FLUKE®
Biomedical

VT305
Gas Flow Analyzer

Users Manual

FBC-0034
January 2013, Rev. 1

Warranty and Product Support

Fluke Biomedical warrants this instrument against defects in materials and workmanship for one full 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 does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than Fluke Biomedical. IN NO EVENT SHALL FLUKE BIOMEDICAL BE LIABLE FOR CONSEQUENTIAL DAMAGES.

Only serialized products and their accessory items (those products and items bearing a distinct serial number tag) are covered under this one-year warranty. PHYSICAL DAMAGE CAUSED BY MISUSE OR PHYSICAL ABUSE IS NOT COVERED UNDER THE WARRANTY. Items such as cables and nonserialized modules are not covered under this warranty.

Recalibration of instruments is not covered under the warranty.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country. This warranty is limited to repairing the instrument to Fluke Biomedical's specifications.

Notices

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Copyright Release

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Unpacking and Inspection

Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

Technical Support

For application support or answers to technical questions, either email techservices@flukebiomedical.com or call 1-800- 850-4608 or 1-440-248-9300. In Europe, email techsupport.emea@flukebiomedical.com or call +31-40-2965314.

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.

Returns and Repairs

Return Procedure

All items being returned (including all warranty-claim shipments) must be sent freight-prepaid to our factory location. When you return an instrument to Fluke Biomedical, we recommend using United Parcel Service, Federal Express, or Air Parcel Post. We also recommend that you insure your shipment for its actual replacement cost. Fluke Biomedical will not be responsible for lost shipments or instruments that are received in damaged condition due to improper packaging or handling.

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 1-440-498-2560.

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: 1-800-850-4608 x2564
Email: globalcal@flukebiomedical.com

Everett Calibration Lab
Tel: 1-888-99 FLUKE (1-888-993-5853)
Email: service.status@fluke.com

In Europe, Middle East, and Africa:
Eindhoven Calibration Lab
Tel: +31-40-2675300
Email: ServiceDesk@fluke.com

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

To ensure the accuracy of the Product is maintained at a high level, Fluke Biomedical recommends the product be calibrated at least once every 12 months. Calibration must be done by qualified personnel. Contact your local Fluke Biomedical representative for calibration.

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.

Restrictions and Liabilities

Information in this document is subject to change and does not represent a commitment by Fluke Biomedical. Changes made to the information in this document will be incorporated in new editions of the publication. No responsibility is assumed by Fluke Biomedical for the use or reliability of software or equipment that is not supplied by Fluke Biomedical, or by its affiliated dealers.

Manufacturing Location

The VT305 Gas Flow Analyzer is manufactured in Switzerland for Fluke Biomedical, 6920 Seaway Blvd., Everett, WA, U.S.A.

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Introduction

⚠⚠ Warning

To prevent the possibility of personal injury, read all safety information before you use the Product.

This manual is applicable for the VT305 (the Product). It is a compact, portable and easy-to-use measurement instrument. The Product measures or calculates:

- Flow
- Volume
- Pressure differences
- High pressure
- Barometric pressure
- Oxygen
- Temperature of gas in the measurement chamber
- Breathing rate
- Inspiratory and expiratory time
- Ratios
- Ti/Tcyc
- Breathing volume
- Volumes per minute
- Peak flow
- Pressure
- Static Compliance (Cstat)
- Triggers (used to separate inspiration time from expiratory time within each breath).

The Product measures and calibrates parameters on breathing apparatuses.

Safety Information

A **Warning** identifies conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury:

- **Read all safety Information before you use the Product.**
- **Use the Product only as specified, or the protection supplied by the Product can be compromised.**
- **Do not connect the Product to a patient or equipment connected to a patient. The Product is intended for equipment analysis only.**
- **Do not use the Product for diagnosis, treatment, or other capacity where the Product touches a patient.**
- **Remove the batteries if the Product is not used for an extended period of time, or if stored in temperatures above 50 °C. If the batteries are not removed, battery leakage can damage the Product.**
- **Recharge the batteries when the low battery indicator shows to prevent incorrect measurements.**
- **Carefully read all instructions.**
- **Do not touch voltages > 30 V ac rms, 42 V ac peak, or 60 V dc.**
- **Do not use and disable the Product if it is damaged.**
- **Do not use the Product if it operates incorrectly.**
- **Examine the case before you use the Product. Look for cracks or missing plastic. Carefully look at the insulation around the terminals.**
- **Use this Product indoors only.**

Table 1 is a list of symbols used in this manual and on the Product.

Table 1. Symbols

Symbol	Definition
	Risk of Danger. Important information. See Manual.
	Hazardous voltage
	Conforms to relevant North American Safety Standards.
	Conforms to European Union directives
	This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste. Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as category 9 "Monitoring and Control Instrumentation" product. Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.

Responsibility and Warranty

The manufacturer assumes no responsibility or warranty, nor accept liability if the user or third parties:

- Do not use the Product as intended.
- Violates the technical specifications.
- Changes the Product (through unauthorized modifications, changes, etc.)
- Uses the Product with accessories other than those shown in the related Product documentation.

Intended Use

This Product is intended to do tests on medical devices or systems that deliver gas flow and pressure. This includes ventilators and anesthesia systems.

The intended user is a trained biomedical equipment technician who does preventative maintenance on medical equipment. Users are associated with hospitals, clinics, original equipment manufacturers, and independent service companies. The end user is an individual, trained in medical instrumentation technology.

This Product is intended to be used in a laboratory environment, outside of patient care areas. It is not intended for use on patients or on equipment connected to patients. It is intended for over-the-counter use. This Product is not intended to be used to calibrate medical equipment.

Software and Firmware versions

This manual is applicable for the Product with software version 3.1 or higher and hardware version 1.0 or higher. A product with different versions can operate differently from this manual.

System Requirements

Your computer must have the minimum requirements below:

- Microsoft Windows x86 or x64 (64-bit mode support for IE only)
- 1.6 GHz or higher
- 512 Mb RAM
- Microsoft Windows, Vista, 7, 7 SP1, Windows Server 2008 SP2, Windows Server 2008 R2 SP1, Windows Server 2003, XP SP2 and SP3

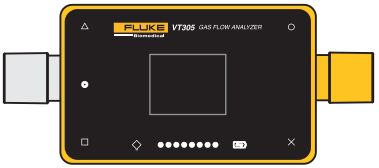
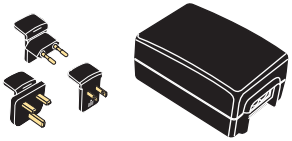
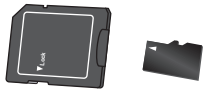
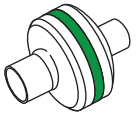
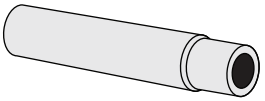
Female Users

This manual uses the male pronoun “he” for simplicity and better understanding. This notwithstanding expressly includes female users as well.

Start Up

Table 2 is a list of parts included with the Product.

Table 2. Product Parts

Name	Item
VT305	
USB Cable	
Power Supply (power adapter)	
Micro-SD 2GB multi kit	
Bacteria/Dust Filter	
Intlet Pipe	

Power Supply

The Product can be operated from the power supply or the built-in rechargeable battery.

Use the USB cable to connect the Product to a computer or the included power supply. The USB port is shown in Figure 1. You can power the Product through the analog, USB, and CAN interfaces when you use the appropriate optional adapters.

A battery symbol shows in the display when the battery charges. The charge level of the battery is shown in the battery display screen. A red LED shows in the left side of the display when the battery is low.

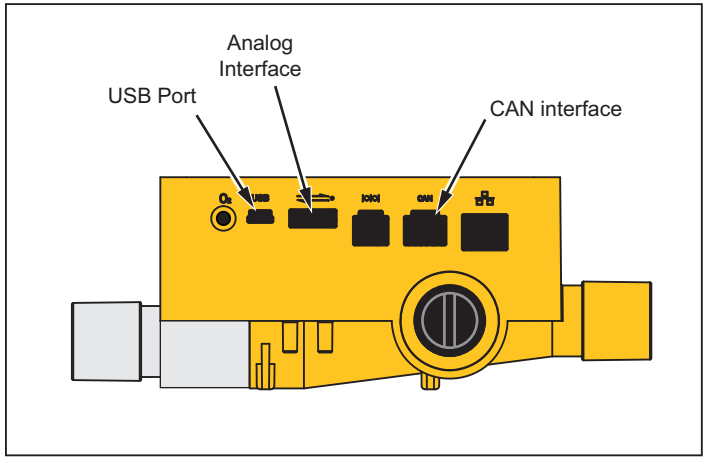


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Figure 1. Ports for Power Connection

Connect the power adapter into a mains socket with a voltage of 100 V ac to 240 V ac at 50 Hz or 60 Hz.

⚠ Caution

To prevent damage to the Product, make sure the mains voltage is in the range specified on the power adapter nameplate. Use the Product only with the power adapter supplied with the Product.

Filter

To prevent damage to the Product from dirt and particles in the air, use the supplied filters for all flow measurements. Use the filter to ensure laminar flow. Laminar flow is necessary to make accurate flow measurements.

Note

Particles in the air can clog the measurement system, and cause an error message. Examine the filter regularly.

Flow Channel

The flow port can be used bidirectionally to measure flow, volume, chamber gas temperature, oxygen, and pressure in the flow channel. See the specifications for these measurement ranges and accuracies. Figure 2 shows the flow channel on the Product.

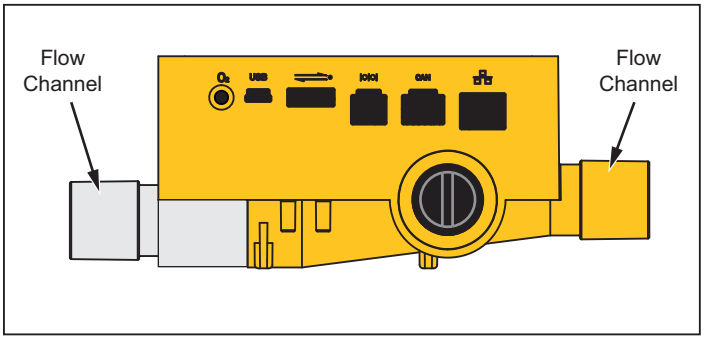

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Figure 2. Flow Channel

Differential Pressure

The differential pressure connections are used to measure differential pressure. Figure 3 shows the differential pressure connections.

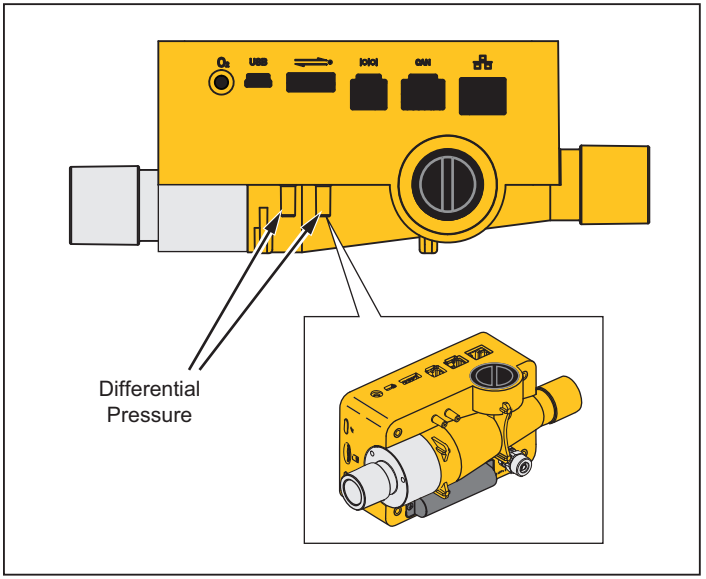

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Figure 3. Differential Pressure Ports

High Pressure

The high pressure port is used to measure pressure more than 200 mbars. Figure 4 shows the high pressure port on the Product.

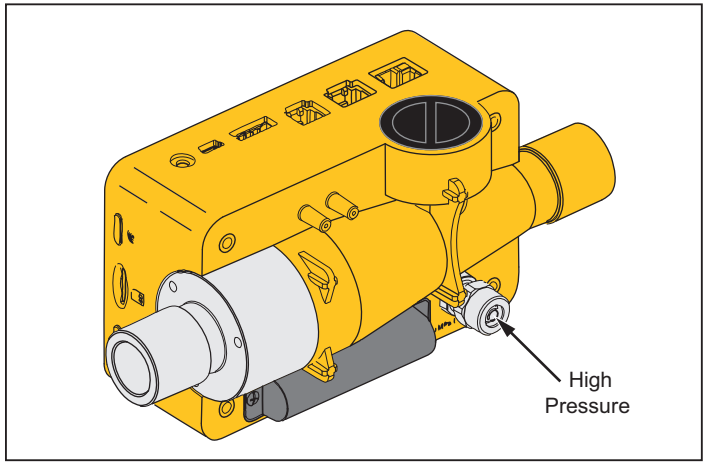

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Figure 4. High Pressure Port

Note

For measurements to a maximum of 200 mbar, Fluke Biomedical recommends you use the differential pressure port. Accuracy is 100 times higher.

⚠ Caution

To prevent damage to the high-pressure sensor, do not measure pressure more than 15 bar.

O_2 Measurement Cell

The Product has an interface for an O_2 measurement cell. See Figure 5. For more information, see the O_2 Sensor section in this manual.

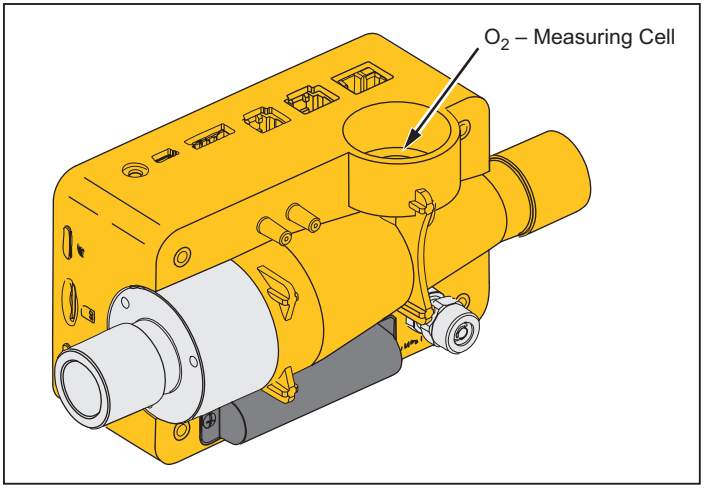

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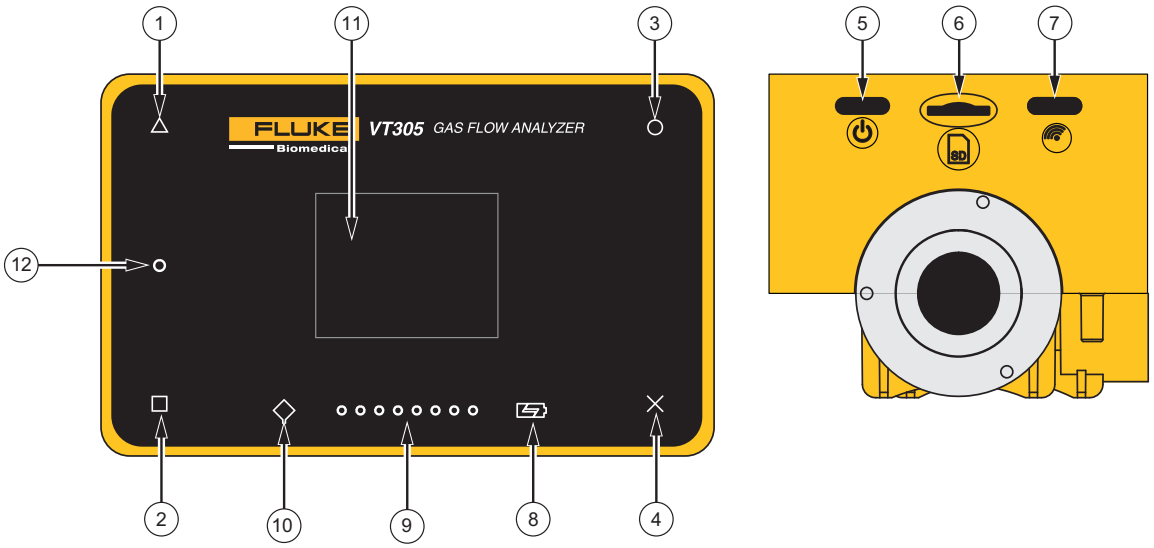
Figure 5. O_2 Cell

Controls

Table 3 is a list of the front-panel controls.

Table 3. Front-Panel Controls



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Item	Description	Item	Description
1	Display/Change measurement curves	7	Future use
2	Show/Change numerical measurement values	8	Battery on charge
3	Change settings/save data	9	Flow direction LEDs
4	Show menu/change menu/zero calibration	10	Function error LED
5	On/Off	11	Screen
6	Micro SD card slot	12	Low battery warning

Electrical Interfaces

The Product has six electrical interfaces. Table 4 is a list of the electrical interfaces and references Figure 6.

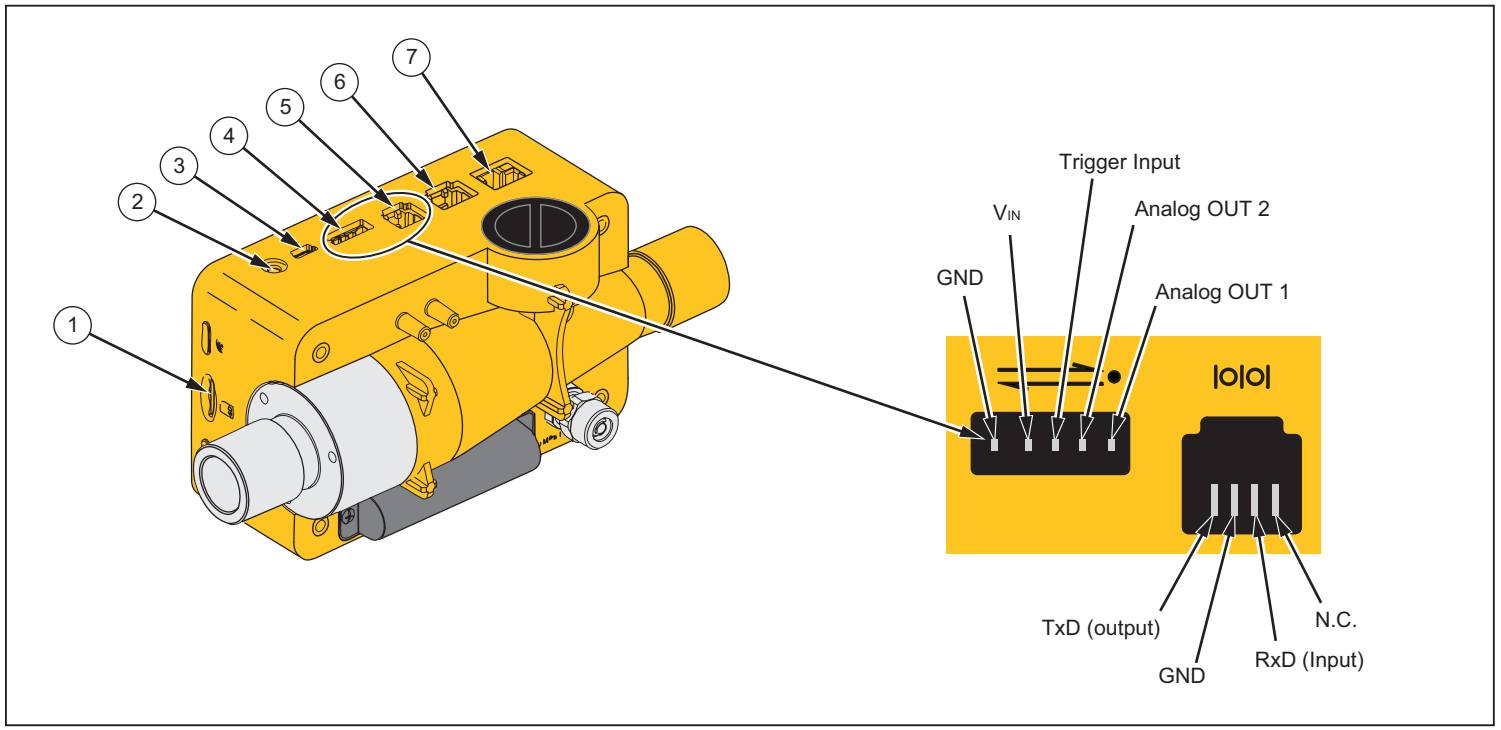

Figure 6. Electrical Interfaces

Table 4. Electrical Interfaces

Item	Description
1	The Micro-SD card is used for software updates and Product configurations. Measurement data can be output through the micro SD card. See the Measurement Data section.
2	The O_2 interface is used to connect the O2 sensor to the Product.
3	The USB port is a data interface. It can also be used to operate with the mains power supply and to charge the battery.
4	The Analog OUT port is used to output analog signals, connect to an external trigger, operate with the optional mains power supply, and charge the battery of the Product. See the Specifications section for more data.
5	The RS-232 interface is used as a data interface. See the Specifications section for more data.
6	The CAN interface – future use.
7	The Ethernet interface is used to configure the Product and save the file to the SD card.

Operation

The sections that follow tell how to use the Product.

How to Turn On and Turn Off the Product

The Product is turned on and turned off when you push the power button (⏻).

The Start Screen

When the Product is turned on, the start-up screen in Figure 7 shows in the display. After approximately 3 seconds the numerical measurement values show in the display.

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Figure 7. Start-Up Screen

Settings

Push **X** on the front panel to show the information screen. This shows the device data. Push **X** again to show more menu items to make adjustments. Push **O** to change

individual settings. Table 5 is a list of screens that show in the display.

Table 5. Settings Screens

Screen	Description
	**Information** Shows device data. You can set Owner and Company data fields with the browser-based configurator. See the Product Configuration section.
	**Battery** Shows the current charge of the battery.

Table 5. Settings Screens (cont.)

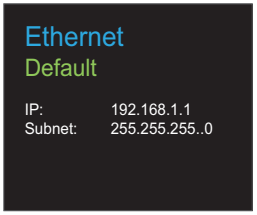
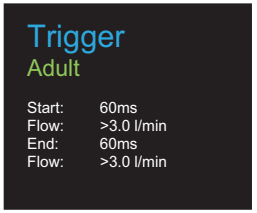
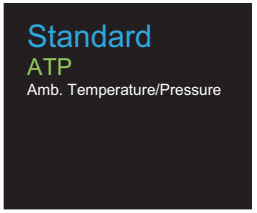
Screen	Description
	**Ethernet** The Ethernet screen is used to set the Ethernet communication parameters.
	**Set Trigger** The Trigger events screen is used to set when the Product calculates volume, and respiratory parameters. The factory defaults show adult, pediatric, and high frequency trigger configuration. See the Measure Key Respiratory Data section.
	**Set Gas Standard** The Product calculates the measured flow and volume values for the set standard. See the Gas Standard after the Specifications section.

Table 5. Settings Screens (cont.)

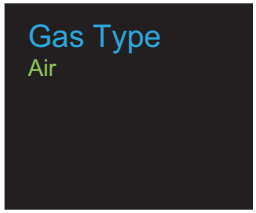
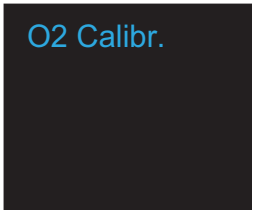
Screen	Description
	**Set Gas Types** Sets the gas type for the gas to be measured. See the Measurement Variables section.
	**Set the X-Axis** Sets the time base line for the graphic/waveform displays (2, 4, 6, 8, and 10 seconds).
	**Humidity** Sets the percent (%) of relative humidity in the gas flow (0 % to 100 % in 10 % steps).

Table 5. Settings Screens (cont.)

Screen	Description
	**O2 Calibration** Used to calibrate the O_2 cell. See the O_2 Sensor section.

Numerical Values

Push □ on the display to show the numerical values screen in the display. See Figure 8. You can change one, two, four, or six numerical values on each screen. You configure individual values and units through the web browser-based configurator. See the Product Configuration section.

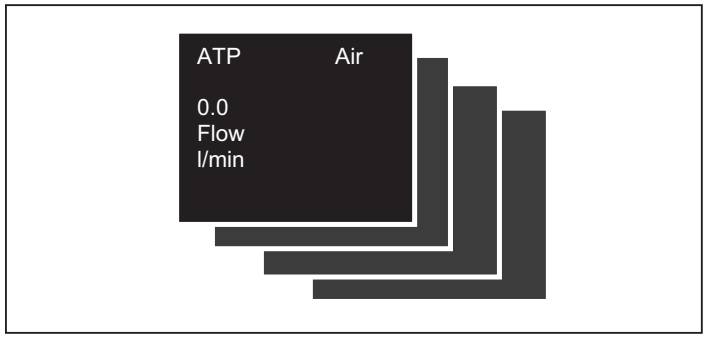


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Figure 8. Numerical Values Screens

The Product measures the temperature of the gas in the measurement chamber inside the Product. This temperature is not the same as the gas temperature that enters the Product. The heat of the gas changes due to the heat inside the Product.

The Product calculates static compliance (Cstat) with this formula:

$$Cstat = \frac{V_t}{P_{plateau} - PEEP}$$

When no plateau pressure is available, the formula has a divisor of zero. The Product will show "---" in the display when this happens.

Graphical Values

Push Δ on the display to show the measured curves in the display. See Figure 9. You can change one or two measured curves each screen. You configure individual values and units through the online application. See the Product Configuration section.

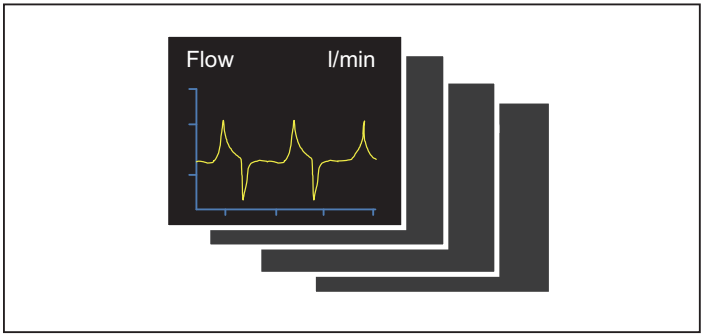

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Figure 9. Measured Curves Screens

Filter

The display update period is 500 ms or two times each second. The acquisition time of new measurements is 5 ms to 8 ms. Without the filter, the latest measured value is shown in the display when the screen updates. Because each measurement has some noise, use the filter to average the values equally for a specified period of time.

The available filter selections are as follows:

- None (Display of the latest measured value without thresholds)
- Low (Mean value over 240 ms)
- Medium (Mean value over 480 ms)
- High (Mean value over 960 ms)

The factory default for the filter is high.

You can change the filter selection in the browser-based Product configuration tool. To learn more, see the Product Configuration section.

How to Save Data

Push and hold **O** for 5 seconds to store data on the micro-SD card. The screen in Figure 10 shows in the display while the Product saves the data. See the How to Read Out Measurement Data section.

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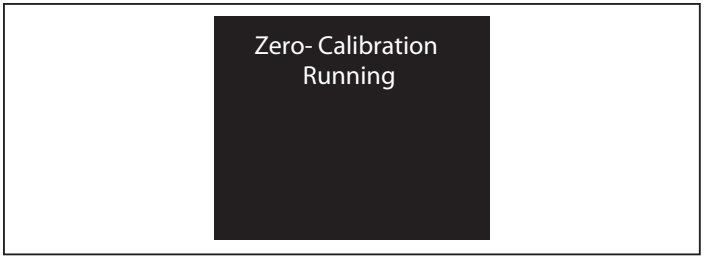
Figure 10. Saving Data Screen

Zero-Point Calibration

Push and hold **X** for 5 seconds to start the zero calibration of the pressure and flow sensors. While the Product does the calibration procedure, the screen in Figure 11 shows in the display.



gyo023.eps

Figure 11. Zero Calibration Screen

It is important to do a zero calibration periodically to remove off-sets in the flow measurement.

⚠ Caution

To make accurate measurements, do not apply pressure to the Product when you do a zero calibration. This caution is not shown in the display when you use the X symbol.

It is very important to do the zero calibration while the airway pressure transducer stabilizes and before a measurement is made.

Connect the Product

Refer to Figure 12 when you do the subsequent steps.

1. Always use the dust filter.
2. Connect the tube system.

Note

Avoid tight bends, kinks, or dents in the tubing.

3. Connect the test lung.
4. Connect the breathing apparatus.

For more information on how to connect the breathing apparatus, see the How to Measure Respiratory Data section.

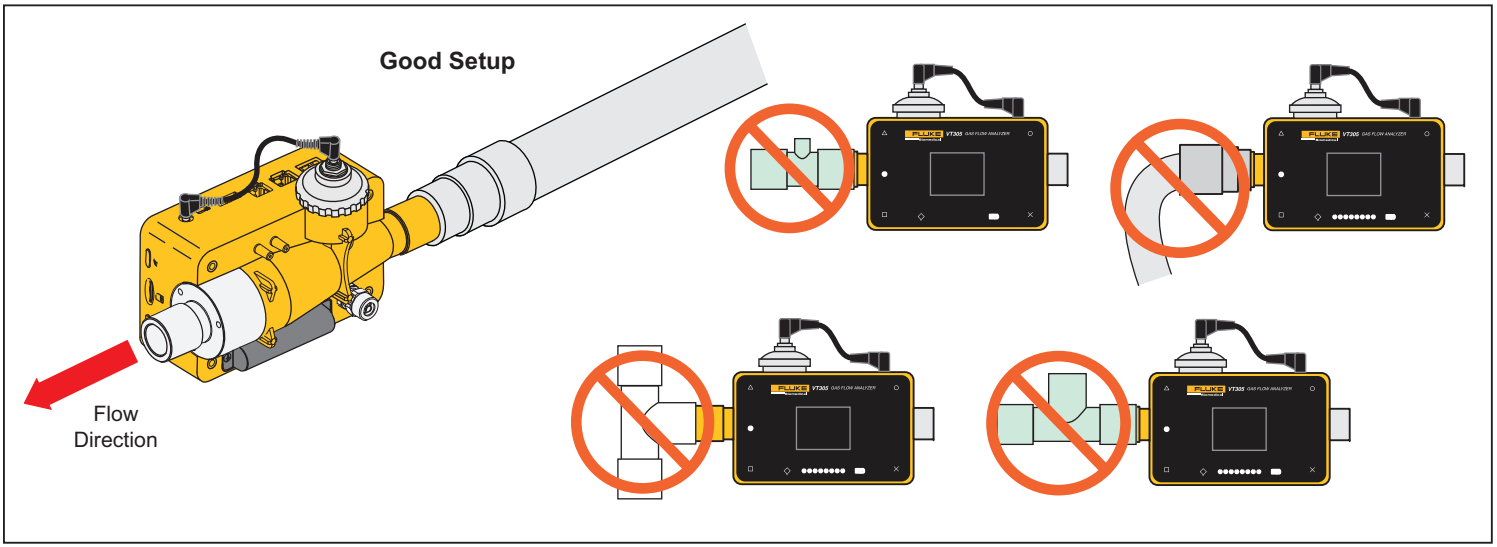


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Figure 12. Product to Breathing Apparatus Connections

Setup for Ventilator Measurements

To test and calibrate ventilators, use the inlet pipe between the breathing circuit and the Product, as shown in Figure 13. Use the filter to improve laminarity of the flow. This improves measurement accuracy.

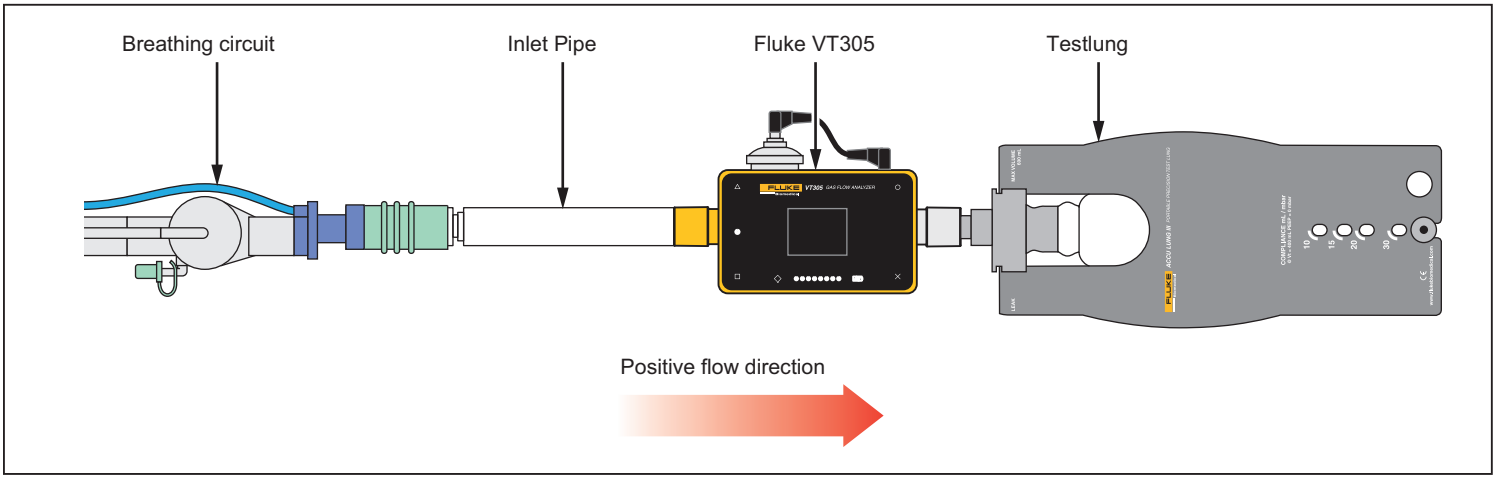

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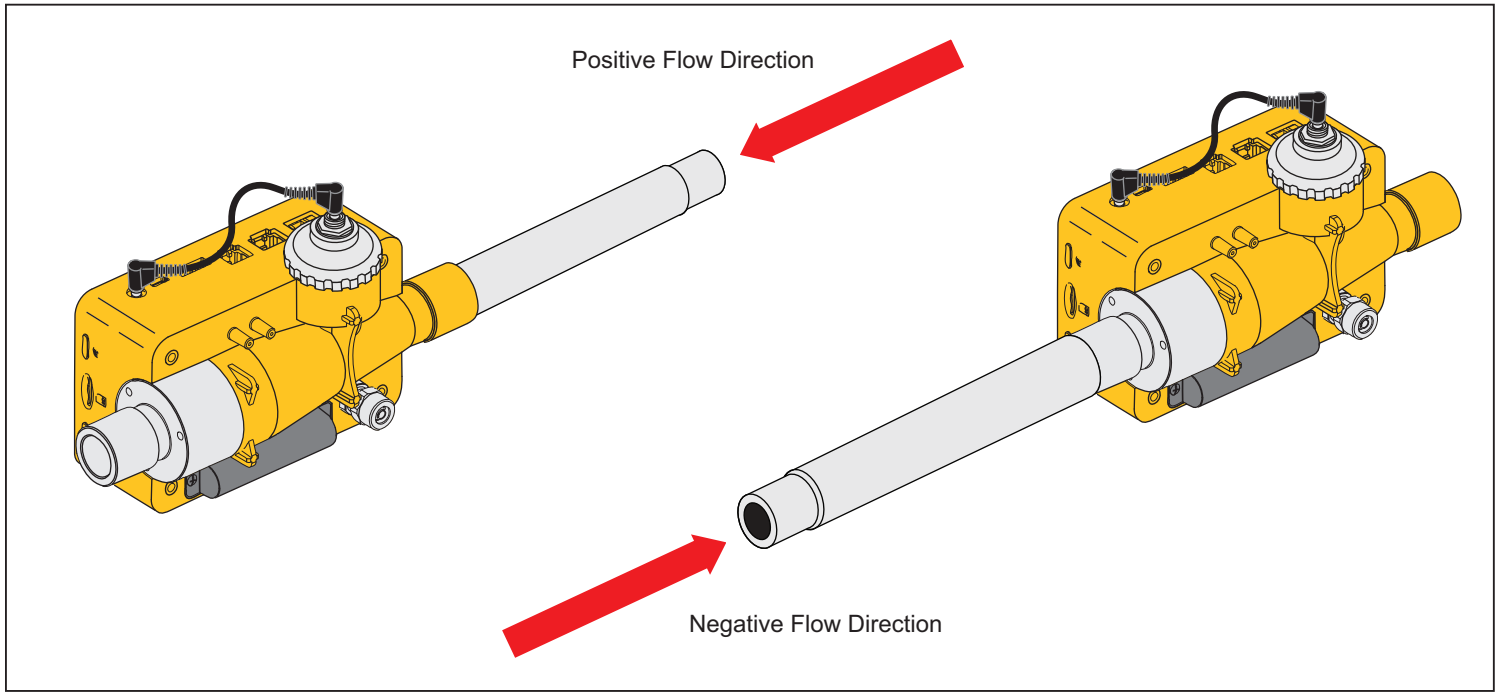
Figure 13. Ventilator Connections

Setup for Precise Flow Measurements

Note

The measured gas must be free of oil, grease, and dust. For best measurement results, set the trigger to "adult."

For precise flow measurements, put the inlet pipe and filter on the Product as shown in Figure 14.



gyo049.eps

Figure 14. Precise Flow Measurement Connections

Setup for Dusty or Contaminated Gases

When you use the Product to measure gas that contains dust or other contaminants, use the filter as shown in Figure 15.

Note

The gas must not contain oil or grease.

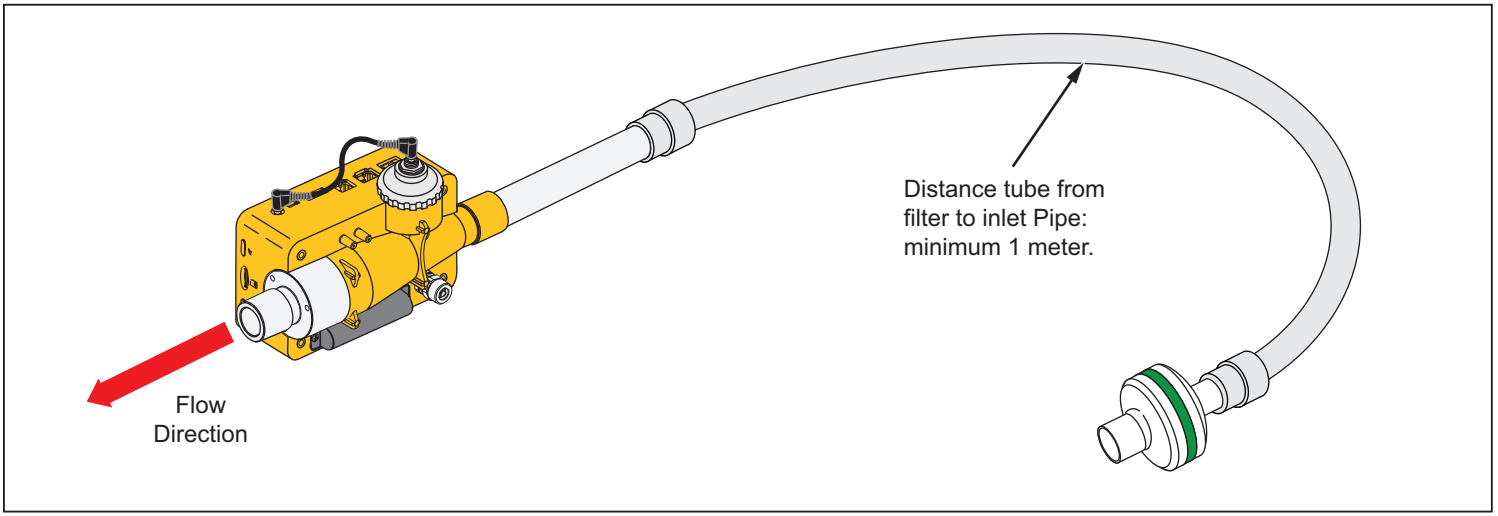


Figure 15. Filter Use

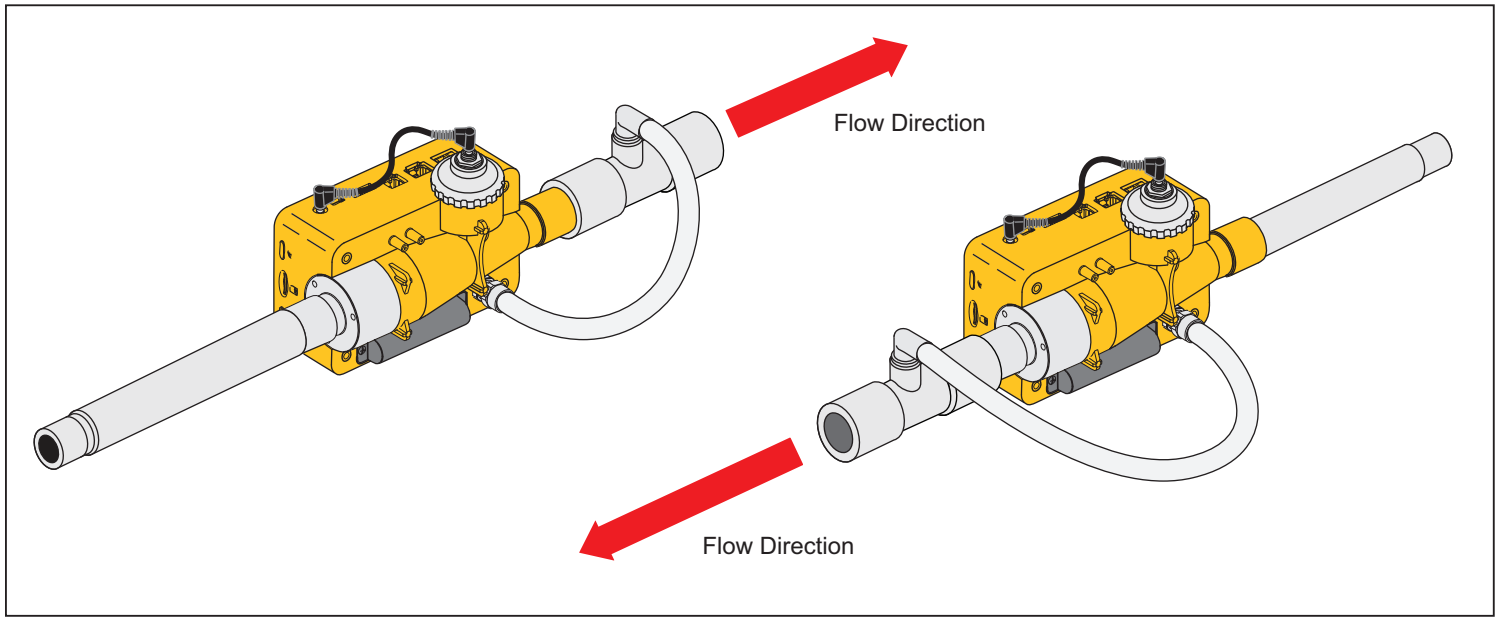
Setup for High Pressure Gases

The Product automatically compensates for the gas pressure in the flow channel up to 150 mbar. Use the high pressure port as shown in Figure 16 for pressures greater than 150 mbar.

⚠ Caution

To prevent damage to the Product, do not apply more than 800 mbars to the airway channel port of the Product.

In the flow channel, the Product adjusts for pressures to a maximum of 150 mbars. When the high pressure port is used, the Product adjusts for pressures up to a maximum of 300 mbars.



gyo051.eps

Figure 16. High Pressure Connections

Measurement Data

Product measurements can be exported on the micro-SD card, analog out interface, or the RS-232 interface.

Store Measurement Data on the Micro-SD Card

Push and hold **O** for 5 seconds. This stores the measurement data on the Micro-SD card. A message that shows the filename that contains the measured data shows in the display. The filename format is DataXX.csv. See Figure 10.

There are two ways to get to the data on the Micro-SD card. Use the USB port of the Product or put the Micro-SD card into a computer.

To access data through the USB port, connect the USB port of the Product to a computer.

Note

To communicate with the Product from a computer, you must install a device driver. The driver file "usb_cdc_ser.inf" is stored on the Micro-SD card. Call or email technical support for help.

When the Product senses USB communications, the message in Figure 17 shows in this display. If you do not make a choice in 5 seconds, the Product will not become a USB mass storage device

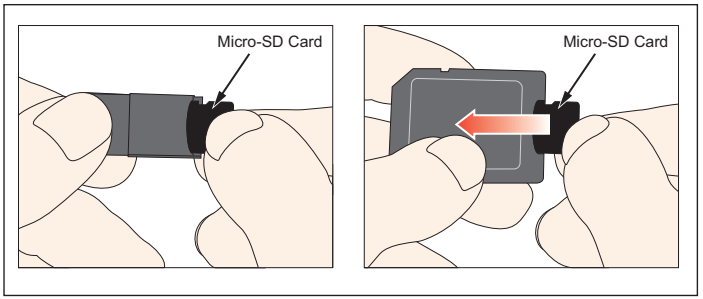
gyo063.eps

Figure 17. Mass Storage Message

When you use the Product as a USB mass storage device, you cannot use the configuration tool to configure the Product.

How to Connect to the Computer

Push the Micro-SD card to release it from the Product. You can connect the Micro-SD card to your computer through a USB port or SD-card socket. See Figure 18.

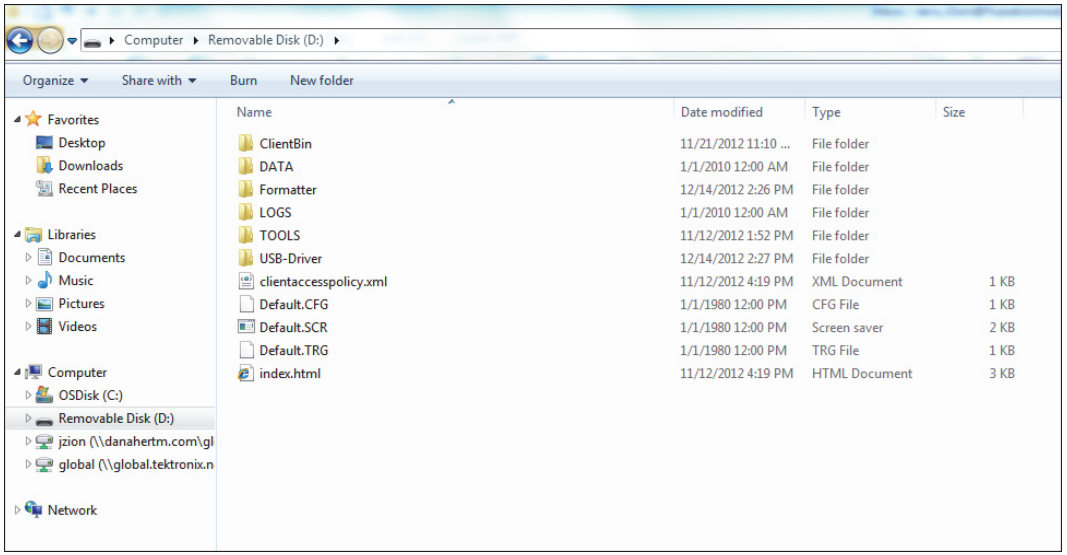


gyo025.eps

Figure 18. Micro-SD Card

How to Read the Data on the Computer

Figure 19 shows the files and directory structure on the Micro-SD card used by the Product.



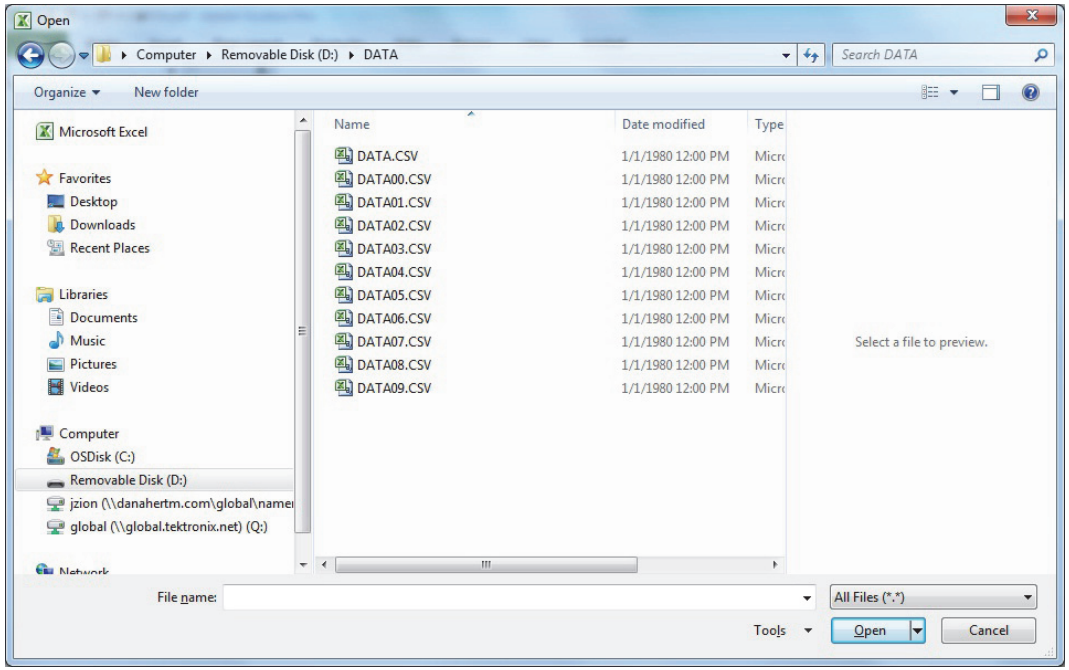
gyo073.jpg

Figure 19. Micro SD Card Files

To Make an Excel File with Saved Values

1. Open the SetupReportFormatter.bat file. This file installs ReportFormatter.xlsb in the Report/XLSTART folder. This causes the ReportFormatter file to open when Microsoft Excel is started. A list of files in the Excel file open dialog box. See Figure 20. Double click on a .csv file in the DATA folder to open it.

   When you open a .csv file, a dialog box shows in the computer display where you can set whether the report data is formatted or not.



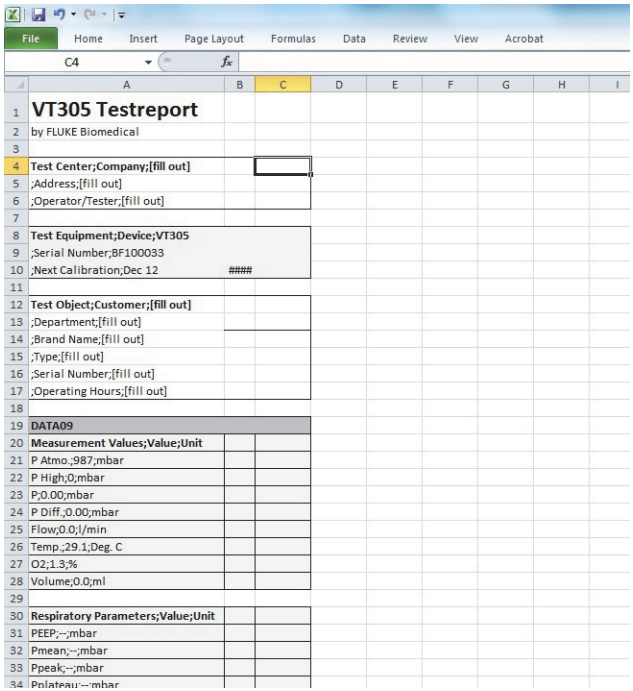
gyo072.jpg

Figure 20. Report Data Files

2. Click **Yes** to make a formatted file. The Product test report like that shown in Figure 21 is made.
3. You can change the Excel file as necessary.

Note

Files on the Micro-SD card cannot be renamed.



gyo028.jpg

Figure 21. Formatted Excel File of Measurement Data

Product Configuration

You can configure the Product through the Ethernet interface. When a configuration parameter is changed, the change will be made in the Product and saved on the micro SD card immediately.

Note

You must install Microsoft Silverlight 5 on Internet Explorer 7+, Safari 4+, Chrome 12+, or Firefox 3.6+ to configure the Product through the internet.

1. Insert a micro SD card that contains the necessary files into the Product. The SD card must contain the ClientBin folder that includes ConfigurationWeb.asp file, the clientaccesspolicy.xml file, and the index.html file.

   Note

   The micro SD card must be installed in the Product if you want to save the configuration. If you cannot find the micro SD card, talk to your Fluke Biomedical distributor or call Fluke Biomedical technical support. See Technical Support in the front of this manual.

2. Connect the Ethernet port of the Product to a network or directly to a computer.
3. Push **X** on the Product to show the Ethernet screen.
4. Push **O** to select one of the three internet connection methods: Default, Configured, and DHCP-Client.

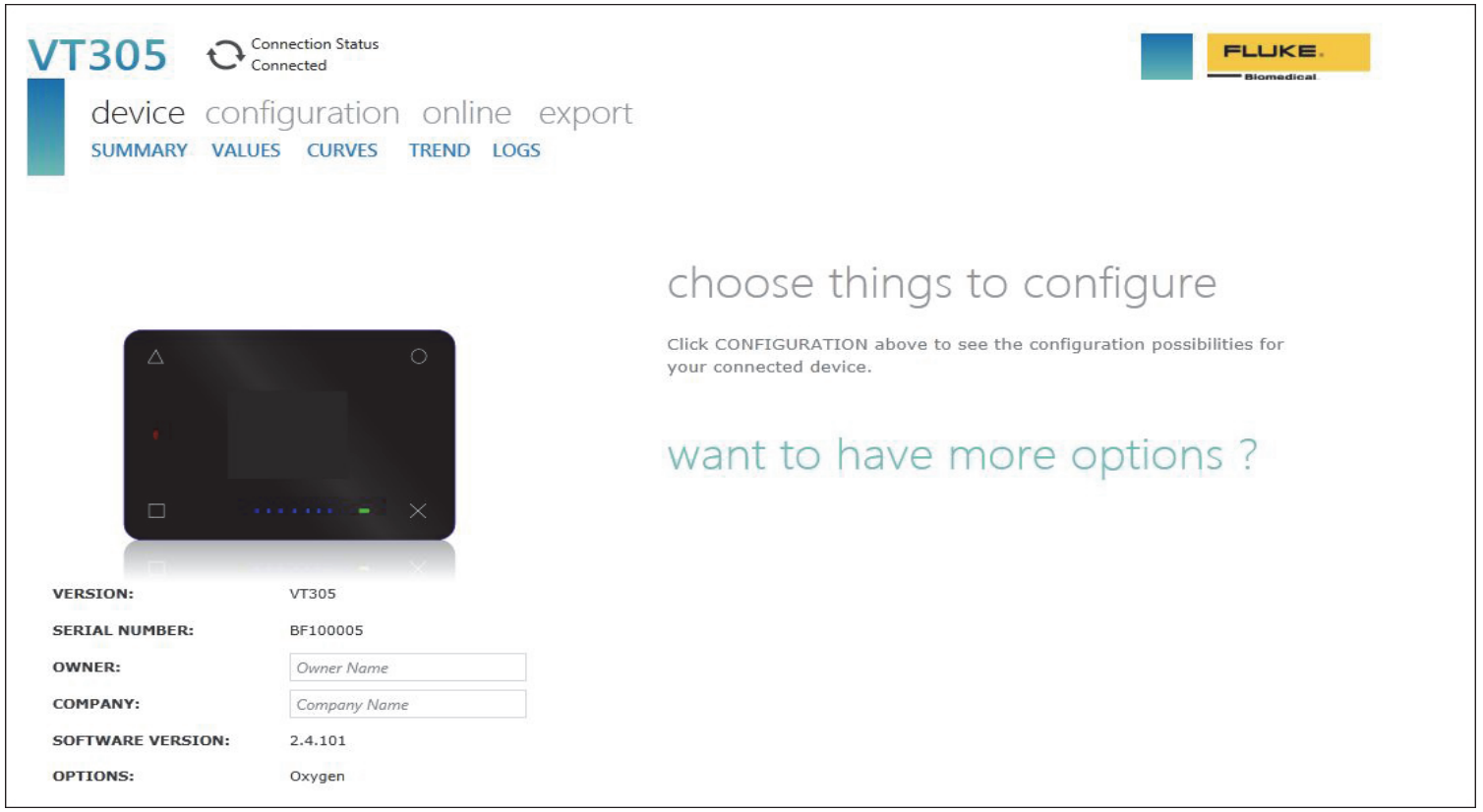
   The **Default** selection is the recommended method when you connect the Product directly to a computer. The **Configured** and **DHCP-Client** selection should be used when you connect to an existing network.

   See the How to Setup an Ethernet Connection section for instructions to set an IP Address and subnet mask.

   The browser-based configuration page in Figure 22 shows in the computer display when an Ethernet connection is made.

5. To personalize the Product, type a name in the owner field and a name in the company name field of the web page.
6. In the upper-left corner of the web page, there are main menu and submenu hyperlinks that you use to navigate in the configuration tool.
7. To change Product configuration parameter values, click on the **configuration** hyperlink. The configuration page in Figure 23 shows in the computer display.

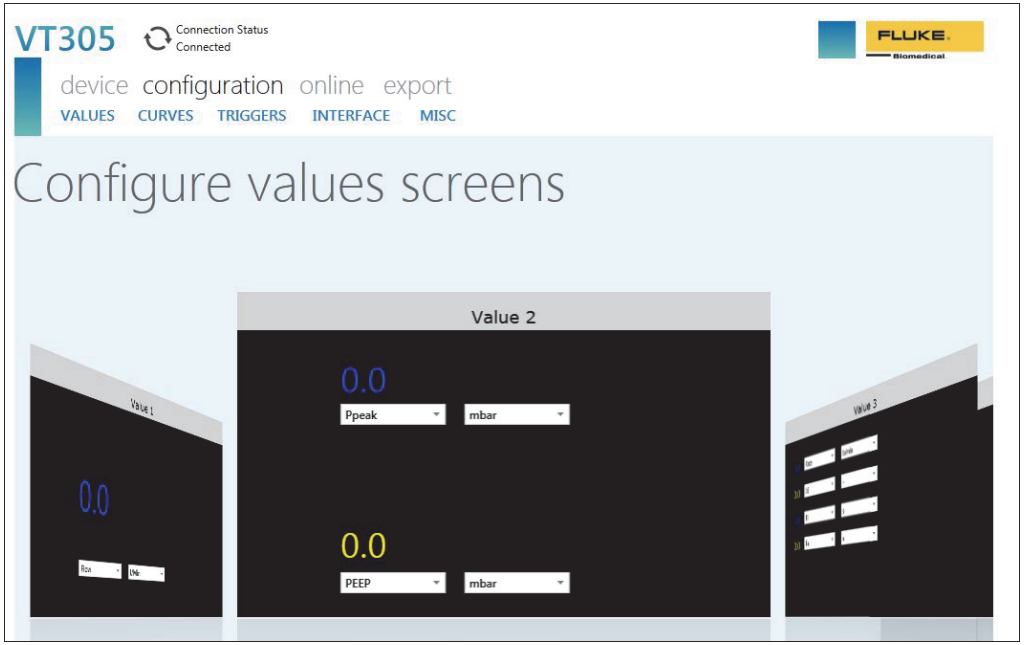
The submenu selections are **VALUES**, **CURVES**, **TRIGGERS**, **INTERFACE**, and **MISC**. You click on these submenu hyperlinks to open the configuration page that will show the parameters for the selected parameter group.



gyo030.jpg

Figure 22. Configuration Utility Web Page

Values Configuration



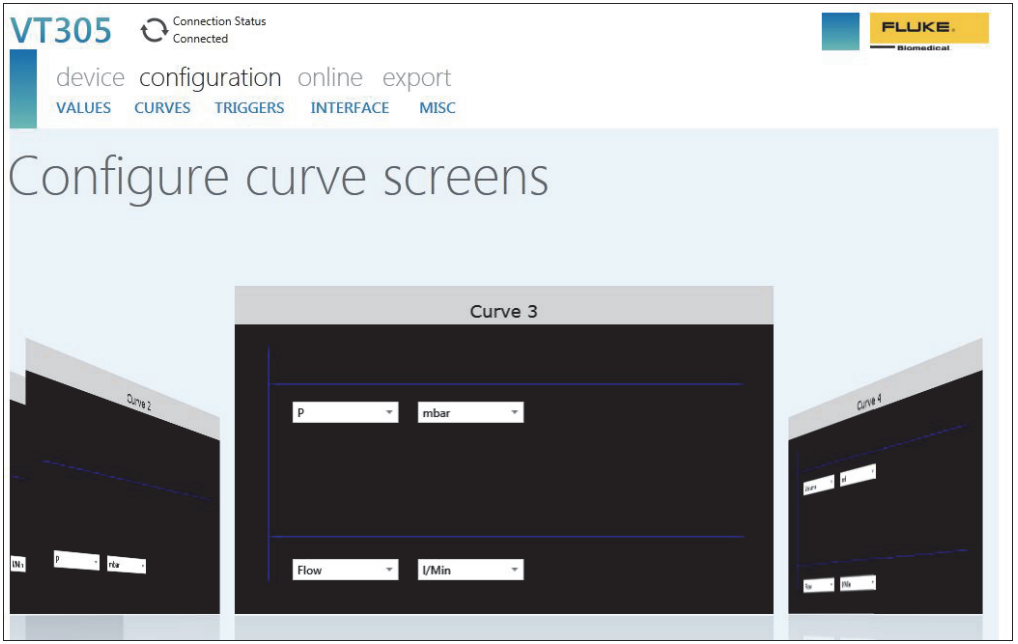
gyo031.jpg

Figure 23. Trigger Values Web Page

The values configuration screen lets you set the value parameters in the Product. Click on the down arrow in each combo box to show a list of parameters or values that you click on to set. To switch between Value 1, Value 2, and Value 3, click on the grey banner of the window that shows the values you want to change. The Value 2 window is selected in Figure 23. To select the Value 1 window shown on the left, click the grey Value 1 banner at the top of that window.

Curves Configuration

Change the displayed curves or associated units on the Product with the drop down combo boxes shown in Figure 24.



gyo032.jpg

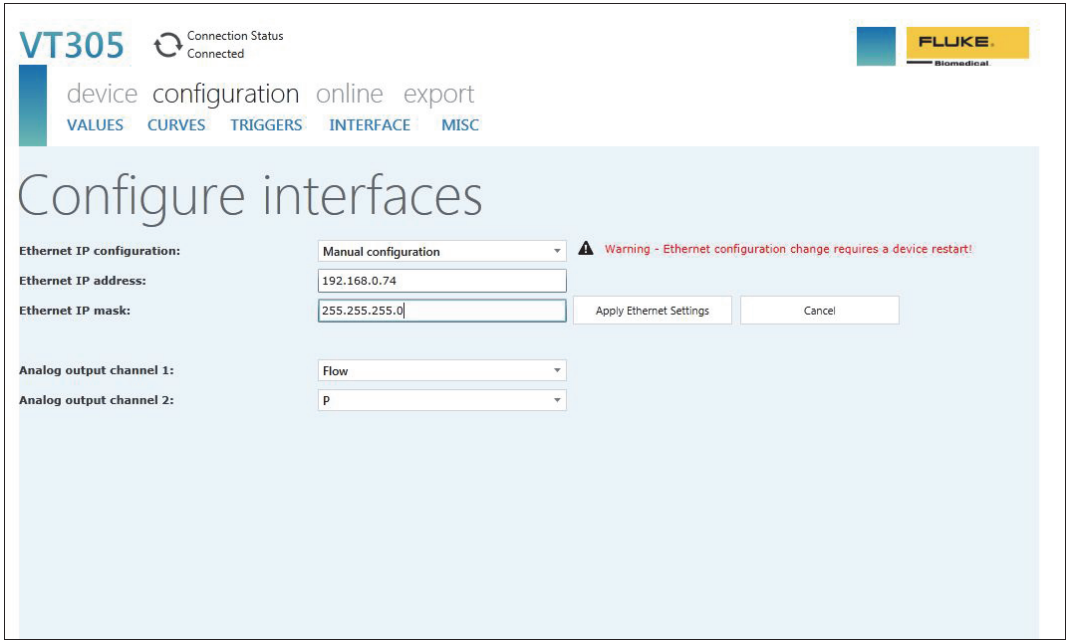
Figure 24. Graphical Screen Configuration Web Page

Note

The gas temperature shown on the display is the temperature of the gas in the measurement chamber and not the temperature of the gas that flows into the Product. The temperature of the Product will change the temperature of the gas that flows into the Product.

Interface Configuration

Use the Configure interfaces screen to setup the Ethernet connection and analog output channels. Use the drop-down lists to set the IP configuration and analog outputs. See Figure 25.



gyo034.jpg

Figure 25. Create Configuration File Web Page

Trigger Configuration

Use the Configure triggers screen sown in Figure 26 to set one of the three preconfigured triggers.

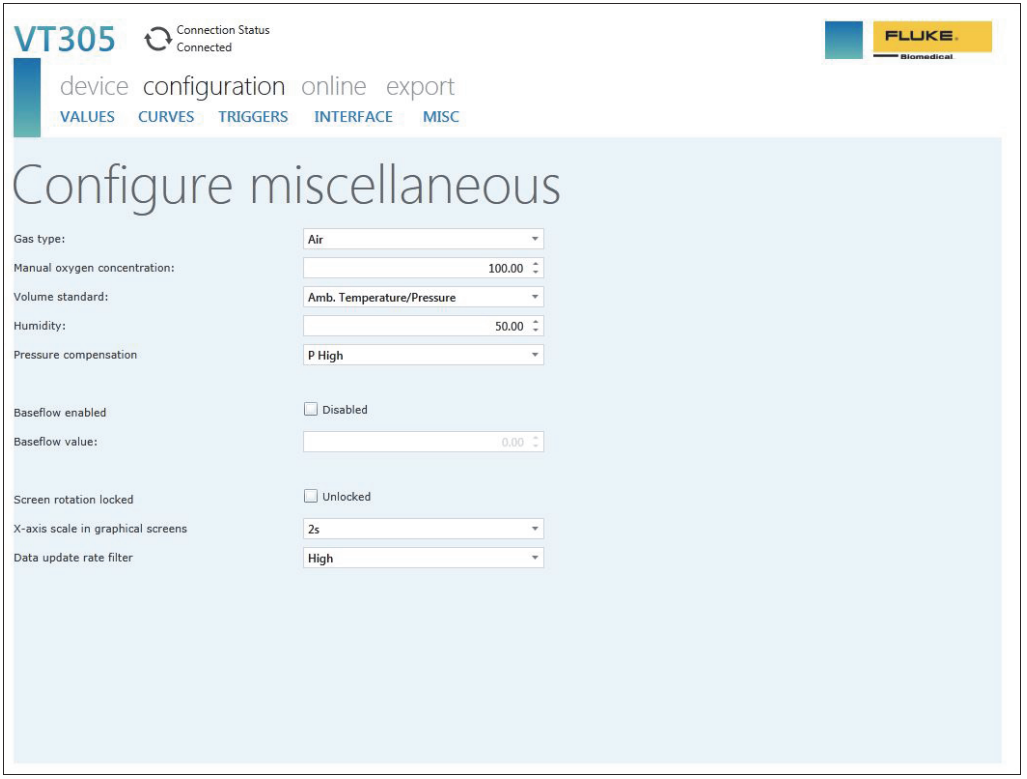
gyo064.jpg

Figure 26. Configure Triggers Screen

Click on the active button in one of the three windows to select the trigger you want to use in the Product. Some parameters are set with the drop-down lists. Click on the Reset to Defaults button to set all trigger parameters to their factory default values.

Miscellaneous Configuration

Change the miscellaneous parameters on the Product with the drop down combo boxes shown in Figure 27.



gyo054.jpg

Figure 27. Miscellaneous Configuration Window

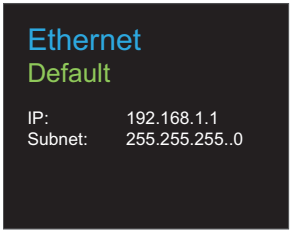
How to Setup an Ethernet Connection

There are three Ethernet setup procedures: Default, Configured, and DHCP-Client.

Default Ethernet Setup

The default setup is used when no network exists and you connect the Product directly to the computer.

1. Use an Ethernet cable to connect the Ethernet port on the computer to the Product.
2. Push **X** on the Product until the Ethernet screen shows in the display. See Figure 28.

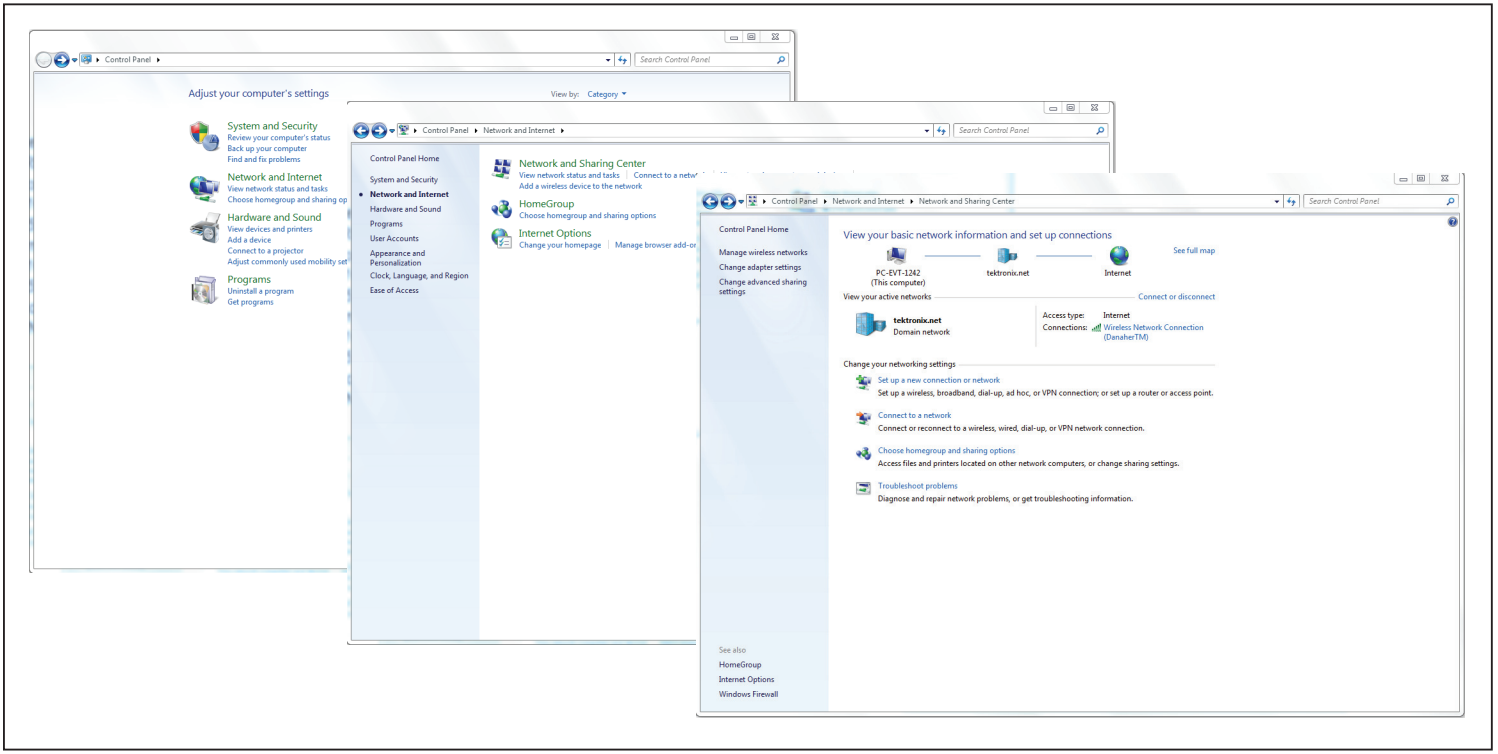


gyo062.eps

Figure 28. Ethernet Connection Screen

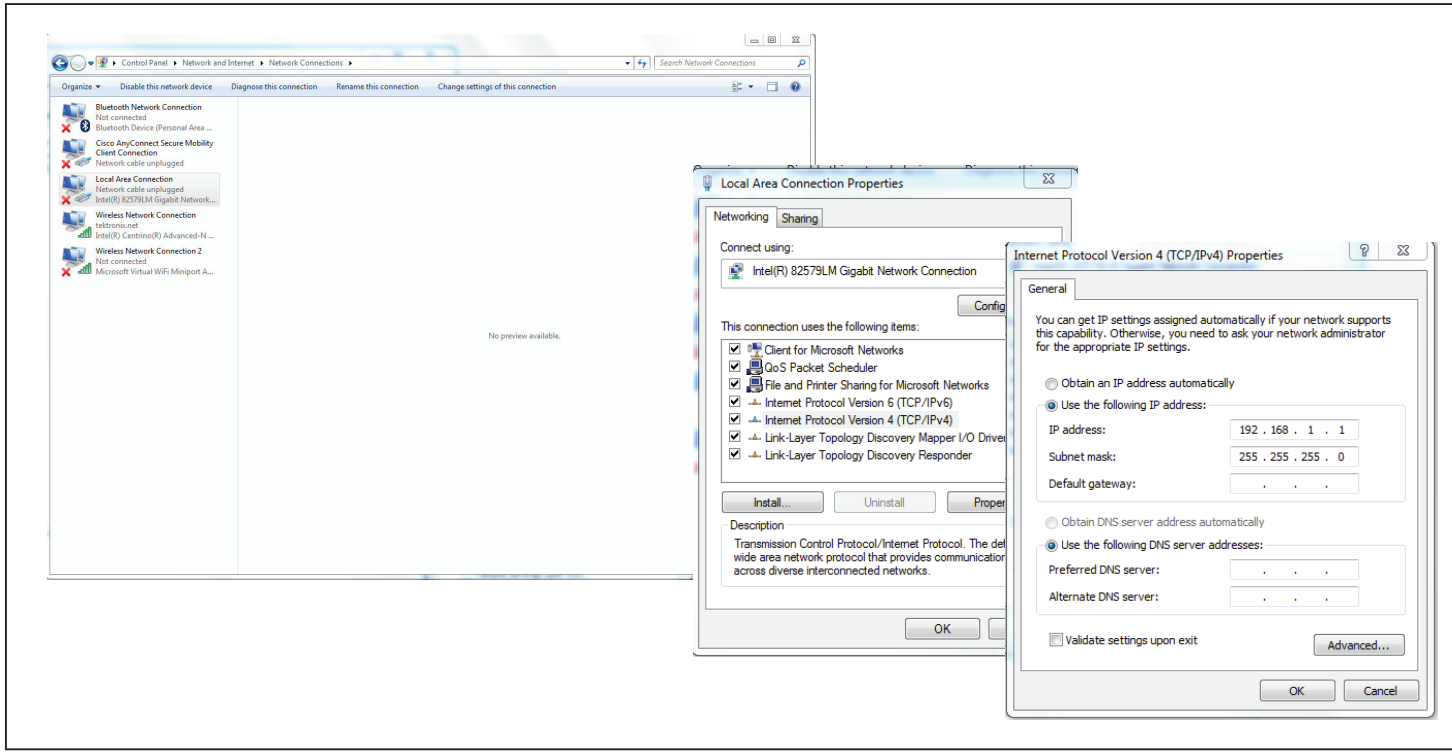
3. If **Default** does not already show in the display, push **O** until it does.

   The default configuration sets the IP Address of the Product to 192.168.1.1 and the subnet mask to 255.255.255.0.
4. Open the Control Panel on the computer.
5. Click on **Network and Internet** in the control panel window.
6. Click on **Change adapter settings**.
7. Double click on the **Local Area Network**. See Figure 29.
8. Highlight **Internet Protocol Version 4 (TCP/Pv4)**.
9. Click the **Properties** button. See Figure 30.
10. Set the IP Address to 192.168.1.2 (or any IP address between 192.168.1.2 through 192.168.1.255) and the subnet mask to 255.255.255.0.
11. Click the **OK** button.
12. Close all the windows you opened through the control panel.
13. Open an Internet Browser.
14. In the address line, type the IP address shown in the display of the Product and push **Enter** on the computer keyboard.



gyo074.eps

Figure 29. Computer Ethernet Setup Windows



gyo075.eps

Figure 30. Ethernet IP Address Properties Form

Configured and DCHP Ethernet Setup

The configured setup is used when a network that does not have a DCHP server exists. The DCHP-Client setup is used when you connect to networks that have a DCHP server.

1. Use an Ethernet cable to connect the Ethernet port on the Product to the network.
2. Push **X** on the Product until the **Ethernet Configured** or **Ethernet DCHP – Client** screen shows in the Product display.
3. Open an Internet Browser.
4. In the address line, type the IP address shown in the display of the Product and push **Enter** on the computer keyboard.

Note

There can only be one connection to the configuration tool for a single Product. With the configuration tool open, the Product cannot be configured from another computer.

The configuration tool will download to the computer and establish a connection.

O_2 Sensor

Activation

The Product has an interface for an oxygen sensor. The oxygen sensor must be calibrated with air and 100 % O_2.

Installation

A kit that has the oxygen sensor and connection cable comes with the oxygen option.

Remove the protective cap (rubber stopper) from the sensor.

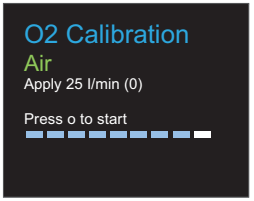
Oxygen Sensor Calibration – Air Only

Note

Fluke Biomedical does not recommend you calibrate the oxygen sensor with air.

To calibrate the oxygen sensor with air:

1. Push **X** on the front panel until **O2 Calibration** with **Air** shows in the display.
2. Push **O** to start the calibration process.
3. Apply 25 l/min of air to the flow channel of the Product when the instruction shows in the display. See Figure 31.



gyo066.eps

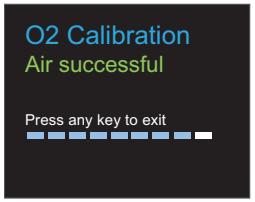
Figure 31. O_2 Calibration - Apply Air

4. Push **O** to continue.

Note

To stop the calibration procedure, push **X**.

Air calibration starts and will take 114 seconds to complete. Under no circumstances interrupt the flow of air through the flow channel. The screen in Figure 32 shows in the display when the calibration is done.



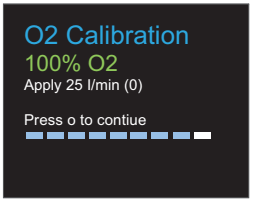
gyo067.eps

Figure 32. O_2 Calibration Successful Screen

Oxygen Sensor Calibration – O_2 and Air

To calibrate the oxygen sensor with air and oxygen:

1. Push **X** on the front panel until **O2 Calibration** with **O2 and Air** shows on the display.
2. Push **O** to start the calibration process.
3. Apply 25 l/min of 100 % oxygen to the flow channel of the Product when the instruction shows in the display. See Figure 33.



gyo070.eps

Figure 33. O_2 Calibration - Apply Oxygen

4. Push **O** to continue.

Note

To stop the calibration procedure, push **X**.

Oxygen calibration starts and will take 114 seconds to complete. Under no circumstances interrupt the flow of gas through the flow channel.

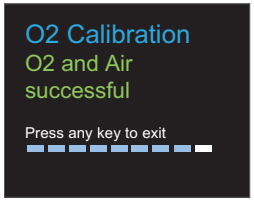
5. Apply 25 l/min of air to the flow channel of the Product when the instruction shows in the display. See Figure 31.

gyo066.eps

Figure 34. O_2 Calibration - Apply Air

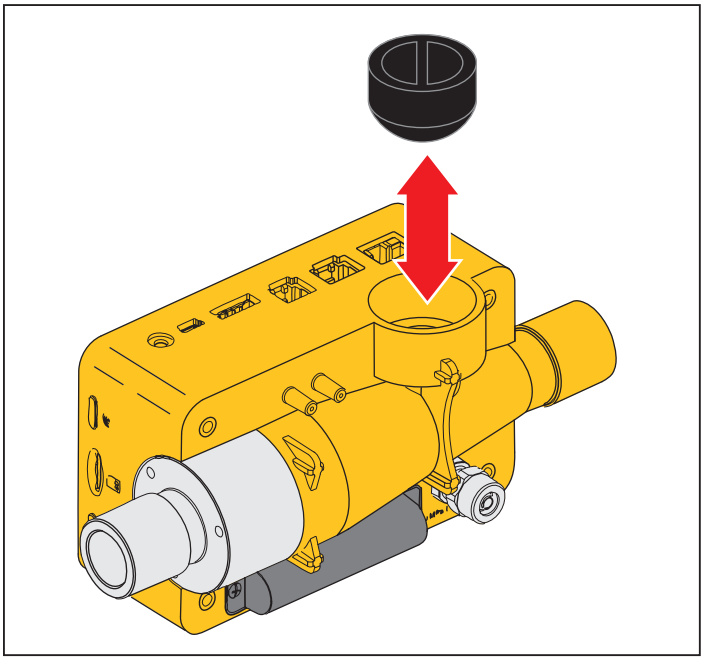
Air calibration starts and will take 114 seconds to complete. Under no circumstances interrupt the flow of air through the flow channel.

The screen in Figure 35 shows in the display when the calibration is done.



gyo069.eps

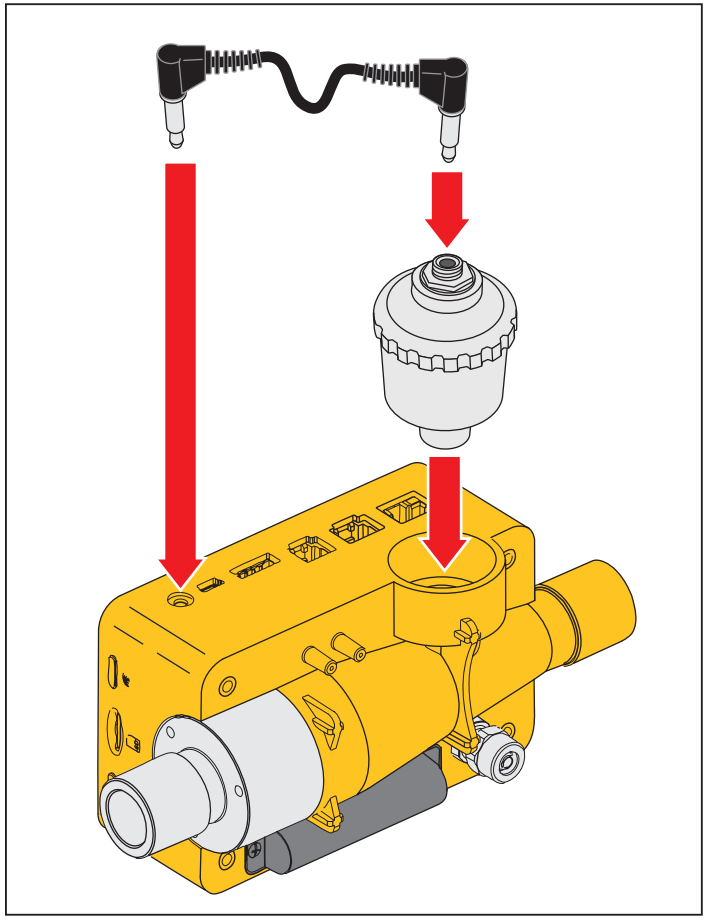
Figure 35. O_2 Calibration Successful Screen



gyo035.eps

Figure 36. Protective Cap Removal

Turn the O_2 sensor clockwise to attach it to the Product. Use the sensor cable to connect it to the Product. See Figure 37.



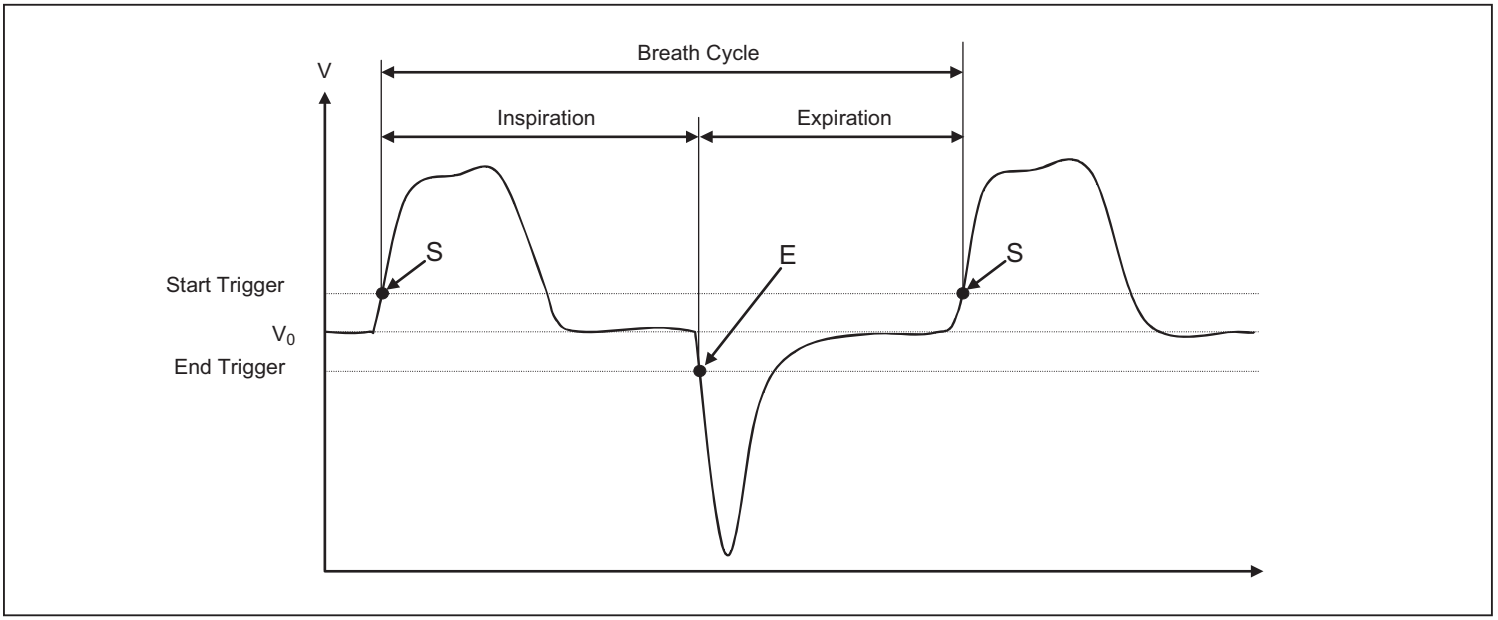
gyo036.eps

Figure 37. O_2 Sensor Installation

Measure Respiratory Data

General

To measure key respiratory data, the Product must read out a breath cycle from the measured pressure and/or flow chart curves. This is controlled through the triggers shown in Figure 38.



gyo037.eps

Figure 38. Breath Cycle

It is very important to set the start and stop triggers correctly. These triggers significantly influence the measurement results because they trigger the breath cycles. Make sure these triggers are set correctly before you start respiratory data measurement.

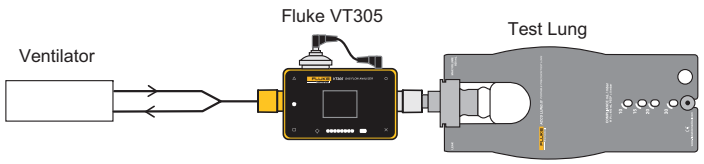
Note

The start trigger is interpreted as the start of the inspiration phase. The stop trigger is interpreted as the end of the inspiration phase and the start of the expiration phase. The expiration continues until the subsequent start trigger.

Connection to the Respiratory Apparatus

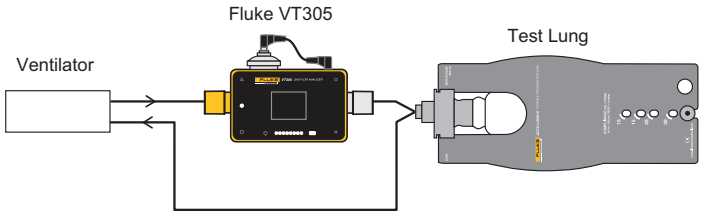
There are three different methods to connect the Product to the respiratory apparatus:

- Downstream of the Y-piece



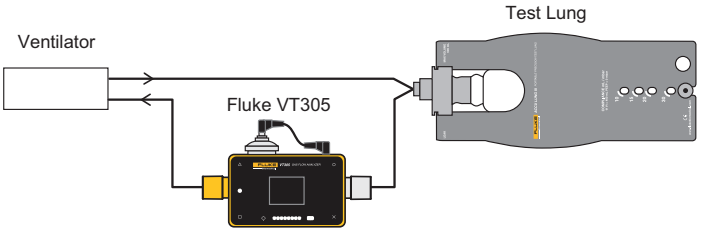
gyo038.eps

- In the inspiration duct upstream of the Y-piece



gyo039.eps

- In the expiration duct upstream of the Y-piece



gyo040.eps

Standard Trigger Values

Because the Product can measure flow in each direction, it makes sense to use the first connection method. In this measurement setup, flow is usually chosen as the trigger value. Flow triggers are stored as standard values in the device and can be reset when necessary. The standard trigger values for the flow trigger for adult breathing, for example, are:

Starttrigger: Flow > 3 l/min

Endtrigger: Flow < -3 l/min

With the second and third connection methods, pressure is usually chosen as the trigger signal. In this case the standard values are as follows:

Starttrigger: Pressure > 1 mbar

Endtrigger: Pressure < 1 mbar

Baseflow

The base flow is the constant flow that must be ignored when you calculate volume. If there is an identified leakage in the system, like a constant discharge of 3 l/min

of air, the 3 l/min is not counted as inspiration volume. When you type in:

Base flow: on 3.0 l/min

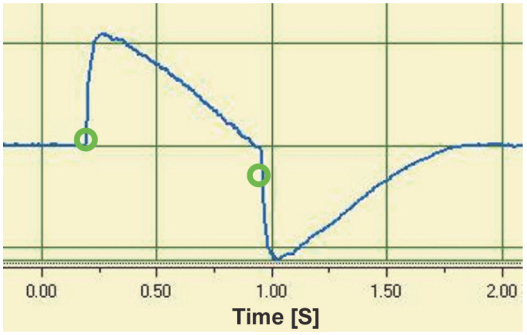
the volume calculation in our example could be corrected. Type the base flow parameter value in the configurator base flow section.

Find the Correct Trigger Setting

When you set a trigger for the first time, it is important to know the curve of the signal for the trigger (flow or pressure). Here are some examples that also show possible problems.

Flow Curve Downstream of the Y-Piece

Figure 39 is an example of a flow curve downstream of the Y-piece. The standard triggers (> 3 l/min/< –3 l/min) can be used without a problem.



gyo041.jpg

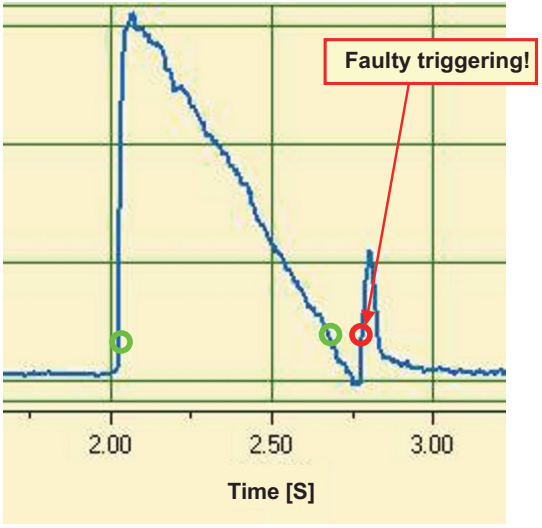
Figure 39. Downstream Flow Curve

Note

In such situations it is important to keep in mind that the trigger is significantly higher than the noise of the base line. Incorrect triggers can be released.

Flow Curve Upstream of the Y-Piece

The curve in Figure 40 shows the flow curve in the inspiration duct upstream of the Y-piece. The first two circles show the triggers that must be used here. The top figure shows a small incorrect signal at the measurement point after the inspiration. This is caused by switching the valves. This results in faulty triggering.



gyo042.eps

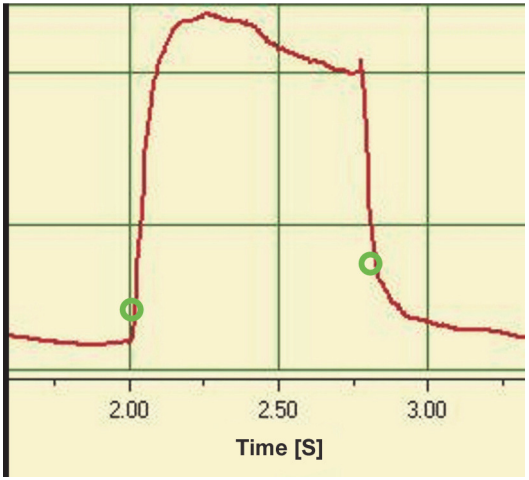
Figure 40. Inspiration Duct Upstream Curve

Note

Flow cannot be used here as a trigger. The pressure curve must be used.

Pressure Curve Upstream of the Y-Piece

For the pressure curve shown in Figure 41, the standard triggers can be used: (> 1 mbar / < 1 mbar).



gyo043.jpg

Figure 41. Upstream Pressure Curve

Note

The trigger is significantly higher than the noise of the base line. If not, the trigger value must be increased.

Special Cases

In measurement technology there can always be a deviation from the standard variants to get a more accurate result. You can get very accurate results with the settings shown in this manual, which is better than the accuracy of all respiratory equipment.

Measurement errors inherent in the overall system occur in the respiratory apparatus and in the Product. The values shown in the display can be different because not the same thing was measured and compared.

Inspiration Volume Vti

If the breath curve shows a plateau or a break, a tiny flow can be measured during this time. A lot of breathing equipment does not include these tiny flows when they calculate Vti. You can match this behavior in the Product when you use the trigger values that follow:

In Figure 42, S shows the start trigger and E the end trigger.

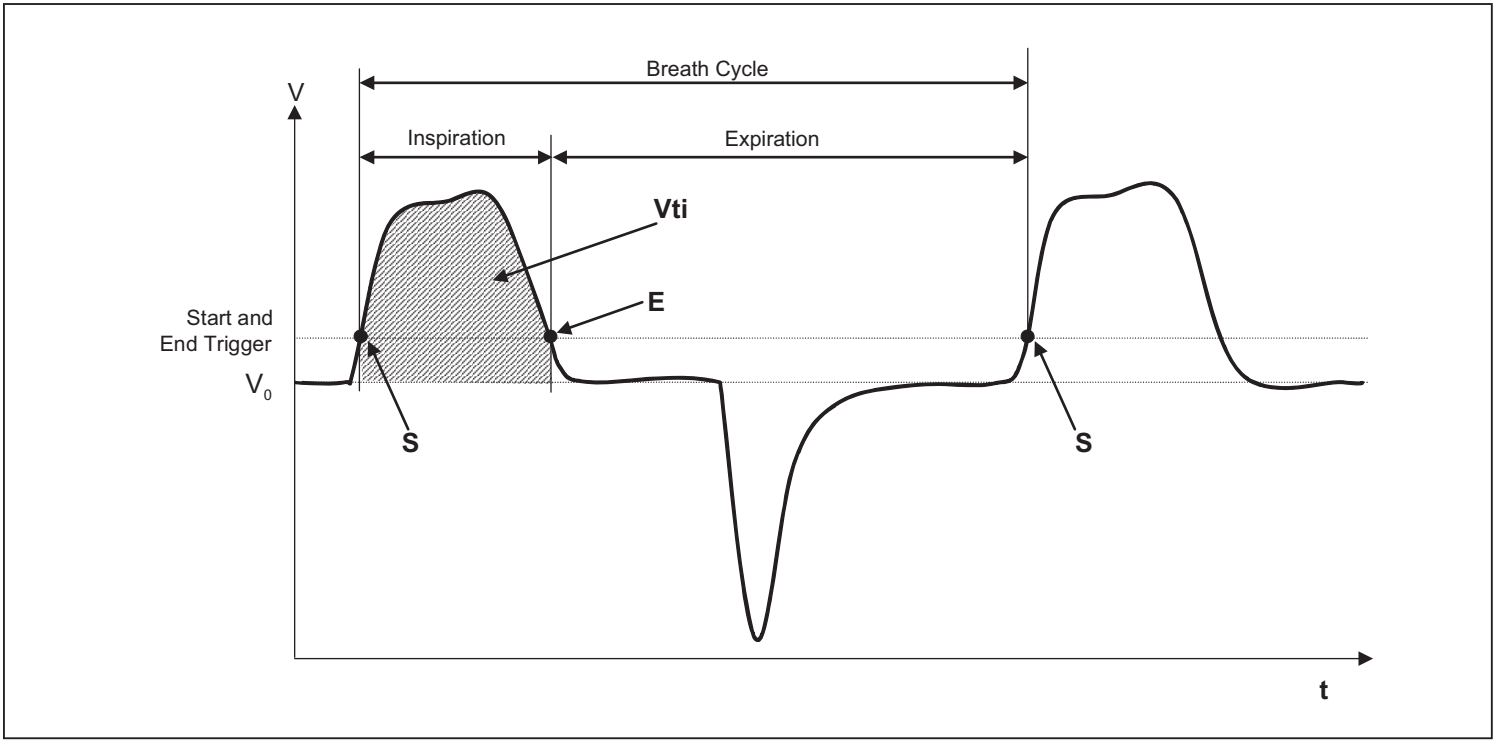


Figure 42. Inspiration Volume

Expiration Volume Vte

Figure 43 shows the optimal trigger values to measure Vte.

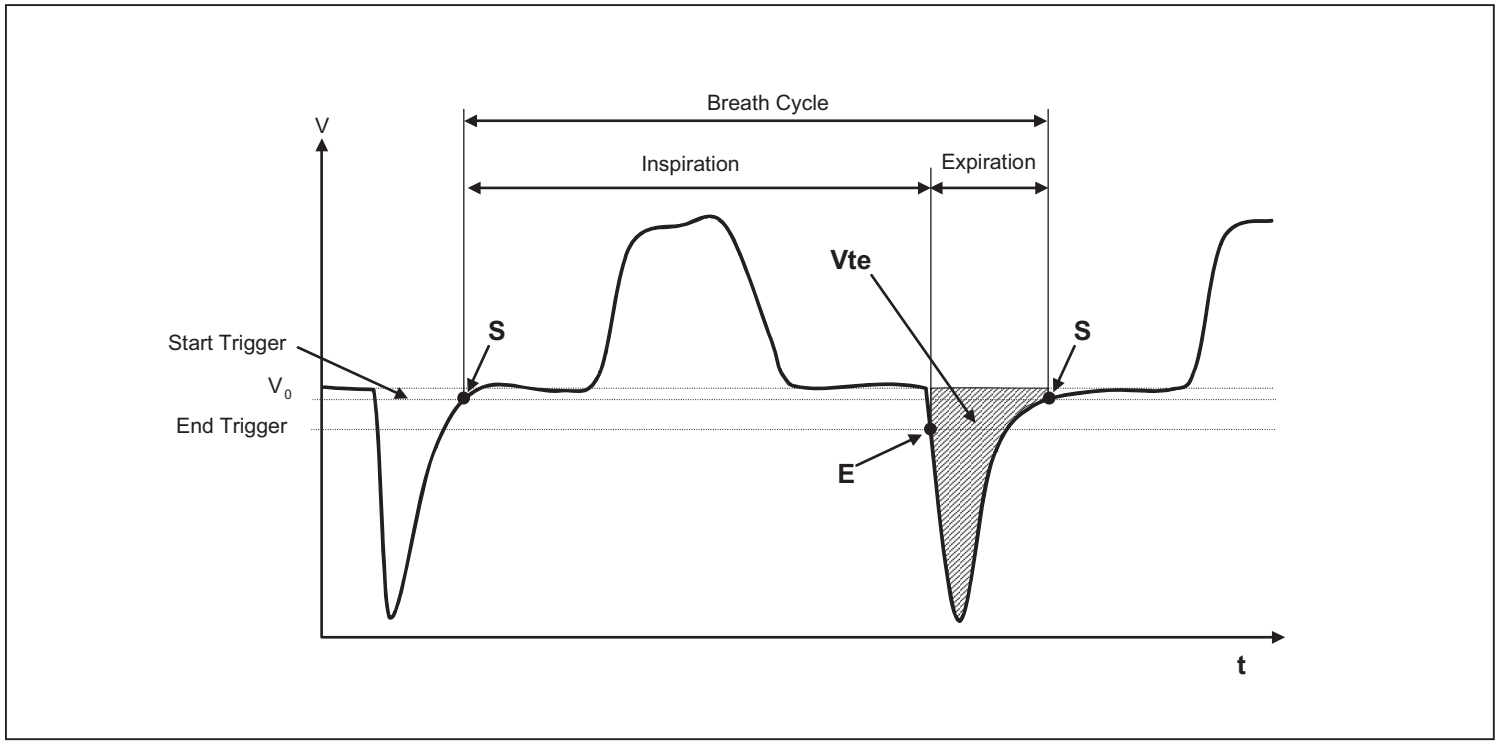


Figure 43. Expiration Volume

The start trigger must be set to S and the end trigger to E.

Care and Maintenance

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury:

- **Batteries contain hazardous chemicals that can cause burns or explode. If exposure to chemicals occurs, clean with water and get medical aid.**
- **Do not disassemble the battery.**
- **Do not disassemble or crush battery cells and battery packs.**
- **Do not put battery cells and battery packs near heat or fire. Do not put in sunlight.**
- **Do not operate the Product with covers removed or the case open. Hazardous voltage exposure is possible.**
- **Use only specified replacement parts.**
- **Have an approved technician repair the Product.**

For safe operation and maintenance of the product:

- **Repair the Product before use if the battery leaks.**
- **Do not short the battery terminals together.**
- **Keep cells and battery packs clean and dry. Clean dirty connectors with a dry, clean cloth.**
- **Do not keep cells or batteries in a container where the terminals can be shorted.**

Guidelines for Care and Maintenance

For safe and reliable operation of the Product, follow these maintenance guidelines. Use only components recommended by the manufacturer.

Note

You must use the guidelines and maintenance instructions supplied by the manufacturer.

Preventive Cleaning and Maintenance

Note

The maintenance tasks shown below must only be done by personnel that know the Product. All other repairs must be done by approved personnel.

To keep the Product accurate and reliable in the long term, follow the maintenance tasks in Table 6 on a regular basis:

Table 6. Maintenance Tasks

Interval	Task
While in operation	Use the supplied filter.
4 weeks	Examine the filter for contamination. To do this, connect the filter inlet and outlet to the differential pressure connection with two T-pieces. Measure the pressure loss across the filter with this connection. The pressure loss for a flow of 60 l/min cannot be more than 2 mbar. If the pressure is more than 2 mbar, the filter must be replaced.
12 Months	Factory calibration to make sure the Product gives reliable measurements.

Accessories and Spare Parts

Ordering Address

Fluke Biomedical
6045 Cochran Rd.
Cleveland, OH 44139
USA

Telephone: +1 440-248-9300
Toll-free: (800) 850-4608
Fax: +1 440-349-2307
E-Mail: sales@flukebiomedical.com

Or

Fluke Biomedical Europe
Science Park Eindhoven 5110
5692EC Son
The Netherlands

Telephone: +31 40 267 5436
Fax: +31 40 267 5436
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Table 7. Standard Accessories

Item	Part No.
O2 SENSOR ASSEMBLY	4281611
ACCULUNG II PORTABLE PRECISION TEST LUNG	4281291
PROTECTION FILTER	4294528
ADAPTER SET	4294537
O2 SNR CABLE	4296104
O2 HIGH PRESSURE ADAPTER	4294543
PWR ADAPTER SET	4308219
SD CARD 2GB	4296162
INLET PIPE	4296170
CARRY CASE	4296181

Table 8. Optional Accessories

Item	Part No.
AIR HIGH PRESSURE ADAPTER	4294555
ANSUR VT PLUG-IN LICENSE	4296065

For more accessories and spare parts, go to www.FlukeBiomedical.com

Disposal

The manufacturer is responsible for disposal of this Product. The device must be shipped (free and with duty paid) to the manufacturer for disposal.

- A licensed private or public collection company can take this Product for disposal.
- The Product can be disassembled into individual components and then recycled or discarded in the correct manner.
- If disposal is done by the manufacturer, the regulations for disposal are contingent on the country and are subject to its laws and legal requirements. You can get the applicable rules and regulations from the responsible authority.

In this regard, the Product is to be recycled or discarded:

- Without effect on human health.
- Without the use of procedures or methods that cause damage to the environment (water, air, soil, flora, and fauna).

Specifications

Display ..... 26 mm x 33 mm
Real time curves ..... Flow, Pressure, Volume, temperature of gas inside the measurement chamber, oxygen, respiratory parameters
Interfaces ..... RS-232, USB, Ethernet, CAN, Analog Out, TTL
Temperature (gas in measurement chamber)
Operating ..... 15 °C to 40 °C (59 °F to 104 °F)
Storage ..... -10 °C to 60 °C
Relative humidity
Operating ..... 10 % to 90 % RH
Storage/Transportation ..... 5 % to 95 % RH
Ambient pressure ..... 500 mbar to 1150 mbar
Power
AC adapter
Voltage input ..... 100 V ac to 240 V ac, 50 Hz to 60 Hz
Supply voltage ..... 5 V dc
Power consumption ..... 2.5 W to 6 W
Battery
Battery life ..... 4 hours. Operation time will be reached in standalone operation (without use of interfaces)
Recharge time ..... 5 to 8 hours (varies with port used)
Dimensions (W x L x H) ..... 16.5 cm x 10.8 cm x 6.4 cm (6.5 in x 4.25 in x2.5 in)
Weight ..... 0.4 kg
Safety ..... IEC 61010-1: Pollution Degree 2
Electromagnetic Environment ..... IEC 61326-1: Portable
Calibration interval ..... annually
Memory Card ..... yes
Data Interfaces
Analog port
Analog Output 1 ..... 0 Vdc to 5 Vdc ±1.8 %, load ≥5 kΩ
Analog Output 2 ..... 0 Vdc to 5 Vdc ±1.8 %, load ≥5 kΩ

- Trigger Input ..... 5 Vdc to 24 Vdc
- VIN ..... 9 Vdc to 29 Vdc
- RS-232 Port
- Baud Rate ..... 19200, 8 bits, no Parity, 1 stop bit

Measurement Variables

- Air and N2
  - Flow Measurements
    - Range ..... ±300 sl/min
    - Accuracy ..... ±1.9 %* or ±0.1 l/min
  - Ambient pressure compensated ..... yes
  - Temperature compensated ..... yes
- O2/Air Mixtures
  - Flow Measurements
    - Range ..... ±300 sl/min
    - Accuracy ..... ±1.9 %* or ±0.1 l/min
  - Ambient pressure compensated ..... yes
  - Temperature compensated ..... yes
- CO2
  - Flow Measurements
    - Range ..... ±140 sl/min
    - Accuracy ..... ±3.0 %* or ±0.1 l/min
  - Ambient pressure compensation accuracy ..... 25 °C to 30 °C
  - Temperature compensated ..... yes
  - Channel pressure compensation accuracy .... -50 to +600 mbar
- Heliox (21 % O2/ 79 % He)
  - Flow Measurements
    - Range ..... ±300 sl/min
    - Accuracy ..... ±4.0 %* or ±0.3 l/min
  - Ambient pressure compensation accuracy ..... 25 °C to 30 °C
  - Temperature compensated ..... yes

N2O/O2 Mixtures
- Flow Measurements
  - Range ..... ±80 sl/min
  - Accuracy ..... ±4.0 %* or ±0.3 l/min
- Ambient pressure compensation accuracy..... 25 °C to 30 °C
- Temperature compensated ..... yes

Pressure
- High
  - Range ..... 0 to 10 bar
  - Accuracy ..... ±1 %* or ±10 mbar**
- Difference
  - Range ..... ±200 mbar
  - Accuracy ..... ±0.75 %* or ±0.1 mbar
- In the flow channel
  - Range ..... -50 to 150 mbar
  - Accuracy ..... ±0.75 %* or ±0.1 mbar
- Barometer
  - Range ..... 500 to 1150 mbar
  - Accuracy ..... ±1.0 %* or ±5.0 mbar

Variables
- Flow ..... l/min, l/s, cfm, ml/min, ml/s
- Pressure ..... bar, mbar, cmH_2O, inH_2O, Torr, inHg, hPa, kPa, mmHg, PSI
- Oxygen concentration (pressure compensated ≤150 mbar)
  - Range ..... 0 % to 100 %
  - Accuracy ..... ±1 % O_2**
- Gas Temperature
  - Range ..... 0 °C to 50 °C
  - Accuracy ..... ±1.75 %* or ±0.5 °C
- Type of gas ..... Air, Air/O_2, N_2O/O_2, Heliox (21 % O_2), He/O_2, N_2, CO_2
- Gas Standard ..... ATP, ATPD, ATPS, AP21, STP, STPH, BTPS, BTPD, 0/1013, 20/981, 15/1013, 25/991, 20/1013

Respiratory Parameters

- Breathing Rate (BR/min)
  - Range ..... 1 bpm to 1000 bpm
  - Accuracy ..... ±1 bpm or ±2.5 % **
- Time (Ti, Te)
  - Range ..... 0.05 s to 60 s
  - Accuracy ..... ±0.02 s
- Ratio (I:E)
  - Range ..... 1:300 to 300:1
  - Accuracy ..... ±2.5 %*
- Ratio (Ti/Tcyc)
  - Range ..... 0 % to 100 %
  - Accuracy ..... ±5 %*
- Breathing Volume (Vti, Vte)
  - Range ..... ±10 l
  - Accuracy ..... ±2 %* or ±20 ml
- Volume per minute (Vi, Ve)
  - Range ..... 0 l/min to 300 l/min
  - Accuracy ..... ±2.5 %*
- Peakflow
  - Range ..... ±300 l/min
  - Accuracy ..... ±1.9 %* or ±0.1 l/min
- Pressure (Ppeak, Pmean, PEEP, Pplateau)
  - Range ..... 0 mbar to 150 mbar
  - Accuracy ..... ±0.75 %* or ±0.1 l/min
- Compliance (Cstat)
  - Range ..... 0 ml/mbar to 1000 ml/mbar
  - Accuracy ..... ±3 %* or ±1 ml/mbar
- Trigger Range (Adult, Pediatric, HFO) ..... Flow and volume (from default settings and adjustable levels) the greater tolerance is valid

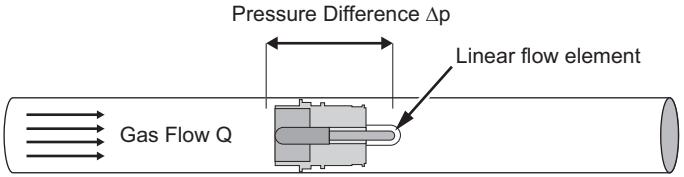
* Tolerance related to the measured value.

** Absolute tolerance.

*** sl/min is based on ambient conditions of 0° C and 1013 mbar (DIN 1343)

Operation Principle of Flow Measurement

A differential pressure measurement is used to find the flow in the flow channel. To make the pressure difference, a linear flow element is used as a flow resistance. See Figure 44.



$$\Delta p = c_1 \cdot \eta \cdot Q + c_2 \cdot \rho \cdot Q^2$$

gyo046.eps

Figure 44. Linear Flow Element

η: dynamic viscosity of the gas (Pa s)

p: Gas density (kg/m^3)

c1, c2: device-specific constants (channel geometry)

Dynamic viscosity

- The viscosity of a medium, is its resistance to flow and tear off of the flow.
- The viscosity is strongly contingent on the temperature.
- The viscosity of the medium is slightly dependent on pressure and humidity of the medium.

Density

- Density is the unit of mass per unit volume of the medium.
- Density is strongly contingent on the pressure and temperature.

The influence of environmental conditions is the reason why the flow is occasionally transformed to standard conditions.

Gas Standard

Gas Standard	Temperature	Pressure
Ambient Temperature and Pressure (ATP)	Current Gas temperature	Current ambient pressure
Ambient Temperature and Pressure Dry (ATPD)	Current Gas temperature	Current ambient pressure
Ambient Temperature and Pressure Saturated (ATPS)	Current Gas temperature	Current ambient pressure
Ambient pressure at 21 °C	21.0 °C (70 °F)	Current ambient pressure
Standard Conditions USA (STP)	21.0 °C (70 °F)	1013.25 mbar (760 mmHg)
Standard Conditions USA Humid (STPH)	21.0 °C (70 °F)	1013.25 mbar (760 mmHg)
Body Temperature and Pressure Saturated (BTPS)	37 °C (99 °F)	Current ambient pressure
Body Temperature and Pressure Dry (BTPD)	37 °C (99 °F)	Current ambient pressure
Standard Conditions DIN1343 (0/1013)	0 °C (32 °F)	1013.25 mbar (760 mmHg)
Standard Conditions ISO 1-1975 (DIN 102 (20/981))	20 °C (68 °F)	981 mbar (736 mmHg)
API Standard Conditions (15/1013)	15 °C (60 °F)	1013.25 mbar (14.7 psia)
Cummings Standard (25/991)	25 °C (77 °F)	991 mbar (500ft Höhe)
20 °C / 1013 mbar (20/1013)	20 °C (68 °F)	1013.25 mbar (760 mmHg)

Abbreviations and Glossary

A	
A	Amp
AC	Alternating current
AT	Amp time-lag
B	
bar	1 bar = 14.50 psi
Base flow	The base flow is a constant flow which should not be considered for the calculation of the volume.
C	
°C	Degrees Celsius Conversion of Celsius (C) to Fahrenheit (F): F = 9*C/5 + 32
Cstat	Statistical compliance
D	
DAC	Direct access control
dBA	Decibel measured with A-filter
DC	Direct current
DIN	Deutsche Industrienorm (German Industry Standard)
E	
EMC	Electro-magnetic compliance

F	
°F	Degrees Fahrenheit Conversion of Fahrenheit (F) to Celsius (C): C = (F–32)*5/9
G	
GND	Ground
H	
H	Hour
HF	High Frequency
Hz	Hertz (1 Hz = 1 s – 1)
I	
I:E	Breathing-time ratio: inspiration to expiration
IP	Protection class according to standard
L	
l	Liter
lb, lbs	Pound
LED	Light emitting diode
l/s	Liter per second

M	
Max., max.	Maximal
mbar	Millibar (1 mbar = 10^{-3} bar)
min	Minute
Min., min.	Minimal
ml	Milliliter (1 ml = 10^{-3} l)
mm	Millimeter (1 mm = 10^{-3} m)
P	
PEEP	Positive End Expiratory Pressure
PF Exp.	Peak flow during expiration
PF Insp.	Peak flow during inspiration
Pmean	Mean pressure
Ppeak	Peak pressure
Pplateau	Plateau pressure at the end of inspiration
ppm	Parts per million ($1*10^{-6}$)
prox.	Proximal
psi	Pounds per square inch (1 bar = 14.50 psi)
R	
rdg.	reading (from the measured value)
RH	Relative humidity
RJ-10 FCC	Plug for external trigger (telephone plug according to FCC registration, U.S. Federal Communications Commission; RJ = Registered Jack)
RS-232	Serial interface

S	
sl/min	Standard liter per minute (converted to ambient conditions of 0°C and 1013 mbar)
T	
Ti/TCycle	Ratio: inspiration time to time of one breathing cycle
V	
V	Volt
VA	Apparent power consumption of the device
VAC	Volt alternating current
VDC	Volt direct current
µm	Micrometer (1 µm = 10^{-6} m)

Measured Values and Units

Table 9 is a list of measured values with their unit of measure.

Table 9. Measured Values and Units

Type	Measured Value	Description	Units
Pressure	Airway Pressure	Pressure in the flow channel, also called Paw (pressure airway)	mbar, bar, inH_2O, cmH_2O, psi, Torr, inHg, mmHg, hPa, kPa
	High Pressure	P High	
	Pressure Difference	P Diff	
Flow	Flow	Flow	l/min, ml/min, d/min, l/s, ml/s
Meteorological	Chamber Gas Temperature	Temp.	°C, K, °F
	Oxygen Content	O_2	%
	Volume	Vol.	ml, l, cf
Gas Concentration	Gas Concentration	Gas Concentration	%
	Partial Pressure	Partial Pressure	mbar, bar, inH_2O, cmH_2O, psi, Torr, inHg, mmHg, hPa, kPa

Table 9. Measured Values and Unit (cont.)

Type	Measured Value	Description	Units
Breathing	Positive End Expiratory Pressure	PEEP	mbar, bar, inH_2O, cmH_2O, psi, Torr, inHg, mmHg, hPa, kPa
	Mean pressure	Pmean	
	Peak pressure	Ppeak	
	Plateau pressure	Pplateau	
	Volume per min: expiration	Ve	l/min, ml/min, d/min, l/s, ml/s
	Volume per min: inspiration	Vi	
	Peak flow inspiration	PF Insp	
	Peak flow expiration	PF Exp	
	Expiration volume	Vte	ml, l, cf
	Inspiration volume	Vti	
	Breathing rate	Rate	bpm
	Breathing-time ratio	I:E	-
	Expiration time	Te	s
	Inspiration time	Ti	
	Compliance	Cstat	ml/bar, ml/mbar, ml/cmH_2O, ml/H_2O

Conversion Factors

Table 10 is a list of conversion factors.

Table 10. Conversion Factors

Units	Equivalent
1 mbar	0.001 bar 100 Pa 1 hPa 0.1 kPa 0.75006 Torr (760 Torr = 1 atm) 0.75006 mmHg (at 0°C) 0.02953 inHg (at 0°C) 1.0197 cmH_2O (at 0°C) 0.4015 inH_2O (at 0°C) 0.0145 psi, psia
1 bar	1000 mbar 100,000 Pa 1000 hPa 100 kPa 750.06 Torr (760 Torr = 1 atm) 750.06 mmHg (at 0°C) 29.53 inHg (at 0°C) 1019.7 cmH_2O (at 0°C) 401.5 inH_2O (at 0°C) 14.50 psi, psia