screen Tabs
⑥	Status Bar
⑦	Selected Flow Port
⑧	Correction Mode
⑨	Zeroing Mode
⑩	Selected File \ System Messages

Review and test screens are accessed through the Screen tabs near the bottom of the screen; these are described in *Main Screens and Tests*, below. Other functions are accessed through the menu, and commonly used menu functions are assigned to buttons on the toolbar.

At the bottom of the screen is a status bar that shows the current status of several user settings, including zeroing mode, correction mode, and the selected flow port. System messages such as ZEROING also appear here.

Menu Bar

VT for Windows provides a menu bar with pull-down options for easy access to the program functions. Figure 4-2 shows the menu bar, and Table 4-2 lists the menu bar options, with a description of each. Table 4-3 lists the options and descriptions of the Setup submenu.

fec082.eps

Figure 4-2. VT for Windows Menu Bar

Table 4-2. Menu Bar Options

Option	Description
File	This menu gives access to the file handling, and printing functions of this software. For a complete description see the Data and File Handling section in this chapter.
Communications	The communications menu allows selection of the communications port and the serial data mode. For a complete description see the Serial Communications section in this chapter.
Plots	The plot menu provides access to the plot re-scaling functions. It allows changing of the plot on any of the monitors, and turn on or off the automatic re-scaling. For a complete description see the Plots section in this chapter.
Statistics	The statistics menu gives access to the clear function for any or all statistics. The **CLEAR ALL** function clears the statistics for all of the signals at once, to clear individual signals select the option with its name.
Zero	The zeroing menu allows manual zeroing any or all of the signals. The **ZERO ALL** function zeros all of the signals except oxygen. To zero any of the individual signals, select its name from the **ZERO** menu. Airway pressure and flow are always zeroed at the same time.
Setup	The setup menu provides access to most of the user setup features found in the Analyzer.

Table 4-3. Setup Submenu Options

Option	Description
Flow Port	Use this menu to select which flow port to use. The checked option is the currently selected flow port.
Zeroing	The Zeroing menu is used to select a zeroing mode, either automatic or manual. The current zeroing mode is checked. See the Zeroing section later in this chapter.
Breath Detect	Use the breath-detect menu to switch breath detection modes, and to set the breath detect threshold for the current flow port.
Gas Settings	The gas settings function brings up the **GAS SETTINGS** dialog box. See the Gas Settings section later in this chapter.
Barometric Pressure	This function brings up the barometric pressure dialog box. Enter the local barometric pressure in mmHg and click OK to calibrate the barometric pressure sensor.
Signal Units	The signal units function brings up a dialog box for entering the desired units for the signals. See Signal Selection under the Plots section of this chapter.
Print Header	The print header function sets the print header in the Analyzer. See the Printing section in this chapter.
Help	Accesses the VT for Windows help file

Toolbar

The toolbar is provided for both convenience and speed. It provides a quick and easy way to call often used functions. Figure 4-3 shows the toolbar, while Table 4-4 lists the toolbar buttons, along with their functions and descriptions.

fec083.bmp

Figure 4-3. VT for Windows Toolbar

Table 4-4. Toolbar Buttons

Icon	Function	Description
	Save to File button	This button calls up the SAVE AS dialog and allows data to be saved to a file. If a file is already open, this button is disabled.
	Open File button	This button calls the open file dialog that allows review of a file. If a file is already open, this button is disabled.
	Close File button	This button closes any open data files. If no file is open, this button is disabled.
	File Controls button	This button calls up the file controls dialog. For more information, see the Data and File Handling section.
	Print button	This button gives quick access to the print functions. Click this and the printer dialog appears.
	Zeroing button	This button forces the Analyzer unit to zero immediately. For more information, see the Zeroing section.
	Clear Statistic button	This button forces the Analyzer to clear a selected statistic or all of them.
	Re-scale button	This button forces all of the plots to automatically re-scale immediately, rather than wait for the auto scale to re-scale them. For more information, see the Re-scale Plots section.
	Breath Detect Mode button	This button allows selection of a given type of breath detection mode such as bi-directional.
	Breath Detection Flow Threshold button	This button brings up a dialog box for entering the breath detection flow threshold. For more information, see the Setup Functions.

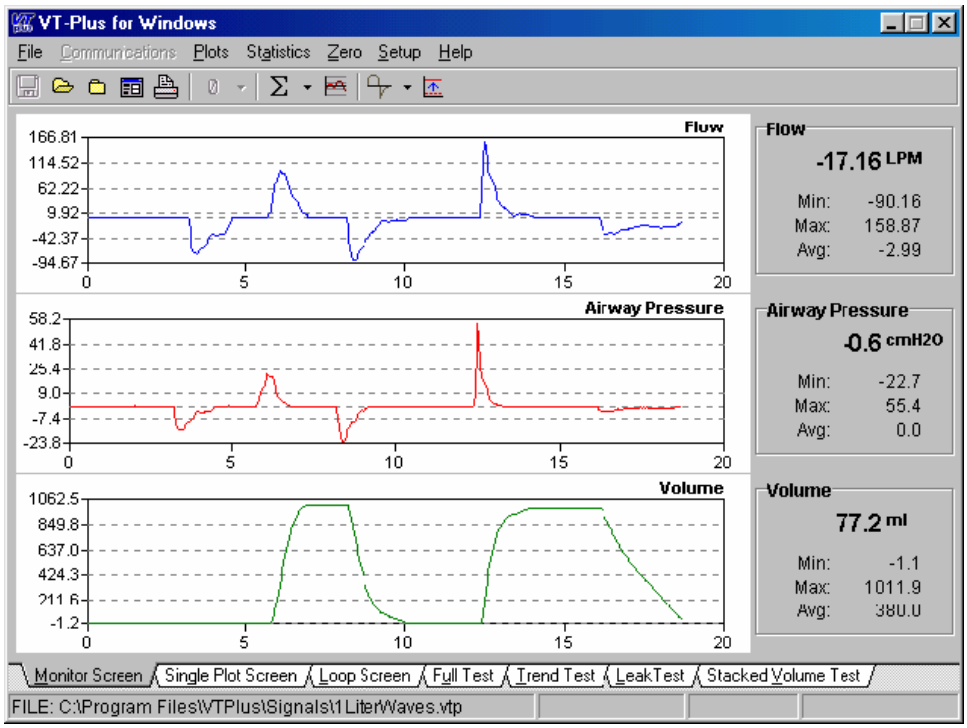
Main Screens and Tests

VT for Windows has seven main screens that are accessed through the Screen tabs; these are listed below:

- Monitor screen
- Single Plot screen
- Loop Plots screen
- Full Test screen
- Trend Test screen
- Leak Test screen
- Stacked Volume Test screen

Monitor Screen

The Monitor screen, shown in Figure 4-4, allows observation of three of the signals at the same time.



fec086.bmp

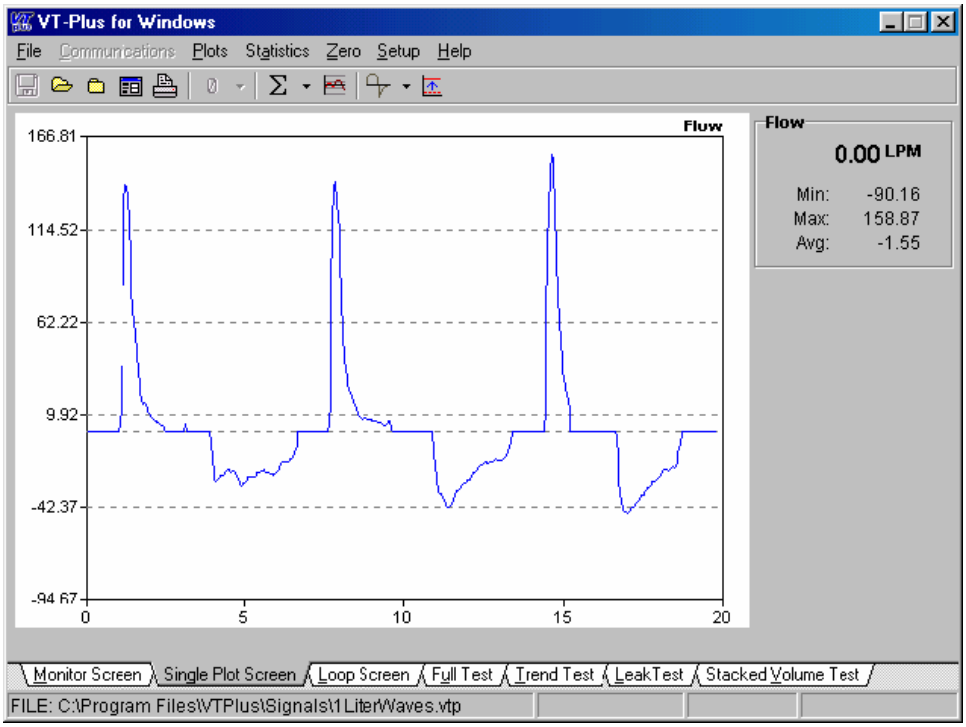
Figure 4-4. Monitor Screen

Each plot can be configured to display any of the signals, (flow, volume, airway pressure, low pressure, high pressure, and oxygen). Each plot can be independently, set to auto-scale or manually re-scaled to the user's desired range of values.

On the right hand side of the screen, the statistics for the selected signals are displayed. These statistics show the min, max, average and current value for the signal that is currently displayed. For more information on configuring plots, refer to *Signal Selection*, *Automatic Rescaling*, and *Manual Re-scaling*.

Single Plot Screen

The Single Plot screen, shown in Figure 4-5, allows observation of one of the signals.



fec087.bmp

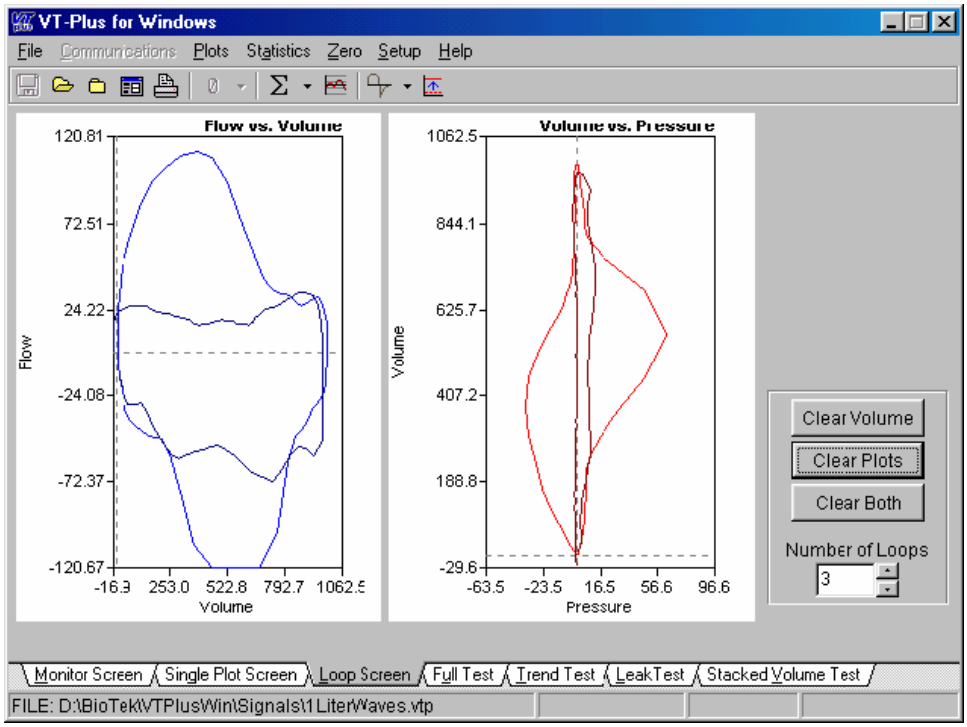
Figure 4-5. Single Plot Screen

The plot can be configured to display any of the signals, (flow, volume, airway pressure, low pressure, high pressure, and oxygen). This plot can be set to auto-scale or it can be manually re-scaled to the user's desired range of values.

On the right hand side of the screen, the statistics for the selected signal are displayed. These statistics show the min, max, average and current value for the signal that is currently displayed. For more information on configuring plots, refer to *Signal Selection*, *Automatic Rescaling*, and *Manual Re-scaling*.

Loop Screen

The Loop, or Loop Plots, screen, shown in Figure 4-6, displays plots of Flow vs. Volume and Volume vs. Airway Pressure.



fec088.bmp

Figure 4-6. Loop Screen

These plots can be independently re-scaled either automatically or manually.

Controls located on the right-hand side of the screen are used to control the appearance of the loop plots:

Clear Volume – allows zeroing of the volume when breath detect has been turned off

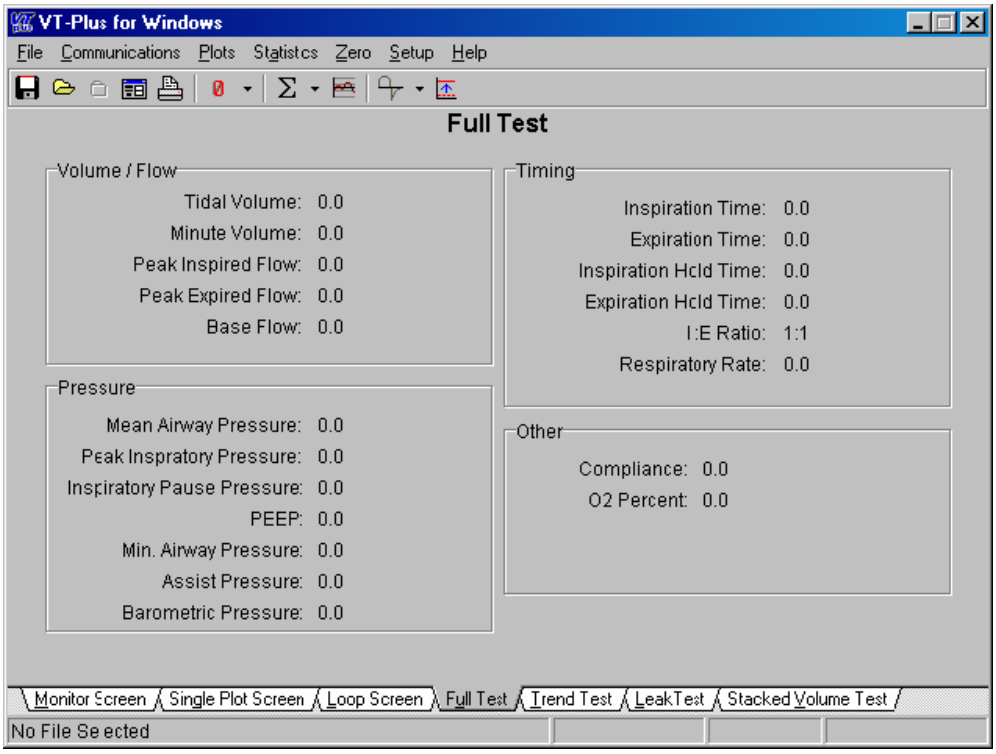
Clear Plots – clears both of the loop plots

Clear Both – performs both Clear Volume and Clear Plot functions

Number of Loops – allows specification of the number of breaths that are drawn before the plots are cleared; one to four breaths may be drawn before the plots are cleared.

Full Test Screen

The Full-Test screen, shown in Figure 4-7, displays the calculated parameters for the last breath.



fec089.bmp

Figure 4-7. Full Test Screen

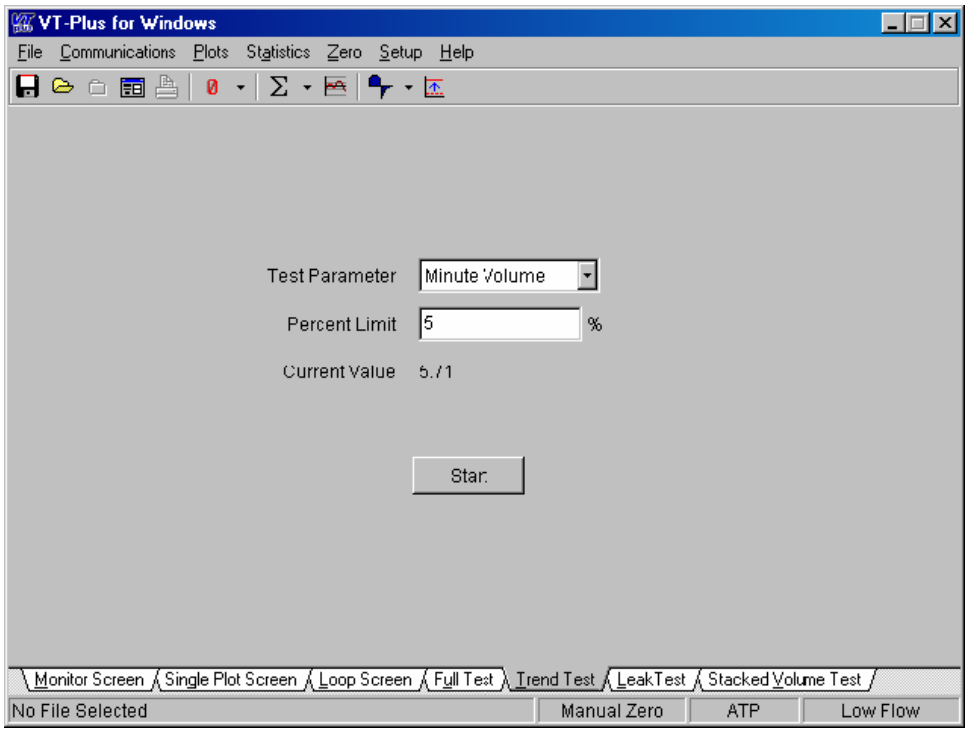
These parameters are only updated when a new breath occurs. A ***** value means that value is invalid or could not be calculated. Depending on the breath-detect mode, some parameters can't be calculated.

Trend Test

The Trend test is used for monitoring a single-breath parameter over an extended period of time. Each time a breath occurs, the chosen breath parameter is compared to an initial value. If it exceeds the percent limit given for the test, an incident is reported. Following the test, a report may be printed detailing all of the incidents that occurred during the test.

Setting Trend Test Parameters

The Trend test setup screen, shown in Figure 4-8, allows the user to choose the parameter to run the test on and to choose the percent limit for the test.



fec090.bmp

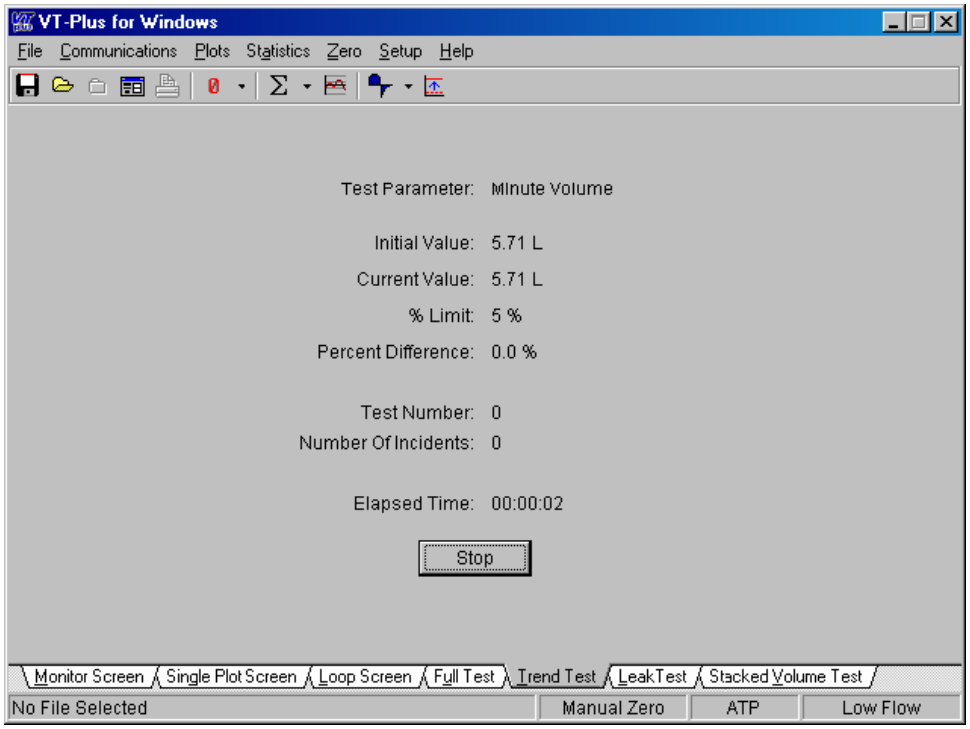
Figure 4-8. Trend Test: Setup Screen

Initially, the start button is not enabled. A trend test may be started only after receiving a valid value for the breath parameter chosen.

Running the Trend Test

To run the Trend test:

1. Click the **START** button. The screen changes, as shown in Figure 4-9.



fec091.bmp

Figure 4-9. Trend Test Screen: Testing Underway

While a test is running, screens cannot be changed until the **STOP** button that appears at the bottom of the screen has been clicked.

During a trend test, the following values are reported to the user every time a breath occurs:

Test Parameter – This is the parameter that was chosen for running this test. This value does not change during the test.

Current Value – This is the current value of the chosen test parameter. Every time a breath occurs, this is updated and compared against the initial value of the test parameter.

Starting Value – Shows the initial value for the test parameter. This value does not change during the test.

% Difference – This value is calculated each time a breath occurs. If it is greater than the % limit, an incident is reported.

% Limit – This is the value entered before starting the test. It does not change during the test.

# of Tests – Incremented each time a breath is detected.

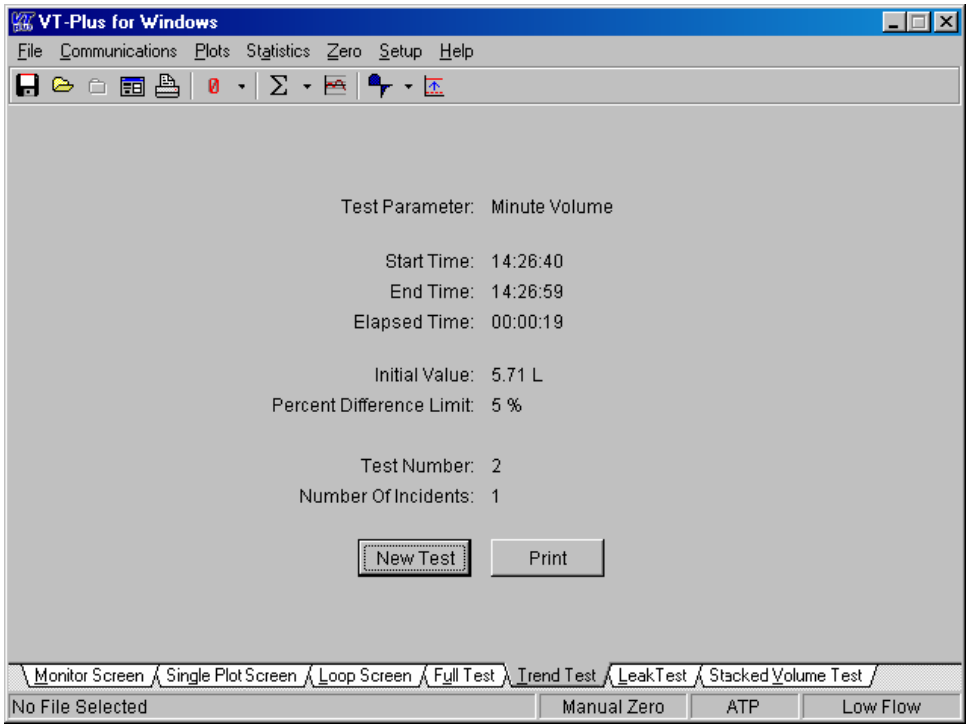
# of Incidents – The number of incidents is incremented each time the percent difference exceeds the percent limit.

Elapsed Time – This value is updated continuously. It keeps track of the length of time the current trend test has been run.

Ending the Trend Test:

To end the Trend test:

1. Click the **STOP** button. When the trend test is stopped, the final values are displayed, as shown in Figure 4-10:



fec092.bmp

Figure 4-10. Trend Test Screen: Final Values Displayed

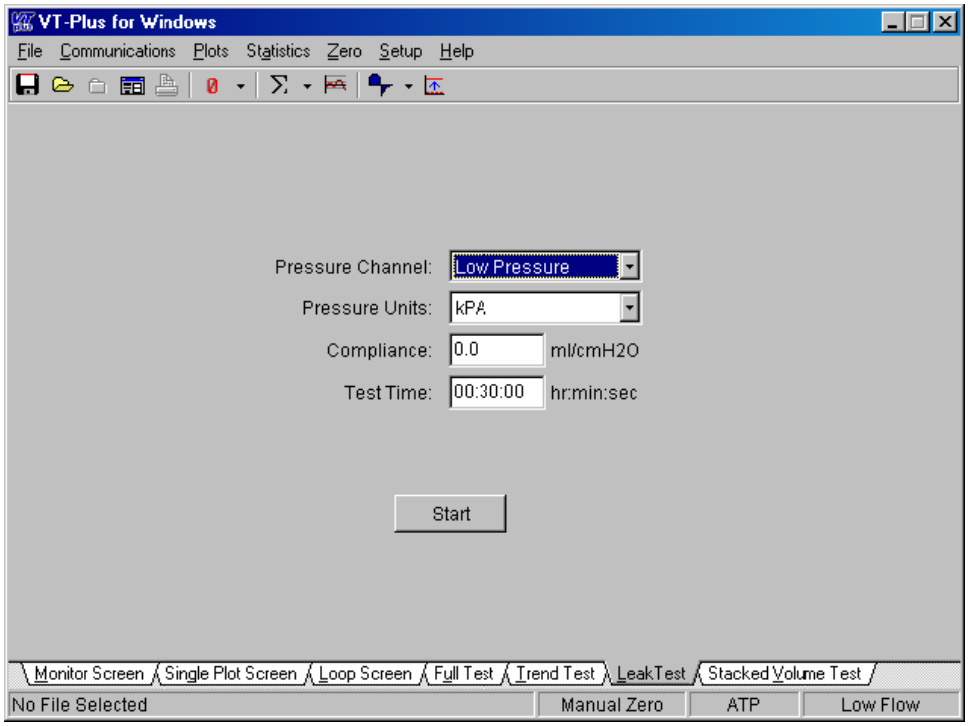
2. Click the **Print** button to print a copy of the results and the incident reports for the test.
3. Click the **New Test** button to start a new trend test.

Leak-Test

The Leak test is used for measuring the leak rate of a sealed vessel or test lung over a period of time.

Setting Leak Test Parameters

The Leak test setup screen, shown in Figure 4-11, allows the user to choose the desired pressure channel on which to run the test.



fec093.bmp

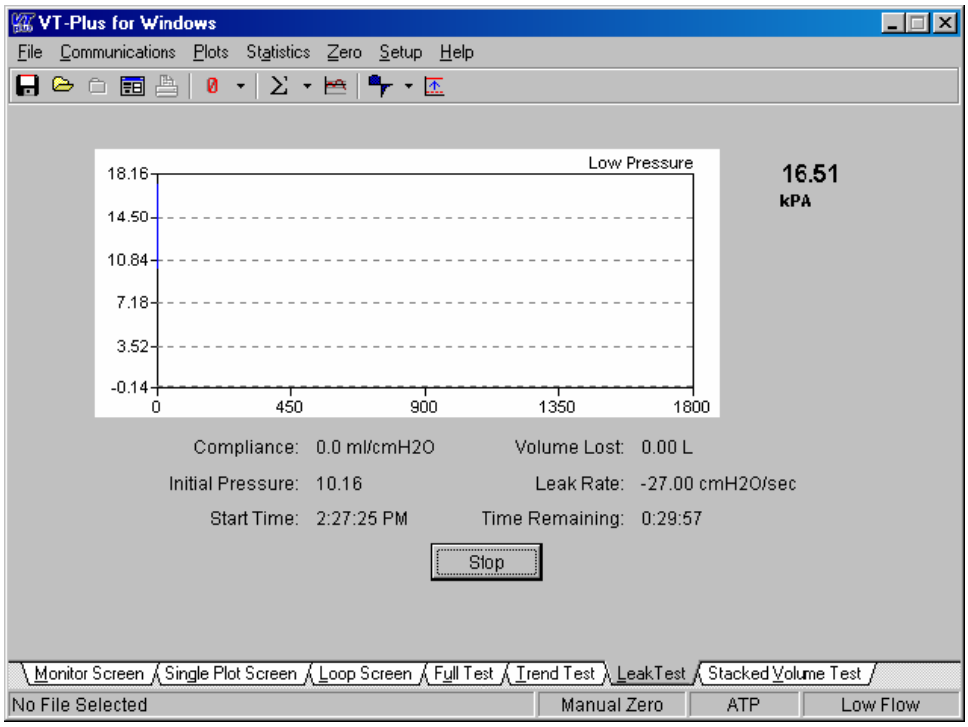
Figure 4-11. Leak Test: Setup Screen

Also, the displayed pressure units can be changed. If a compliance value is entered for the system being tested, the volume lost during the test is calculated. Enter the test time to set the length of time that the Leak test is to run. At the end of that amount of time, the Leak test automatically stops.

Running the Leak Test

To run the Leak test:

1. Press the **START** button to begin the Leak test. The screen changes, as shown in Figure 4-12:



fec094.bmp

Figure 4-12. Leak Test Screen: Testing Underway

Screens cannot be changed until the test being run has ended. The Leak test plots the chosen pressure channel (airway, low, or high pressure) over the chosen length of time. The Leak test also displays the following values that are calculated during the test:

Test Parameter – This is the parameter that was chosen for running this test. This value does not change during the test.

Compliance – This is the compliance value entered when starting the Leak test. This value doesn't change during a Leak test.

Initial Pressure – This is the pressure read on the selected pressure channel when the Leak test was started. The initial value doesn't change during a Leak test.

Start Time – This is the time that the Leak test was started.

Volume Lost – If a compliance value was entered at the start of the Leak test, this value is the amount of volume lost during the Leak test

Leak Rate – This is the rate at which pressure is being lost.

Time Remaining – This shows the amount of time left in the Leak test.

Ending the Leak Test

To end the Leak test:

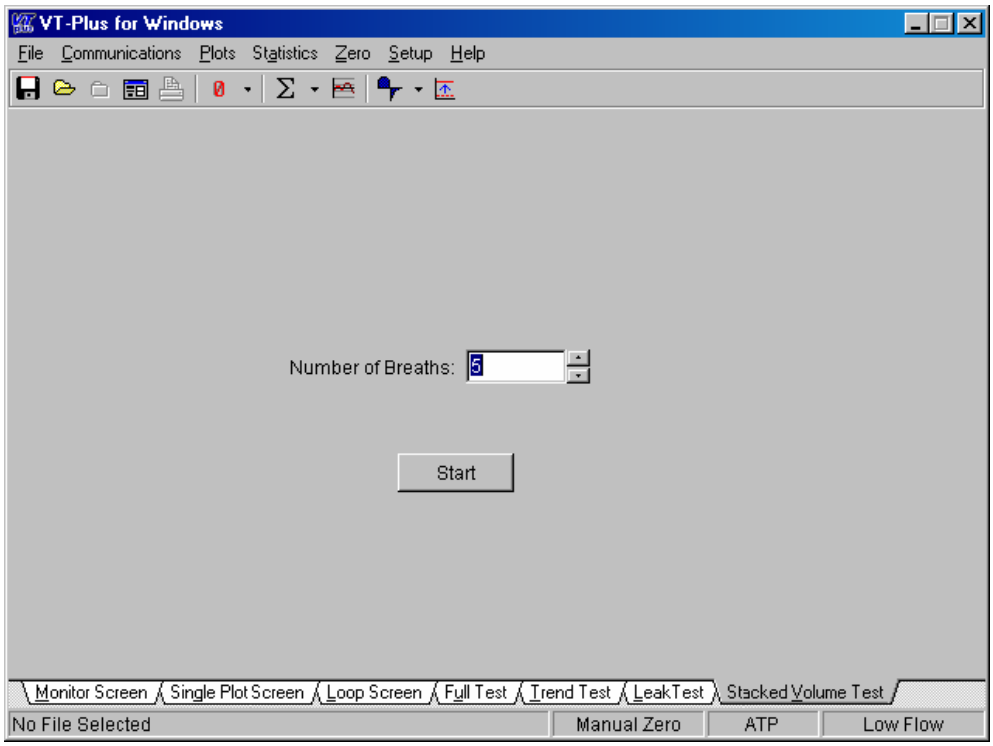
1. Either click the **STOP** button or let the Leak test end by the time running out. When the Leak test is over a report is prepared showing the final values for the calculated parameters.
2. Click the **Print** button to print a final report for the Leak test.
3. Click the **New Test** button to start a new Leak test.

Stacked Volume Test Screen

The Stacked Volume test measures tidal volumes over a given number of breaths and calculates the average tidal volume.

Setting Stacked Volume Test Parameters

The Stacked Volume test setup screen, shown in Figure 4-13, allows the user to enter the number of breaths to be averaged.



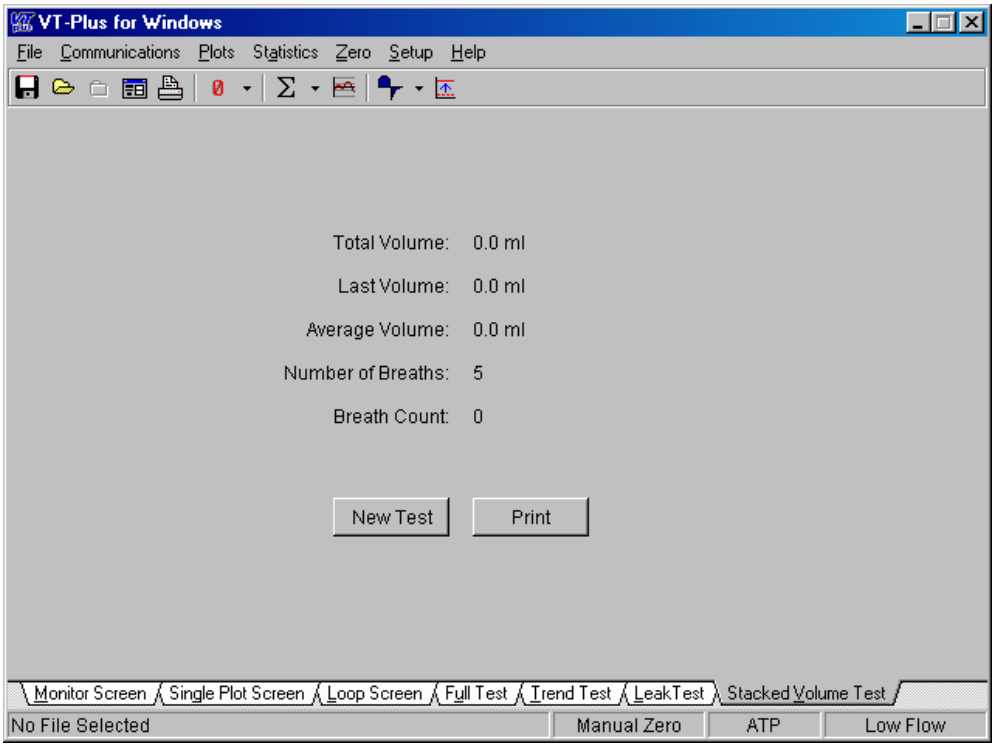
fec095.bmp

Figure 4-13. Stacked Volume Test: Setup Screen

Running the Stacked Volume Test

To run the stacked volume test:

1. Click the **START** button to begin testing. The screen changes, as shown in Figure 4-14:



fec096.bmp

Figure 4-14. Stacked Volume Screen: Testing Underway

When the stacked volume test begins, the Analyzer switches into Inspiratory Only breath-detect mode. At the end of the test, the breath-detect mode is restored to its previous state. The stacked volume test reports five values to the user; they are updated every time a breath is detected:

Total Volume –the total of the tidal volumes for the breaths tested

Last Volume –the tidal volume for the last breath

Average Volume – the average tidal volume over the breaths that have been tested and calculated

Number of Breaths – the number entered at the start of the test; it does not change during a test.

Breath Count –the current number of breaths included in the test; if tidal volume can't be calculated for a breath, that breath and volume are not included in the test.

Ending the Stacked Volume Test

To end the Stacked Volume test:

1. Either click the **STOP** button or let the Stacked Volume test end following the number of requested breaths.
2. Click the **Print** button to print a final report for the Stacked Volume test.
3. Click the **New Test** button to start a new Stacked Volume test.

Serial Communications

The Analyzer communicates with a PC through a serial (COM) port. If the Analyzer is connected to a computer and turned on when the software is started, the software automatically detects which COM port the Analyzer is on and then initiates communications between the Analyzer and your PC.

Selecting COM Port

While running VT for Windows the user may select **Com Port** from the **Communications** menu to change communications settings.

Selecting the Serial Communications Mode

The Analyzer has four modes for data transmission via the serial port, available from the **Communications** menu. The currently selected mode shows a check mark next to its name.

Test Parameter –the parameter that was chosen for running this test; this value does not change during the test.

Wave Form – starts the continuous transmission of waveform data from the Analyzer; flow, volume, airway pressure, auxiliary pressure, and differential pressure data are received at a 50 Hz rate.

Both – starts the automatic transmission of both waveform data and parameter data, as described above.

Parameters – start the automatic transmission of parameters that are calculated at the end of a breath; these parameters are calculated on a breath-to-breath basis.

Note

No parameters are calculated for a breath if a zero occurs during that breath.

None – selects no data transmission; this stops all automatic data transmissions from the Analyzer.

Data and File Handling

VT for Windows files handle three kinds of data, as described in Table 4-5.

Table 4-5. Data Types

Data Type	Descriptions
Signals	Raw flow, pressure, and volume time-series waveforms
Parameters	Breath-by-breath ventilator parameters calculated by the Analyzer device
Events	Information placed into the data files by the user

VT for Windows provides an interface for the user to mark events during data collection and generates three different file types, as described in Table 4-6.

Table 4-6. Generated File Types

File Extension	Description
*.vtp	Generated when the user selects to save data to a file; these files contain signal, parameters, and event information.
*.sig	Signal file of raw waveforms; the .sig files are generated from the .vtp files using a file conversion program. This is done by selecting **GENERATE A SIGNAL FILE** from VT for Windows **FILE** menu bar. Files must be closed to enable this option. The .sig files are in ASCII format and can easily be imported into your favorite spreadsheet.
*.par	Breath-by-breath calculated ventilator parameters; the .par files are generated from the .vtp files using a file conversion program. This is done by selecting **GENERATE A PARAM FILE** from the VT for Windows file menu bar. Files must be closed to enable this option. The .par files are in ASCII format and can easily be imported into your favorite spreadsheet.

Events

VT for Windows has a simple means to annotate data files. Each of the annotations is marked as an event in the data file. When a data file is played back, the annotated text and the time of the event are displayed on the screen.

VT for Windows supports six different types of events:

- Start of file
- Beginning of a recording
- Time stamp
- Annotation
- End of file
- Automatic event

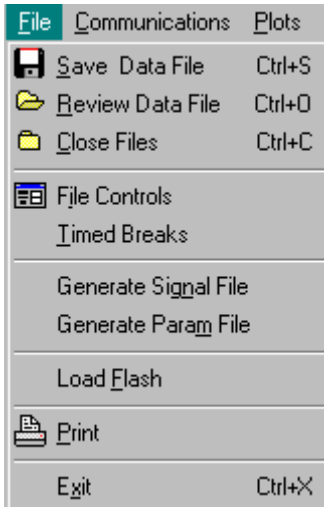
Each event is marked in the .vtp data file with a time stamp. For the beginning of a recording and for an annotated event, a dialog box appears with a space provided for the user to enter the text annotation.

The user initiates **TIME STAMP** and **ANNOTATE** events by pressing a button provided for each. Each event is described below. A file control interface is provided to aid in data collection and data playback.

Automatic events are placed in the file to assist in the rewind and forward functions of the data file playback.

Opening and Closing Data Files

The File menu is shown in Figure 4-15. Selected file opening and closing options and their functions are explained below.



fec097.bmp

Figure 4-15. File Menu

Opening files:

- **Review Data File** – opens an existing file for playback
- **Open File** button on the tool bar
- **Save Data File** – opens data for recording
- **Save to File** button on the toolbar – saves the file as a new or existing file. If it is an existing file, the user is prompted to decide to overwrite the existing file. If **NO** is selected, the end of the file is appended.

Closing files:

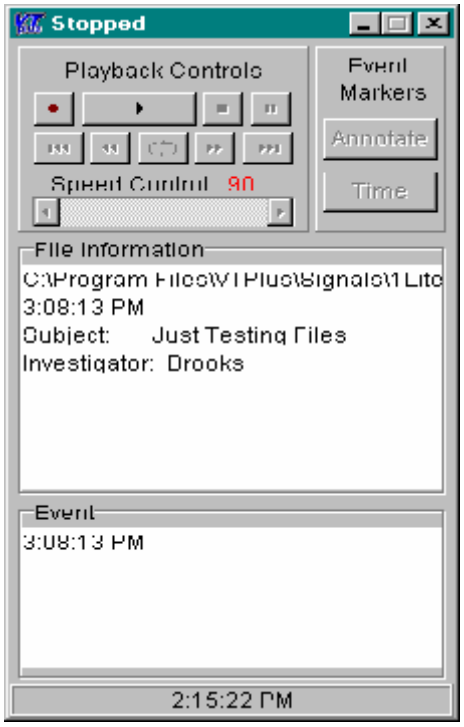
- **Close Files**
- **File Close** button on the toolbar

Note

VT for Windows does not store data in a buffer (temporary file). If a file is not open and the software is recording, no data is saved.

File Control Interface

The File Control interface, shown in Figure , is a sub-screen used for recording, annotating, and playback of data files. It is accessed by clicking the **File Control** button on the toolbar or by selecting **File Controls** from the File menu.



fec098.bmp

Figure 4-16. File Control Interface

The four main elements of the File Controls interface are:

- Playback Controls
- Event Markers
- File Information panel
- Event panel

Playback Controls

Playback controls are provided to facilitate data review and recording. Table 4-7 lists the controls, their icons, and a description of each.

Table 4-7. Playback Controls

Icon	Control	Description
	RECORD	Initiates writing data to the open data file; a TIME STAMP event marker is placed in the data file indicating the beginning of recording.
	PLAY	Initiates data playback from an open file
	STOP	Terminates data recording or playback; the data file is left open.
	PAUSE	Stops data playback temporarily; files should be paused before printing so that the desired plot is captured for printing.
	BEGINNING OF FILE	Rewinds the data file to its beginning; this only affects data playback. All recording is done at the end of the data file.
	REWIND	Backs up the data file during playback to the previous event marker in the file: automatic event markers provide periodic events for the file to be rewound or forwarded to.
	CONTINUOUS PLAY	May be enabled during data playback to allow for continuous play; in continuous play, the data file automatically rewinds to the beginning of the file as soon as the end of the file is reached.
	FORWARD	Advances the data file during playback to the next event marker in the file; automatic event markers provide periodic events for the file to be rewound or forwarded to.
	END OF FILE	Advances the data file to its end; this affects only data playback.
	SPEED CONTROL	Adjusts the playback speed; the number shown is the time in milliseconds (ms) between waveform samples. The data sample rate for the Analyzer is 20 ms. Therefore, a number larger than 20 results in slower-than-normal playback and smaller numbers yield a fast playback speed.

Event Markers

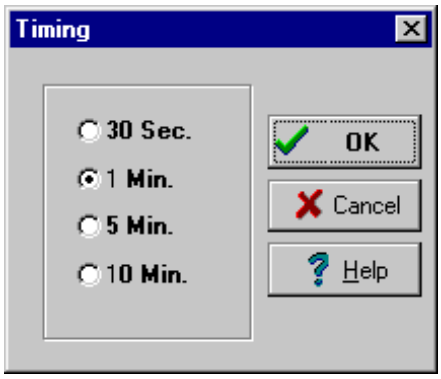
Two buttons allow placement of event markers into a file, assisting the user during data collection: **Annotate and Time**. During file recording, these events appear in the Event panel.

- Pressing the **Time** button during recording places a time stamp in the data file. A dialog box appears, showing the exact time that was written to the file. One use of this function is to correlate data collection in a laboratory notebook or data collection worksheet with the data in the file.
- Pressing the **Annotate** button during recording displays a dialog box wherein the user may enter text notes. Clicking **OK** places the notes and a time stamp in the data file. The time stamp represents the time that the **OK** button was clicked, not the **Annotate** button.

Automatic Event Markers: In the absence of user events, such as **Time** or **Annotate**, there are only beginning and end of file events. Therefore, automatic event markers are placed in data files to assist in the rewind and forward functions during playback. The time intervals between automatic events can be adjusted.

To set the time interval:

1. Select **Timed Breaks** form the File menu. The **Timing** dialog box displays:



fec107.bmp

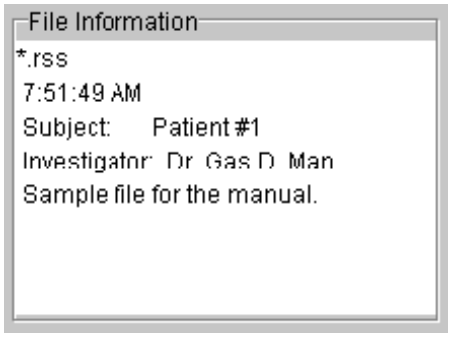
   This setting determines how often an automatic event marker is placed in the data file.

2. Select the desired time interval between automatic event markers and click **OK**. Event markers are used with the **Forward** and **Reverse** functions of file playback. Shorter times let the user see more of the data during playback.

   The software keeps a timer for the automatic event marker. If the user inserts an event by using **Time** or **Annotate**, the timer is reset to avoid having automatic events too close to user events.

File Information Panel

The File Information panel is shown in Figure 4-17.



fec108.bmp

Figure 4-17. File Information Panel

The first line in the File Information panel contains the open file name. The next line is the time that the file was first created. The remaining lines contain the information that the user provided when the file was created.

Event Panel

During file playback, the software checks for event markers in the data files. The Event panel displays information from the data file regarding the last event that was played back. This information remains displayed until another event is reached.

Generating Signal (.sig) Files

A signal file is a data file of raw waveforms. The .sig files are in ASCII format and can easily be imported into a spreadsheet. They contain raw flow, pressure, volume, auxiliary pressure, and differential pressure time series collected at 20 ms time increments (50 Hz sample rate).

The .sig files are generated from the .vtp files using a file conversion program initiated by clicking **Generate Signal File** on the File menu bar. Files must be closed to enable this option.

Generating Parameter (.par) Files

Parameter files store the breath-by-breath calculated ventilator parameters. The .par files are in ASCII format and can be imported into a spreadsheet.

The .par files are generated from the .vtp files using a file conversion program initiated by clicking **Generate Param File** on the File menu. Files must be closed to enable this option.

Report Printing

Reports can be printed from VT for Windows software to any printer installed on a computer. There are two ways to print from VT for Windows:

- Select **Print** from the File menu to display the system print dialog box. This allows the user to select which printer to use and adjust settings on that printer. Click **OK** to send the report to the printer.
- Click the **Print** button on the tool bar. The report is automatically sent to the default system printer. No print dialog displays.

The print header at the top of the reports is stored in the Analyzer. It is loaded into VT for Windows every time it connects to a Analyzer unit. The print header can be changed using the **Print Header** function in the **Setup** menu.

Operating System Loading

VT for Windows can be used as a utility to load new versions of the Analyzer operating system software into the flash memory of the Analyzer. Contact the Fluke Biomedical Service Center for Analyzer software updates.

Note

Using VT for Windows as a utility to load new versions of Analyzer software overwrites any user settings stored in the Analyzer, but it does not change the calibration of the Analyzer.

To load new Analyzer operating system software:

1. Select **File** then **Load Flash** from the menu. The Analyzer operating software is stored on two layers: (1) flash (code file) operating code and (2) text.
2. Click the **Browse** button to point to the file *FLASH.hex* as the code file and to the file *VP-TEXT.hex* as the text file.
3. Click **OK** to begin downloading.

   When communications are established, the Analyzer splash screen displays, and a **Loading Flash** dialog appears on VT for Windows with a status bar.

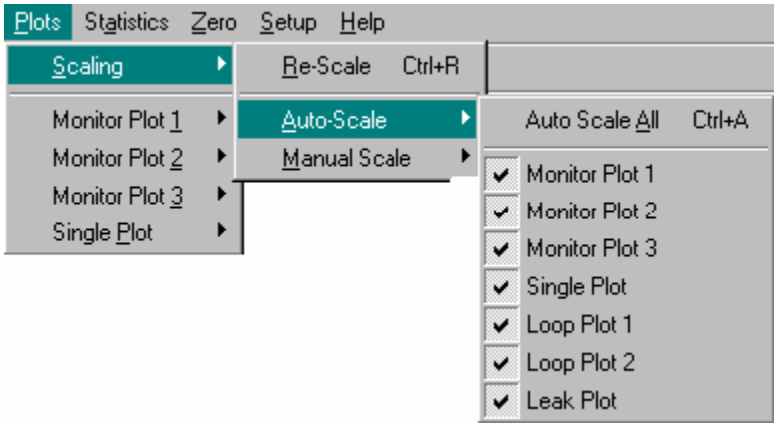
   When the download is complete, the Analyzer returns to the default screen. The download version can be verified by going to the information screen on the Analyzer.

Plots

Automatically Re-scaling Plots

By default, VT for Windows attempts to re-scale plots so that the entire plot is visible. When a re-scale occurs, the high- and low-ranges on the plots are determined by the min and max statistics for the signal shown on the plot. The monitor plots and the single plot are re-scaled every time they reach the end of the plot. The loop plots are re-scaled on every breath.

Automatic re-scaling may be turned off by unchecking the box next to the plot name in the **Plots, Scaling, Auto-Scale** menu, as shown below.



fec110.bmp

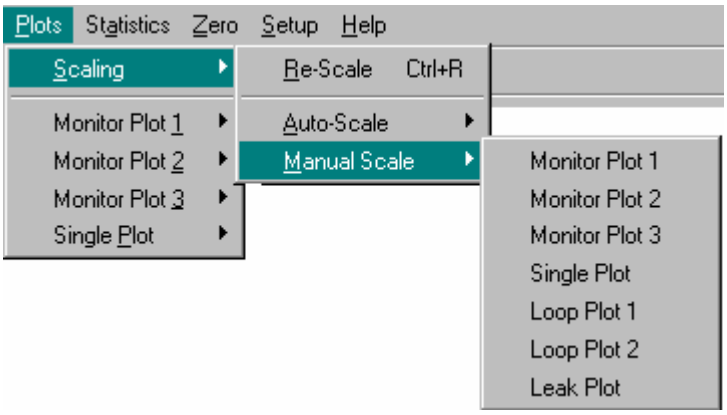
Auto-scaling is automatically turned off for a plot if the plot is manually re-scaled. Auto-scaling can also be turned off by right clicking on a plot and unchecking the **Auto-Scale** option.

Selecting the **Plots, Scaling, Auto-Scale** function, or clicking the **Re-Scale Now** button on the tool bar forces an automatic re-scale to occur immediately.

Manually Re-scaling Plots

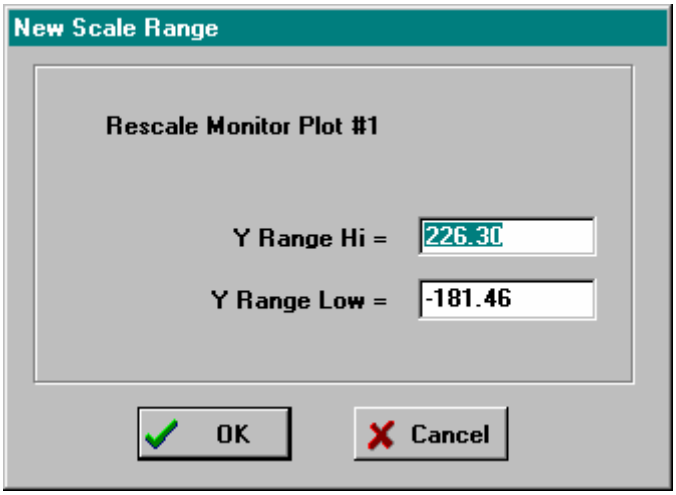
There are two ways to specify a specific range to view on a plot:

- Select **Scaling** and **Manual Scale** from the Plots menu bar, as shown below:



fec111.bmp

Then click the preferred plot. The following dialog box appears:



fec112.bmp

Type the desired the range and click **OK**.

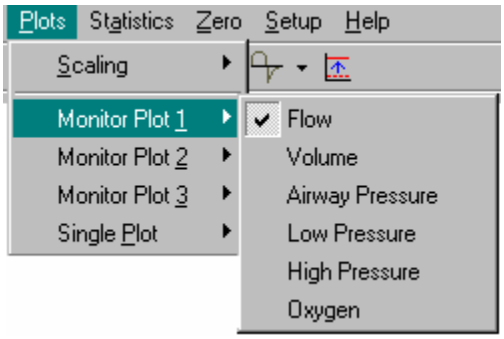
- Right-click the plot to re-scale. Select **Manual Scale**; the above dialog box appears. Type the preferred range and click **OK**.

Signal Selection

Three plots on the Monitor screen and the plot on the single plot screen can be set up to display any of the signals flow, volume, airway pressure, low pressure, high pressure, or oxygen.

To change the displayed signal on a plot:

1. Select the plot name from the Plots menu.
2. Select the name of the signal to be displayed.



fec113.bmp

The desired signal name should appear on the title of the plot and above the statistics to the right of the plot. The statistics and the plot now reflect the new signal and are displayed in the selected units for that signal.

To change the units for a signal:

Select **Signal Units** from the **Setup** menu. All statistics and plots reflect the current units for the assigned signal.

Zeroing

The Analyzer can be zeroed either automatically or manually. Zeroing corrects the flow and pressure sensors for offset to get a more accurate reading.

To switch the Analyzer between automatic and manual zeroing:

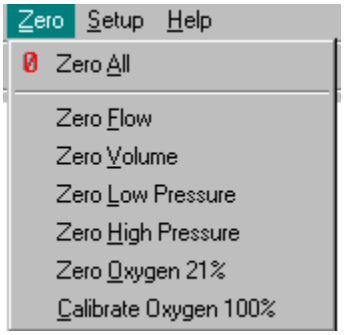
1. From the **Setup** menu, select the **Zeroing** menu. The current zeroing mode has a check next to its name.
2. Select the desired zeroing mode—Manual or Automatic.

Manual Zeroing

When the Analyzer is in manual zero mode, no automatic zeros occur. Periodically, it is a good idea to zero the signals on the Analyzer to null any offset errors in the flow and pressure sensors.

The Analyzer has two ways to perform a manual zeroing:

1. Select **Zero** from the menu.
2. Choose **Zero All** or select the signal to be zeroed from the given list.



fec114.bmp

Or

1. Click the **Zeroing Speed** button on the toolbar.
2. Choose the preferred plot from the given list.
3. Click the **Zeroing** button; this is the same as selecting **Zero All**.

Automatic Zeroing

The Analyzer can be set to automatically zero flow and airway pressure periodically. This nulls offset errors in the pressure transducers. During an auto-zero, the Analyzer uses pneumatic valves to temporally switch flow ports for the zero. Do not use this option if there is flow in both flow ports. A zero can be forced by manually zeroing a signal, even if automatic zeroing is turned on.

Other Setup Functions

VT for Windows allows selection of settings in the **Setup** menu.

Breath Detect

The Analyzer has a built-in breath detection algorithm. The algorithm determines the breath phase (inspiration, expiration, inspiratory pause, single phase bi-directional) This algorithm is designed to reject signal noise and other artifact when determining the phases of a breath.

To change the breath detect mode:

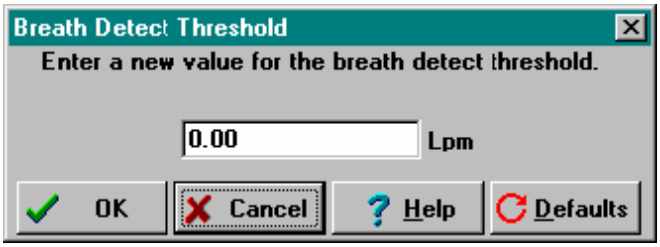
1. From the **Setup** menu, select **Breath Detect**.
2. Click the preferred option.

Breath Detect Threshold

The Analyzer breath detection algorithm uses a flow rate threshold that the flow must cross to trigger a change in the breath phase. Higher flow rate thresholds yield less sensitive breath detection. Lower thresholds yield more sensitive breath detection.

To enter a new breath detect threshold:

1. From the **Setup** menu, select **Breath Detect**; then select **Threshold**. The following dialog box displays:



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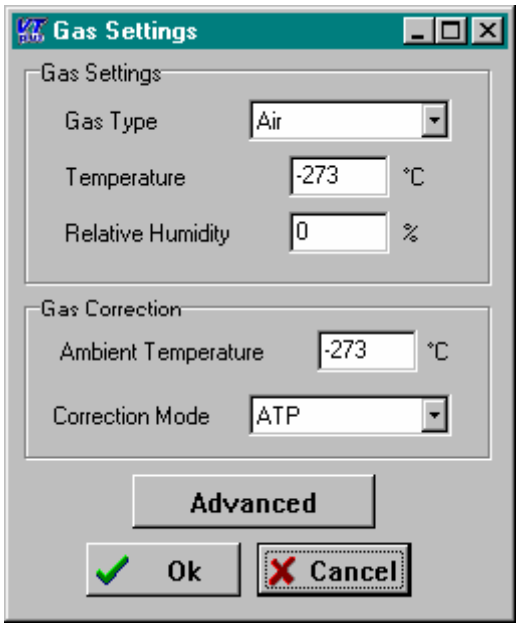
2. Enter a new value and click **OK**.

Gas Settings

Through the **Gas Settings** option, the Analyzer can compensate for the effects of gas temperature, viscosity, molecular weight, and relative humidity, on flow measurement, as well as correct flow calculations to one of several standard conditions. For more information on the gas settings, refer to *System Setup*.

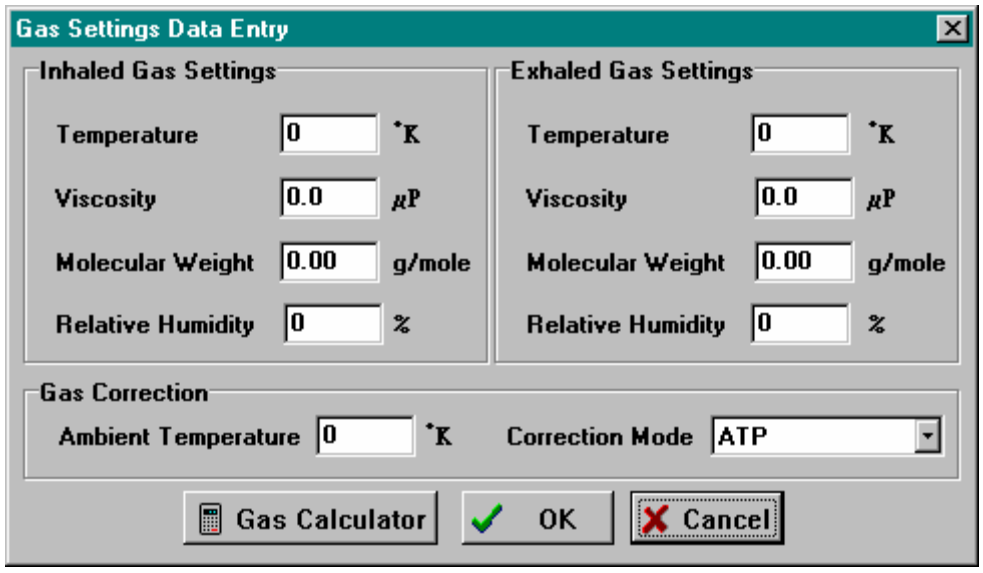
To change the gas settings:

1. From the **Setup** menu, select **GAS SETTINGS**. The following dialog box appears, allowing changes to be made:



fec116.bmp

2. Enter changes as desired.
3. If necessary, click the **Advanced** button. The **Gas Settings Date Entry** dialog box displays.



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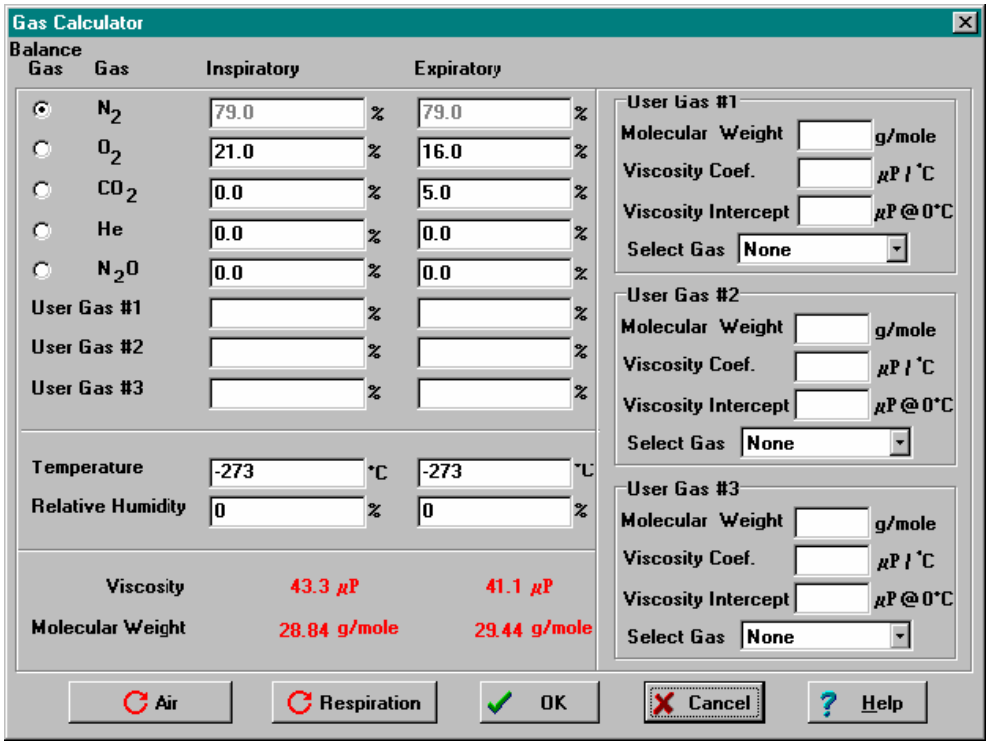
4. Make appropriate entries to adjust temperature, viscosity, molecular weight, and relative humidity for both inhaled and exhaled gases. Ambient temperature can be adjusted, and the flow can be adjusted to one of six standard modes (ATP, BTPS, STPD), as shown below:
5. If the viscosity or molecular weight of the gas being used is unknown, click the **Gas Calculator** button. The **Gas Calculator** dialog box displays:



fec118.bmp

The gas calculator allows calculation of the viscosity and molecular weight of a gas mixture. One gas serves as a balance gas. This means that the percentage of this gas is automatically adjusted to insure that the total percentage of gases totals 100 %.

6. Make the following changes, as necessary:
   a. To change the balance gas, click the **radio button** to the left of the gas name. Any of the five standard gases may be used as a balance gas.
   b. Adjust the percentage of each gas in the mixture by changing the values in the two columns to the right of the gas name. If any gas in the mixture is not one of the five standard gases, one of the other gases may be chosen.
   c. Select a gas from the list of predefined gases or, if the gas being used is not one of the predefined gases, select the user-defined option. There are three predefined gas options and one user-defined option.
   d. Enter the molecular weight, viscosity coefficient, and viscosity intercept into the boxes provided.
   e. Click the **Air** button or the **Respiration** button to set the calculator to the defaults for air or respiration.
   f. Enter the temperature and relative humidity for both inspired and expiratory gases in the boxes provided. Viscosity and molecular weight are calculated every time a change is made to any of the controls.
   g. When finished, click **OK** to accept the values and return to the **Gas Settings Data Entry** dialog box. The viscosity, relative humidity, molecular weight, and temperature populate the appropriate boxes.
7. Continue entering changes in the **Gas Settings Data Entry** dialog box.
8. Click **OK** to return to the **Gas Settings** dialog box.

9. Click **OK** to accept all gas settings changes.

Barometric Pressure

The Analyzer automatically calculates the barometric pressure to within 2 % of full scale. To give greater accuracy, the Analyzer allows the user to calibrate the barometric pressure offset by entering the local barometric pressure into the system. This value is used to calibrate the system barometric pressure offset during future use.

To change the barometric pressure:

1. From the **Setup** menu, select **Barometric Pressure**.
2. Enter the local barometric pressure in the box provided.
3. Click **OK**.

Chapter 5
Maintenance, Service, and Calibration

Title **Page**

Maintenance

The Analyzer requires little maintenance or special care; however, it is a calibrated measuring instrument and should be treated as such. The optional carry case is recommended for storage. It is further recommended that the storage environment be free from vibration.

Avoiding Damage

Do not drop the instrument or subject it to any mechanical abuse that could cause a shift in the calibrated settings.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, do not expose the system to temperature extremes. Ambient temperatures should remain between 10 °C and 40 °C.

Cleaning

Clean the exterior of the Analyzer occasionally with a cloth dampened with a mild detergent solution. A solution of 70 % isopropyl alcohol may be used to remove stains and clean the system. No other solvents are recommended.

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, do not spray liquid directly on or immerse the unit.

Oxygen Sensor Replacement

The Analyzer uses a galvanic oxygen sensor that is under warranty for 12 months. The oxygen sensor cell must be replaced when the oxygen calibration cannot be successfully completed. The oxygen sensor may operate for longer than 12 months depending on use.

To replace the oxygen sensor:

1. Disconnect the power cord before opening the oxygen sensor door.
2. Remove the three screws in the oxygen sensor door on the back of the Analyzer. The oxygen sensor is a round plastic cylinder about one inch in diameter with wires protruding from the back of the sensor.
3. Disconnect the in-line electrical connector on the sensor wire.
4. Un-screw the old sensor and remove it.
5. Screw in the new sensor (Fluke part #2138514).
6. Re-connect the sensor wire.
7. Replace the oxygen sensor door.
8. Re-calibrate the oxygen sensor following the instructions under *Connection and Setup: Utilities: Oxygen Sensor Calibration*.

Fuse Replacement

The Analyzer fuses may have to be replaced. The fuse compartment is located on the side panel of the instrument, as shown in Figure 5-1.

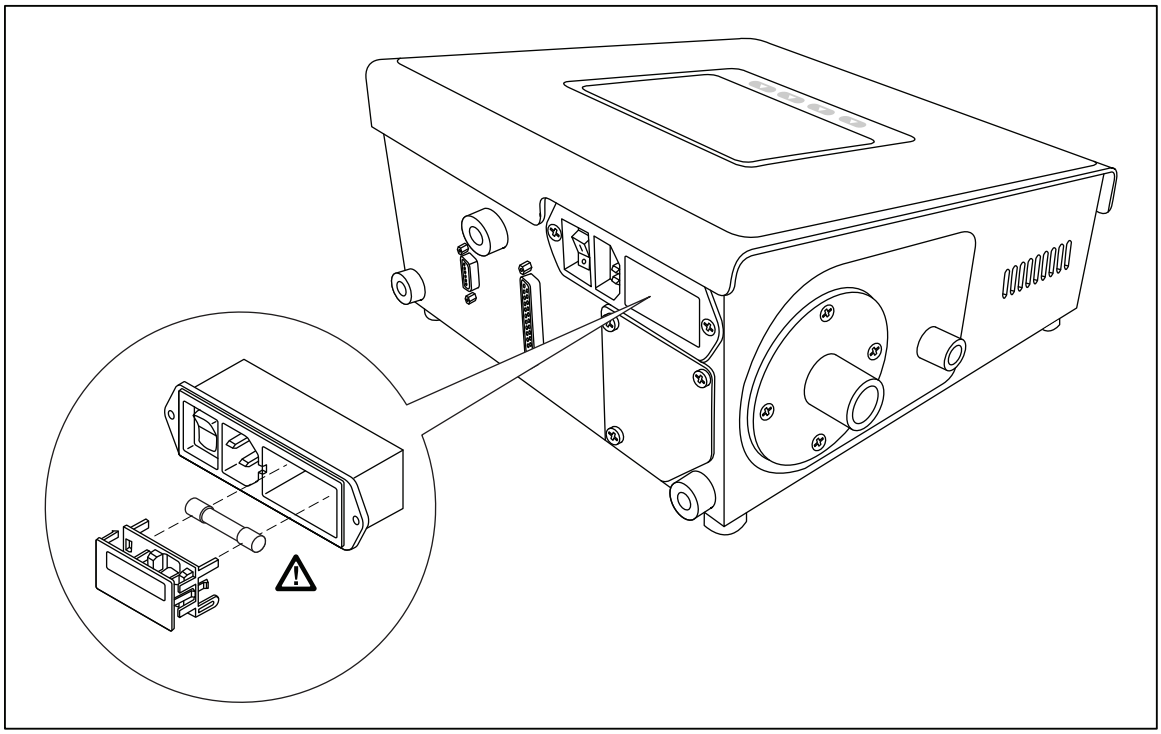


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Figure 5-1. Fuse Compartment

To replace the fuses:

1. Power off Analyzer and unplug the main power cord.
2. Using a small, flat-blade screwdriver or similar tool, carefully pry off the cover to the fuse compartment. The fuse block assembly is attached to the back of the cover.
3. Pull out the fuse block assembly and carefully lift the old fuses from the fuse slots.
4. Replace the fuses (two 0.5 A Slo-Blo fuses, Fluke part #46026).

⚠⚠ Warning

To avoid possible fire, electrical shock, or personal injury, use only the recommended fuse.

5. Replace the cover/fuse block in the fuse compartment.
6. Plug in the Analyzer.

Service and Calibration

The Analyzer should be calibrated annually to maintain accurate measurements. If the Analyzer fails to operate successfully or if it needs calibration, return it to the Fluke Biomedical Service Center, as indicated under *Warranty and Product Support*. As part of this service, hardware and software updates are automatically installed.

Product upgrades are also available for an additional fee. The available upgrade for the Analyzer includes the RT-200 mode (a user interactive mode) and HFOV mode (performance evaluation for high frequency ventilators).

⚠ Caution

To avoid damage to the Analyzer or adverse affects on its performance, adhere to the following:

- **Service of the Analyzer, other than replacement of minor components such as the fuse and O_2 sensor, service should be done only by qualified service personnel.**
- **Internal flow port filters for protecting the flow sensors are only to be changed by qualified service personnel.**
- **Use high/low-flow protective caps when transporting to keep foreign debris from entering high/low-flow ports.**
- **Calibration of the tester should be left to qualified Fluke Biomedical Service personnel to ensure that the Analyzer remains under warranty.**

Packing

If repairs or calibration are required, return the Analyzer to the factory or the nearest service center.

1. Before returning the Analyzer for factory service, contact Fluke Biomedical Service Center for a required Return Authorization Number.
2. Provide the following information:
3. The Analyzer serial number
4. The specific steps that reproduce your problem
5. A daytime phone number
6. Your name / company
7. A fax number (if available)
8. Pack the instrument carefully, using the original shipping container and packing materials supplied by Fluke Biomedical. If the original packing materials are not available, refer to *Return Procedures* for a list of preferred materials or contact Fluke Biomedical for replacement packing.

Note

Failure to pack the instrument properly could void the warranty.

Shipping

1. Place the Return Authorization Number in a prominent place on the outside of the packing box, and refer to the number in any correspondence with Fluke Biomedical Service.
2. Enclose your return address and Return Authorization Number.
3. Insure the unit for full retail value and ship to the nearest Fluke Biomedical Service Center.

Appendices

Appendix A
Gas Analyzer Tutorial

The Analyzer measures the basic signals of pressure, flow, and oxygen. From these basic signals, other parameters are computed. Volume is obtained from the integration, or summation, of the flow signal over a period of time.

Pressure Measurements

The Analyzer provides several pressure measurement capabilities. There are two external pressure measurements and three internal pressure measurements available to the user.

External Pressure Measurements

These measurements are called *Low Pressure* and *High Pressure*. The low-pressure measurement has a range of ±500 mmHg (about 10 psi). The high-pressure measurement has a range of ±100 psi (about 5200 mmHg).

Both high and low pressures are *differential* measurements. As such, the measured pressure is the pressure difference between the positive and negative ports. If only one of the pressure connections is made, the measurement is equivalent to a *gauge measurement*. For gauge pressures, the measurement is relative to the ambient pressure. This is how a normal pressure gauge works.

If a positive gauge pressure is applied to the (+) measurement port, a positive pressure reading results. If a negative gauge pressure is applied to the (+) measurement port, a negative pressure reading results. Likewise, if a positive gauge pressure is applied to the (-) measurement port, a negative pressure reading results. If a negative gauge pressure is applied to the (-) measurement port, a positive pressure reading results.

Fluidic Pressure Measurements: The (+) connection for both high and low pressures are labeled as compatible with either fluids or gases. When measuring fluidic pressures, it is important to realize that any fluid entering the pressure measurement port or the connecting tubing may cause a bias (error) in the measured pressure. For example, if a fluidic pressure measurement is made and a 5 cmH_2O column is in the connecting tubing, an error of about 5 cmH_2O may occur.

If fluid enters into the pressure measurements connections of the Analyzer, it is important to evacuate the fluid before storage and before any pressure measurements are made. The fluid can be evacuated by connecting a 100 cc syringe directly to the pressure measurement connection and then pulling back the syringe to create a vacuum.

Internal Pressure Measurements

The Analyzer also has several internal pressure measurements. These include barometric pressure, differential pressure for the flow measurement, and airway pressure.

Airway pressure is measured internally in the tube for the flow sensors. This is done for convenience for the user while measuring ventilator parameters. Having a pressure measurement for airway pressure in addition to the external low-pressure measurement ensures that the pressure is measured at a consistent location and eliminates the need for cumbersome adapters for placing pressure taps in the airway circuit.

When the Analyzer is set to measure from the high-flow port, the airway pressure is measured from the high-flow port. Likewise, when the low-flow range is selected, the airway pressure is measured from the low-flow port. In both cases, the airway pressure measurement is made on the *exhaust* side of the flow sensor.

Zeroing the Pressure Signals

The zero reading (offset) of the pressure measurements may drift slightly with time and temperature. A zeroing function is provided for the user to zero the offset drift. Typically, this is done when a non-zero reading occurs when there is zero applied pressure. However, it is good practice to zero the respective signal before any measurement is taken.

Although a five-minute warm-up period is built into the Analyzer power-up cycle, a 40-minute warm-up period is suggested for maximum measurement accuracy and stability. The offset drift is most significant while the sensors for the pressure measurements are warming up. If the warm-up period is skipped, be aware that the offset drift may be significant for the first 40 minutes of operation. If the Analyzer has been through an extreme temperature change, additional time may be required for the warm-up. If the Analyzer has only been turned off for, say a minute, the warm-up period may be skipped.

The zeroing function for pressure acts as a *tare* function. As such, the applied pressure when the signal is *zeroed* is saved as the new *zero* reading. The applied pressure during zero would then be read as zero. Measured pressures would have an offset error equal to the applied pressure when the Analyzer was zeroed.

Airway Zeroing, A Special Case

The airway pressure may be zeroed manually using the **ZERO/7** key while the airway pressure screen is active. The airway pressure is also zeroed automatically when the flow zero occurs. Note that the flow zero may either be performed manually or in an auto zero mode.

Barometric Pressure, Another Special Case

The offset drift can be adjusted on the barometric pressure measurement by entering the correct barometric pressure on the **Setup > Settings** menu. Although typically not needed, it provides a means for the user to ensure that the barometric pressure measurement is as accurate as possible.

Oxygen Measurements

Oxygen measurement is performed using a galvanic oxygen cell on the high-flow port near the exhaust. The Analyzer interprets the measurement from the oxygen sensor as a partial pressure of the total pressure in the high-flow circuit. The total pressure is the airway pressure plus the barometric pressure.

The oxygen percentage is calculated as the fraction of the partial pressure of oxygen relative to the total pressure. It should be noted that changes in the total pressure (airway pressure) result in a change in the partial pressure of the measured oxygen even though the percentage of oxygen is the same. Because the pressure can change much faster than the response time of the oxygen sensor, a small transient (1 to 2 % of full-scale) error can occur in the oxygen measurement when there is a fast change in the pressure at the oxygen sensor.

Whenever an oxygen measurement is made, or when the oxygen sensor is calibrated or zeroed, there should be sufficient gas flow past the oxygen sensor. Only a small flow of gas (say, 10 LPM) is needed to ensure that the oxygen concentration at the oxygen sensor is as expected. For example, just opening the high-flow exhaust to room air does not ensure that the oxygen sensor detects 20.9 % oxygen. The oxygen concentration at the sensor does not equilibrate with the room air unless a small amount of flow is present to ensure gas mixing.

The oxygen sensor should last for more than one year, and is replaced during an annual calibration of the unit. Sensor life is shortened, the longer the sensor is exposed to oxygen. This includes oxygen in room air as well as higher flow rates of oxygen-containing gases past the sensor. The Analyzer checks to detect if the oxygen sensor is depleted every time an oxygen zero is performed.

The oxygen sensor should be recalibrated by the user with 100 % oxygen and dry air at the beginning of any testing day in which oxygen concentrations are to be measured.

Flow Measurements

The flow measurements in the Analyzer are made by measuring the differential pressure across a resistive screen mesh. The resulting differential pressure is nearly linear with respect to the volumetric flow. Simple corrections are applied to correct for any nonlinearities. A table of correction factors is applied for each the low- and high-flow sensors. The information regarding these tables can be seen using the **Setup > Utilites > Linearization** screen on the Analyzer.

Gas Settings

The flow measurement sensors in the Analyzer are linearly dependent on the viscosity of the applied gas. The Analyzer setup options allow the user to specify what type of gas is being used. Additional choices are available using the User Define mode. The user defined gas settings are set using the PC software. The gas calculator on the PC software can determine the effective viscosity for a combination of various gases.

The Analyzer calculates the temperature dependent viscosity for the gas type selected (except for user-defined gases). Therefore, when a new flowing gas temperature is entered by the user, the Analyzer calculates the new viscosity. For air, the sensitivity to temperature is about 0.25 % of reading per °C.

The Analyzer viscosity calculation for the gas settings assumes that dry gas is being used. Increased water vapor content can slightly affect the flow accuracy. At room temperature, a flow measurement error of -0.5 % of reading can occur if the relative humidity of the flowing gas is 50 %.

Note

Never apply humidified gases to the Analyzer flow sensors.

Condensation on the flow sensors causes errors in the flow readings until it is dried off.

Balance Gas Settings

The gas settings allow for gas combinations with oxygen. For example, the Analyzer can be set to use Helium balance Oxygen. In this mode, the Analyzer uses the oxygen measurement to determine the oxygen concentration and then assumes the balance of the gas concentration is helium. The Analyzer calculates the effective viscosity for the combination gas at the specified temperature. The oxygen concentration used in the gas setting for the balance gases is automatically updated every second.

Note

For air / oxygen mixtures use the nitrogen balance oxygen (N_2 bal O_2) gas setting. The flowing gas is assumed to be dry and therefore the relative humidity used in the viscosity calculation is assumed to be zero percent.

BTPS and STPD Corrections

The Analyzer corrects all flow measurements to conditions of ambient temperature and pressure without adjusting for the volume of water vapor. The ambient pressure is obtained from the measured barometric pressure. The user sets the ambient temperature by using the setup menu. It should be noted that the relative humidity setting on the Analyzer is used only for the BTPS and STPD correction.

BTPS stands for *Body Temperature and Pressure Saturated with water vapor*. In this compensation mode, the flow rate (and therefore, volumes) are corrected such that the reported flow is equal to the flow if the gas temperature and pressure were changed to body conditions (37 °C and ambient pressure). Further, the flow is compensated to add the amount of water vapor as if to make the gas fully saturated (100 % relative humidity). In this correction, the relative humidity setting is used to determine the amount of water vapor that must be added.

STPD0 stands for *Standard Temperature and Pressure Dry*. In this compensation mode, the flow rate (and therefore, volumes) are corrected such that the reported flow is equal to the flow if the gas temperature and pressure were changed to standard conditions (0 °C and 760 mmHg). Further, the flow is compensated to subtract the amount of water vapor as if the gas were dry (0 % relative humidity). In this correction, the relative humidity setting is used to determine the amount of water vapor that must be subtracted.

STPD21 stands for *Standard Temperature and Pressure Dry*. In this compensation mode, the flow rate (and therefore, volumes) are corrected such that the reported flow is equal to the flow if the gas temperature and pressure were changed to standard conditions (21°C and 760 mmHg). Further, the flow is compensated to subtract the amount of water vapor as if the gas were dry (i.e. 0 % relative humidity). In this correction, the relative humidity setting is used to determine the amount of water vapor that must be subtracted.

Flow Zeroing

The differential pressure transducer used to measure the flow rate is subject to baseline (offset) drift. This is most pronounced during the Analyzer warm-up period. The Analyzer provides both a manual and an automatic zero function for zeroing the flow.

In measuring flow, the same pressure transducer is used for both high- and low-flow ports. A set of valves selects between high- and low-flow ranges. Because one pressure transducer is used for both, zeroing one flow range also zeros the other.

In the manual zero mode, if the user presses the **ZERO/7** key when the Analyzer is at the **Flow** screen, a message appears, indicating that the flow must be removed from the currently selected flow port. The user must remove the flow so that a correct zero reading can occur.

In the auto zero mode, the Analyzer uses the valves that switch between the high- and low-flow ports to obtain a zero reading. It is assumed that there is no flow in the unselected port. The purpose of this is to provide a means to zero the flow without having to disconnect from the ventilator circuit (or other flow source being measured).

Note

When auto zeroing is selected, it is important that there is no flow on the unselected flow port. For example, if the high flow range is selected, there should not be any flow in the low flow port if auto zeroing is selected.

When auto zero is selected, the user may still push the **ZERO/7** key to initiate a flow zero. The valves still automatically switch to obtain the zero reading. Therefore, it is not necessary for the user to disconnect the flow to zero. No message appears indicating that the flow source should be removed.

With the auto zero setting enabled, the flow automatically zeros every 20 minutes. If more frequent zeroing is desired, manually zero the flow using the **ZERO/7** key. Because some data is lost during a zero, ventilator parameter data for breaths affected by an auto zero are discarded.

Airway pressure is also zeroed whenever flow is zeroed. Airway pressure can also be independently zeroed from the airway pressure screen.

Breath Detection

To monitor ventilator parameters, the Analyzer must first determine when a breath occurred and delineate the various phases of the breath. For example, the breath detection algorithm determines the beginning and ending of the integration periods for calculating tidal volumes.

The breath detection algorithm is implemented as a state machine. The flow waveform is the input to the state machine. The state changes are based on flow waveform crossing of predefined thresholds. A threshold is applied to both positive (inspiratory) and negative (expiratory) flows. The breath detection threshold can be set to a high flow rate to reject noise near zero flow.

Bi-directional, Inspiratory, Expiratory Breath Detect Modes

Figure A-1 shows the circuit connection for setting up the Analyzer in a bi-directional mode. The gas flows in both directions through the Analyzer. This is the preferred setup for using the Analyzer with a ventilator.

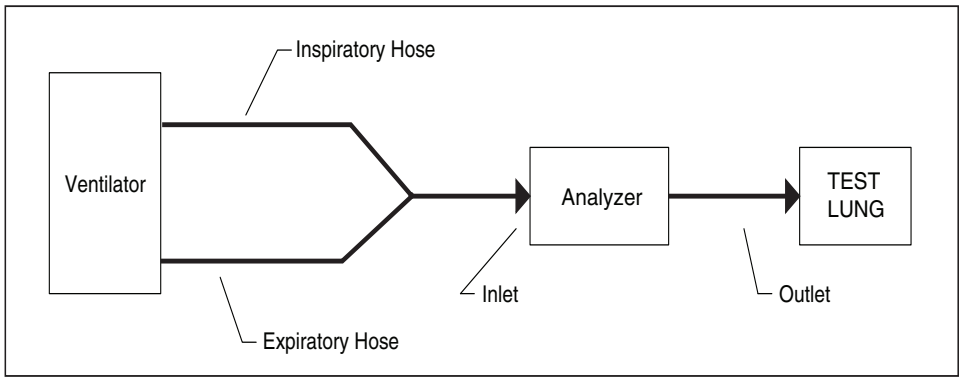

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Figure A-1. Circuit Connection for the Analyzer in Bi-directional Mode

Note

When using the Analyzer with a ventilator and a test lung, the bidirectional breath detect mode is preferred. Only use the inspiratory and expiratory breath detect modes if measurements cannot be made in the bi-directional mode.

Additional breath detect modes were implemented for users that are accustomed to performing measurements with flow devices that can only measure flow in one direction.

Base Flow

In the inspiratory and expiratory limb of the breathing circuit, some ventilators may have a bias flow when no flow is going to or from the patient (test lung). This is implemented differently on different ventilators and is called by different names by the various ventilator manufactures. It may be called base flow, bias flow, flow-by, blow-by, or many other names.

In the inspiratory- or expiratory-only breath detection modes, the Analyzer can measure the base flow present. The detection and calculation of base flow may take 30 to 60 seconds. In expiratory-only mode, detection of base flow requires a sufficient end-expiratory period and sufficient change in pressure. The use of lower-lung compliance settings improves performance in expiratory mode.

During expiratory-only mode, the base flow is subtracted from the flow signal for obtaining the ventilator parameters, such as tidal volume and peak flow. During inspiratory-only mode, the base flow is not subtracted, because the base flow is typically turned of during the inspiratory phase on most ventilators.

Appendix B
Error Messages

Table B-1 lists error messages, their descriptions, and corrective actions.

Table B-1. Error Messages

Error Message	Description	Corrective Action
Flow Out of Range	Differential pressure for the flow measurement causes a measurement greater than the maximum (or less than the minimum) reading of the analog to digital converter.	Ensure that flow is within the specified range of the Analyzer.
Gas Settings Error	Oxygen concentration is measured at greater than 50 % and the gas settings are not set to an oxygen or a balance oxygen setting. This is provided as a warning to set the gas settings if measuring flow with a gas type that has high oxygen concentrations.	The error/warning occurs only once after the Analyzer is powered on. If measuring flow, ensure that the correct gas setting is being used for gas type being measured.

Table B-1. Error Messages (cont.)

Error Message	Description	Corrective Action
Airway Pressure Out of Range	Airway-pressure measurement causes a measurement greater than the maximum (or less than the minimum) reading of the analog-to-digital converter.	Ensure that pressure is within the specified range of the Analyzer.
Low Pressure Out of Range	Low-pressure measurement causes a measurement greater than the maximum (or less than the minimum) reading of the analog to digital converter.	Ensure that pressure is within the specified range of the Analyzer.
High Pressure Out of Range	High-pressure measurement causes a measurement greater than the maximum (or less than the minimum) reading of the analog to digital converter.	Ensure that pressure is within the specified range of the Analyzer.
Linearization Tables Invalid	Either of the linearization tables for the high- and low-flow sensors are invalid at startup. If this condition is detected, linearization tables aren't used to calculate flow. Accuracy could diminish by 3 to 10 %.	Call Service.
Negative Flow Detected	An average negative flow is detected in either inspiratory only or expiratory only breath detect mode.	If error message repeats, the Analyzer is installed in the ventilator circuit backwards. Ensure the INLET flow connection on the Analyzer is nearest to the INSPIRATORY hose from the ventilator.
No Load Applied	The difference between min and max airway pressure is less than 5.0 cmH_2O while in expiratory only breath detect mode.	Ensure that a load (Test Lung) is installed in the ventilator circuit and that the circuit is not open to air (i.e. an unconnected hose). Decrease lung compliance so that the change in airway pressure is greater than 5 cmH_2O during the breath. A better solution, use the bi-directional breath-detect mode.
AD Buffer Overrun	The Analyzer cannot keep up with the data input. The Analyzer can buffer a few seconds of data when it is busy changing screens and such.	If the error message appears several times during normal monitoring (i.e. no keys are being pushed) call factory for service.

Table B-1. Error Messages (cont.)

Error Message	Description	Corrective Action
Zero Time Out	A flow zero isn't complete after 150 attempts.	Attempt to zero again. Ensure that no flow or pressure is on either the high- or low-flow ports. If message does not go away after several attempts (with no flow or pressure applied), call service.
Transmit Buffer Overflow	More than 1000 characters are waiting to be sent.	RS232 serial communications is probably awaiting hardware handshaking. If using a terminal program, ensure the hardware handshaking is enabled. Ensure that the RS232 cable is the cable supplied with the Analyzer.
No Printer Selected	Users try to print with no printer selected.	Select a printer using the setup menu.
Printer Not Selected	The printer's select line doesn't stay high.	Ensure the correct printer type is selected. Refer to your printer's user manual to ensure the printer is setup correctly for the printer language set on the Analyzer (i.e., HP PCL/3). Note: your printer may require special dip switch settings for a given printer language support. Ensure the printer cable is correctly installed.
Printer Time-out	A time-out occurs while trying to write to the printer.	Ensure the correct printer type is selected. Refer to your printer's user manual to ensure the printer is setup correctly for the printer language set on the Analyzer (i.e., HP PCL/3). Note: your printer may require special dip switch settings for a given printer language support. Ensure the printer cable is correctly installed.

Table B-1. Error Messages (cont.)

Error Message	Description	Corrective Action
Printer Busy	The printer's busy line is set.	Ensure that the printer is selected (refer to printer's user manual). Ensure the correct printer type is selected. Refer to your printer's user manual to ensure the printer is setup correctly for the printer language set on the Analyzer (i.e., HP PCL/3). Note: your printer may require special dip switch settings for a given printer language support. Ensure the printer cable is correctly installed.
Printer Paper Out	The printer reports an out of paper error. Not all printers report this condition.	Put paper in printer. Ensure the correct printer type is selected. Refer to your printer's user manual to ensure the printer is setup correctly for the printer language set on the Analyzer (i.e., HP PCL/3). Note: your printer may require special dip switch settings for a given printer language support. Ensure that the printer cable is correctly installed.

Appendix C
Troubleshooting

Table C-1 lists problems, possible causes, and corrective actions.

Table C-1. Troubleshooting

Problem	Possible Cause	Corrective Action
Analyzer does not turn on – Screen is dark	No power Screen contrast not set Blown fuse	Plug unit into an AC mains outlet using the supplied power cord. Turn the switch on. Adjust screen contrast using multiple pushes of the contrast key on the side of the Analyzer display. Replace fuse with one of correct rating as marked on the Analyzer rear panel or as specified in the manual.
Analyzer screen turns on but is just white. Splash may or may not appear before screen goes white	Flash program memory not loaded Flash memory or boot memory resulted in incorrect checksum. Screen contrast not set	If problem persists, call Service. If problem persists, call Service. Adjust screen contrast using multiple pushes of the contrast key on the side of the Analyzer display.
Screen is difficult to read	Screen contrast not set	Adjust screen contrast using multiple pushes of the contrast key on the side of the Analyzer display.
Flicker is observed on left side of Analyzer screen	Slight flicker is normal	Adjust contrast to diminish effect.

Table C-1. Troubleshooting (cont.)

Problem	Possible Cause	Corrective Action
Out of Range messages appear	Measured signals out of specified range	Ensure that all pressures and flow rates are within the Analyzer specified limits.
	Units are not set to those used for the range specifications. User mistakenly assumes that range is not exceeded due to readings in the different units. For example, monitoring pressures in psi while trying not to exceed a range specified in cmH2O. Ensure the units selected are the same as the specified limits.	
	Unit calibration is incorrect	If problem persists, call Service.
Tidal Volumes are erratic in bi-directional breath detect mode	Breath detection threshold set too low. Noise from ventilator is causing false breaths.	Set the breath detection threshold to a higher value.
Tidal volumes different than expected	User's expected value was incorrect.	Review expectations.
	Flow baseline drifts, causing a false non-zero flow reading when flow was actually zero. Zero the flow reading. Consider using the auto-zero mode.	
	Analyzer is out of calibration.	If possible, verify calibration with a 3-liter calibration syringe. Ensure gas settings are correct. With the Analyzer in the bi-directional breath detect mode and the gas correction mode set to ATP, stroke syringe such that flows are near the midrange for the flow sensor. Compare the Analyzer tidal volume to calibration syringe volume. If difference is out of specification, return unit for calibration.
	Gas settings are incorrect. Review Analyzer gas settings.	
	Correction mode is set to BTPS or STPD instead of ATP.	Set gas mode to appropriate setting for your application. Most applications may require the ATP mode

Table C-1. Troubleshooting (cont.)

Problem	Possible Cause	Corrective Action
	BTPS or STPD correction method on the Analyzer is different that the method used by the ventilator manufacturer.	Corrections for BTPS and STPD may vary among different ventilator manufactures. The biggest difference is in the water vapor volume correction. The Analyzer uses the setting for relative humidity and temperature to determine the actual volume of water vapor in the flowing gas. This volume is subtracted from the total volume for dry gas corrections. For saturated gas correction, a make-up volume of water vapor is computed and added to the measured volume.
	Compliance of breathing circuit tubing is causing a compressible volume loss.	Determine the breathing circuit compliance to calculate the expected volume loss due to compressibility of the gas and expansion of the hose.
	The Analyzer is used with humidified gases. Condensation on the flow sensors causes a calibration error on the flow measurement.	Run DRY air through the flow sensor for 10 to 30 minutes to allow the screen mesh to dry. Do not use the Analyzer with condensing humidified gases.
Invalid parameters exist in expiratory-only breath-detect mode.	Some parameter values are always invalid in this mode due to insufficient information in the expiratory-only signal.	Use the bi-directional breath detect mode. Ensure the Analyzer is placed between the Y of the breathing circuit and a test lung.
	All parameters are invalid including base flow. The Analyzer must be able to accurately detect base flow for the parameters to be valid.	Increase the end-expiratory period by either changing the I:E ratio or by decreasing the lung compliance (higher pressures). Ensure that the change in airway pressure during the breath is greater than 5 cmH2O.
Tidal volume errors in expiratory only mode.	Some ventilators servo control the base flow during the expiratory period. Because the Analyzer must assume the base flow is constant during expiration, errors result due to the changing base flow from the ventilator during the expiratory phase.	Use the bi-directional breath detect mode. Ensure that the Analyzer is placed between the Y of the breathing circuit and a test lung.

Table C-1. Troubleshooting (cont.)

Problem	Possible Cause	Corrective Action
Flow or pressure measurement is not equal to zero when zero flow or pressure is applied.	Baseline drift of pressure transducer	Zero the affected signal by using the zero key while the affected signal is being displayed. For example, low pressure can be zeroed while the low-pressure screen is currently displayed.
No message appears to remove flow when attempting to zero flow. Appears that system will not zero flow. No message appears.	Auto zeroing mode is enabled. The Analyzer is zeroing flow, but no message is supposed to be displayed, because the Analyzer uses valves to switch to the unused flow port	This is normal. Because the auto zero mode is enabled, the Analyzer assumes that the unused flow sensor can be used to obtain the zero reading. Ensure the unused flow sensor has zero flow when the auto zero mode is enabled.
Zeroing flow results in unexpected flow readings or an error message.	Flow was not zero.	Ensure that there is no flow when zeroing the flow sensor.
	Auto zero mode was enabled and the unused flow sensor had a non-zero flow present.	Whenever the auto zero mode is enabled, ensure that there is no flow on the unused flow sensor.
Barometric pressure is incorrect.	Barometric pressure offset drift	Enter correct barometric pressure.
No flow measurement is observed when flow is applied.	Wrong flow range is selected	From the flow screen, ensure that the range (low vs. high flow) matches the range depicted on the side panel of the Analyzer for the port where the flow is being applied.
No airway pressure is observed.	Wrong flow range (low vs. high flow) selected.	From the flow screen, ensure that the range (low vs. high flow) matches the range depicted on the side panel of the Analyzer for the port where the flow is being applied.
Pressure is negative when a positive pressure is applied.	Pressure is being applied to the (-) connection instead of the (+) connection.	Ensure that pressure is applied to the correct connection.
Ventilator parameters seem incorrect.	Analyzer in circuit backwards	Ensure the inlet side of the Analyzer is connected closest to the inspiratory hose from the ventilator. In bi-directional mode, this means the inlet is near to the Y piece.

Table C-1. Troubleshooting (cont.)

Problem	Possible Cause	Corrective Action
Analyzer does not print.	Wrong printer type selected	Select correct printer type on the Analyzer.
	Printer not set up for selected printer language	Review printer's user manual to determine how to set up printer to work with the selected Analyzer printer mode
	Printer not connected	Connect printer.
Analyzer takes a long time to establish communications with PC software.	This is normal.	If the Analyzer does not eventually communicate with the PC software, ensure the cable is correctly connected and that the PC hardware can support the communication port selected. Make sure no other device is trying to use the serial port on your PC. Close any software that may be using the serial port. Make sure that Windows recognizes the serial port in the Control Panel. Restart VT for Windows.