

Agilent Technologies, Inc.

Flow Tracker Series



Gas Chromatography Flow Meters



Agilent Technologies
Innovating the HP Way

Agilent Technologies Flow Tracker Series Gas Chromatography Flow Meters

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Introduction

The Flow Tracker 1000 Series Gas Chromatography Flow Meter is designed to provide a multitude of useful flow data in one simple, reliable, and portable instrument. Power is provided by six (6) standard AA size batteries or via an optional AC/DC adapter. The full scale flow range for the meter is 0-500 ml/min.

The Flow Tracker 1000 has two operating modes, Flow Mode and GC (Gas Chromatography) Mode. The Flow Tracker 2000 has an additional Leak Detector Mode and incorporates a separate, built in sampling pump and probe.

The Flow Tracker data presentation format uses a multi-line LCD display that allows simultaneous viewing of all parameters associated with the current operating mode. Selected parameters can be brought to the enlarged "Primary Data" position to simplify viewing of the parameter in which the user is most interested at any given time.

The Flow Tracker RS-232 output allows data from the current operating mode to be streamed in real time to a laptop computer for collection or analysis without specialized software.

For Indoor Use Only. This product should not be used in Hazardous Locations. Operating temperature range is 10-50 °C, operating humidity range is 0-90% RH (non-condensing), and maximum recommended altitude is 15,000 ft. This product is rated as Safety Class II, Installation category II, and Pollution Degree 2. If this equipment is used in a manner not specified, the protection of the equipment may be impaired. Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.

NOTE: This device has been tested and found to comply with the limits of CISPR 11. These limits are designed to provide reasonable protection against harmful interference in an installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Unauthorized modification or installation of this equipment may invalidate the user's ability to operate this equipment.

This ISM device complies with Canadian ICES-001.
Cet appareil ISM est conforme à la norme NMB-001 du Canada.

This device is CE marked for ISM Group 1, Class A equipment.

Flow Measurement Operating Principle

The volumetric flow rate is determined by creating a pressure drop across a unique internal restriction, known as a Laminar Flow Element, and measuring differential pressure across it. The restriction is designed so that the gas molecules are forced to move in parallel paths along the entire length of the passage; hence Laminar (streamline) flow is established for the entire range of operation of the device.

Unlike other flow measuring devices, in laminar flow meters the relationship between pressure drop and flow is linear. The underlying principle of operation of the Flow Tracker Series flow meters is known as the Poiseuille Equation:

$$Q = (P_1 - P_2) \pi r^4 / 8 \eta L \quad (\text{Equation 1})$$

Where:

- Q = Volumetric Flow Rate
- P₁ = Static pressure at the inlet
- P₂ = Static pressure at the outlet
- r = Radius of the restriction
- η = (eta) absolute viscosity of the fluid
- L = Length of the restriction

Since π, r and L are constant; Equation 1 can be rewritten as:

$$Q = K (\Delta P / \eta) \quad (\text{Equation 2})$$

Where K is a constant factor determined by the geometry of the restriction.

Equation 2 shows the linear relationship between volumetric flow rate (Q) differential pressure (ΔP) and absolute viscosity (η) in a simpler form.

Installation

Connections: The Flow Tracker has standard 1/8" NPT(Female) inlet and outlet fittings as shown in Figure 1. To prevent possible clogging of the internal structure, it is recommended that a 20 micron filter be installed upstream of the meter. The unit is packaged with simple plastic hose barbs for your convenience, however it can be used with any fitting that is appropriate for the application. **Caution: When installing fittings into the NPT ports, do not exceed 12 ft-lbs of torque.** Avoid use of pipe dopes and sealants on the NPT ports as these compounds can cause permanent damage to the meter should they get into the flow stream. If a thread sealing tape is required, avoid wrapping the first thread or two to minimize the possibility of getting a piece of shredded tape into the flow stream. When changing fittings, always clean any tape out of the threads that may come loose and enter the flow stream.

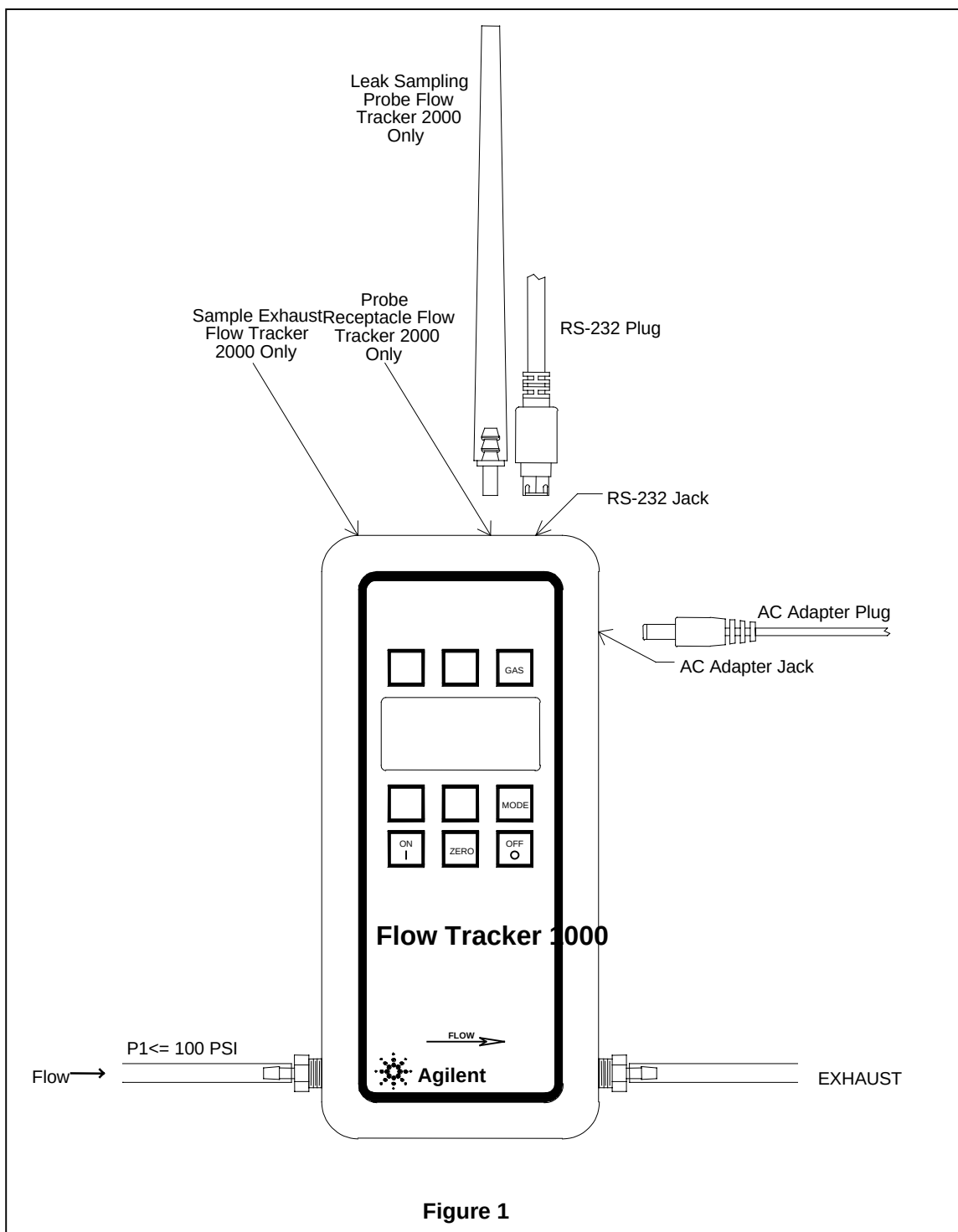
Maximum operating line pressure is 100 PSIG (690 kPa). **Caution: Exceeding the maximum specified line pressure may cause permanent damage to the solid-state differential pressure transducer.** If the line pressure is higher than the 100 PSIG (690 kPa), a pressure regulator must be used upstream from the flow meter to reduce the pressure to 100 PSIG (690 kPa) or less. Although the meter's operation is uni-directional, reversing the flow direction will inflict no damage as long as the maximum specified limits are not exceeded. The differential pressure sensor utilized in the Flow Tracker is a very sensitive device capable of detecting minute differences in pressure. Avoid installations (such as snap acting solenoid valves upstream) that apply instantaneous high pressure to the meter as permanent damage to the differential pressure sensor could result.

Power/Batteries: Power is supplied by six (6) standard AA size batteries or by an optional AC/DC adapter. New batteries can provide power for several days of continuous operation depending on the quality of the batteries and whether the leak-sampling pump in the 2000 is used. The power adapter jack is located as shown in **Figure 1**. A P-5 style, positive center, 6-15 Vdc adapter rated for at least 100 mA is required.

Note: The **auto-off** feature automatically shuts the flow meter off after approximately 5 minutes of continuous no flow (less than 4 ml/min) condition. This applies **ONLY** under battery power. The auto-off feature is disabled when power is supplied via an AC to DC adapter.

Replacing the Batteries:

1. Remove the flexible boot from the meter housing.
2. Remove all three screws from the back cover.
3. Carefully remove the back cover to expose batteries.
4. Carefully remove old batteries.
5. Install new batteries as shown in on the back cover.
6. Replace back cover and re-install screws.
7. Replace the flexible boot, pushing the bottom end of the meter into the boot first.



RS-232 Output Cable: The Flow Tracker is equipped with an 8 pin Mini-DIN data output jack located as shown in **Figure 1**. The included data cable plugs into this jack with the flat on the cable plug towards the back of the flow meter. If the serial port on your computer is female, the flow meter can simply be plugged into your serial port via

the 8 Pin Mini-DIN to DB-9 serial adapter cable included with the Flow Tracker. If the serial port on your computer is male, you will need a common double ended female adapter cable.

Basic Operation

General: Operating the Flow Tracker Series Flow Meters is quite intuitive and will require only a minimum of effort to learn. The 1000 Series has two operating modes and the 2000 Series has three operating modes. These operating modes are explored in considerable detail in the section labeled “Operating Modes”. Generally speaking, each operating mode displays all of the parameters that are associated with that mode of operation. Each parameter has a button associated with it. Each parameter is either labeled with a “dynamic label” on the display, or if it is a global parameter, meaning that it is common to all modes, the button associated with it will be labeled. The two global parameters are the gas (GAS) and the operating mode (MODE).

Dynamically labeled parameters are either active or passive. Active parameters are directly affected by the flow and are constantly changing. Generally speaking active parameters can be moved to the primary display by pushing the button associated with the parameter. Passive parameters are generally variables that require input from the user. The button associated with passive parameters is generally used to select the value of the variable.

A quick overview of the operating modes and their parameters are as follows:

Flow Mode (default on power up):

Parameter	Label	Active or Passive	Button Action
Line Pressure	PSIA	Active	Primary Display
Gas Temp	°C	Active	Primary Display
Volumetric Flow	Vol	Active	Primary Display
Mass Flow	Mass	Active	Primary Display (default)
Gas	GAS	Passive	Toggles Thru Gas List
Operating Mode	MODE	Passive	Toggles Thru Modes

Gas Chromatography Mode:

Parameter	Label	Active or Passive	Button Action
Linear Velocity	LinVel	Active	Primary Display (default)
Capillary Inside Diameter	Dia. mm	Passive	Toggles Thru Column List
Split Ratio	Split	Active	Primary Display
Reference Flow	Ref.	Passive	Sets Ref. To Present Flow
Gas	GAS	Passive	Toggles Thru Gas List
Operating Mode	MODE	Passive	Toggles Thru Modes

Leak Mode (2000 Series Only):

Parameter	Label	Active or Passive	Button Action
Leak Rate	Rate	Active	Primary Display (default)
Thermal Conductivity	Cond.	Active	Primary Display
Relative Conductivity	Rel.	Active	Primary Display
Sound	Sound	Passive	Toggles Sound On or Off
Gas	GAS	Passive	Toggles Thru Gas List
Operating Mode	MODE	Passive	Toggles Thru Modes

Operating the Flow Tracker:

ON – To turn the unit on, press and hold the button labeled “ON” for approximately a half second. Two horizontal bars will appear momentarily before the flow mode screen appears on the display. Should the unit ever fail to come on as expected, push the “OFF” button and then press and hold the “ON” button.

ZERO – Pushing the button labeled “ZERO” tares the flow meter and provides it with a reference point for zero flow. *This is a very simple but important step in obtaining accurate measurements.* It is good practice to “zero” the flow meter each time it is turned on. If the flow reading varies significantly from zero after an initial tare, give the unit a minute or so to warm up and re-zero it. If possible, it is helpful to zero the unit near the expected operating pressure by positively blocking the flow downstream of the flow meter prior to pushing the “ZERO” button. Zeroing the unit while there is any flow will directly affect the accuracy by providing a false zero point. If in doubt about whether the flow is positively blocked, remove it from the line and positively block both ports before pressing the “ZERO” button. If the unit reads a significant negative value when removed from the line and blocked, it is a good indication that it was given a false zero. It is better to zero the unit at atmospheric pressure and a confirmed no flow conditions than to give it a false zero under line pressure.

GAS – Pushing the button labeled “GAS” scrolls through the gas list. The default gas is air. The selected gas is shown on the display under the “GAS” button. The selected gas is a global parameter that stays the same regardless of operating mode. Use this button to select the gas presently being measured. The viscosity of the selected gas is used in the calculation of flow. It is very important that the gas being measured is selected to get an accurate flow rate measurement. Selectable gases are:

Gas	Label
Air (default)	Air
Nitrogen	N2
Carbon Dioxide	CO2
Methane	CH4
Hydrogen	H2
95% Argon- 5% Methane Mix	95% Ar 5% CH4
Helium	He

MODE – Push the button labeled “MODE” to switch between operating modes. There are two operating modes (Flow and GC) in the 1000 Series Flow Meters and three operating modes (Flow, GC, and Leak) in the 2000 Series Flow Meters.

OFF – Push the button labeled “OFF” to turn the unit power off from any operating mode.

Features:

- | | |
|-------------------------|--|
| Auto Off - | The auto-off feature automatically shuts the flow meter off after approximately 5 minutes of continuous no flow (less than 4 ml/min) condition. This applies ONLY under battery power. The auto-off feature is disabled when power is supplied via an AC to DC adapter. |
| Low Battery Indicator - | This indicator is located on the lower right corner of the display just above the mode indicator and is displayed only if the batteries run below a certain voltage level that can affect the accuracy of the meter. <u>Caution: To avoid inaccurate readings, change the batteries when the LO BAT indicator is displayed!</u> Low power can result in inflated temperature sensor readings, which affects the expected gas viscosity and mass flow calculations. |
| RS-232 Output - | The Flow Tracker Series Flow Meters are equipped with a serial RS-232 output that toggles with the selected operating mode. All parameters in the selected mode are output in space-delimited format for data collection and analysis. No special software is required; any terminal program, such as HyperTerminal®, which comes packaged with all Microsoft Windows® operating systems is all that is required. |

Operating Modes

Flow Mode

The Flow Mode is the default operating mode. The flow mode screen shown in **Figure 2** displays the following parameters:

Gas Absolute Pressure: The Flow Tracker Series Flow Meters utilize an absolute pressure sensor to measure the line pressure of the gas flow being monitored. This sensor references hard vacuum and accurately reads line pressure both above and below local atmospheric pressure. This parameter is located in the upper left corner of the display under the dynamic label “PSIA”. The engineering unit associated with absolute pressure is pounds per square inch absolute (PSIA). This can be converted to gage pressure (psig = the reading obtained by a pressure gauge that reads zero at atmospheric pressure) by simply subtracting local atmospheric pressure from the absolute pressure reading:

$$\text{PSIG} = \text{PSIA} - (\text{Local Atmospheric Pressure})$$

The flow meters use the absolute pressure of the gas in the calculation of the mass flow rate. For working in metric units, note that 1 PSI = 6.89 kPa.

Gas Temperature: The Flow Tracker Series Flow Meters also utilize a temperature sensor to measure the line temperature of the gas flow being monitored. The temperature is displayed in engineering units of degrees Celsius (°C). The flow meters use the temperature of the gas in the calculation of the mass flow rate. This parameter is located in the upper middle portion of the display under the dynamic label “°C”.

Volumetric Flow Rate: The volumetric flow rate is determined as described in the Flow Measurement Operating Principle above. The engineering unit associated with the volumetric flow rate is milliliters per minute (mL/min). This parameter is located in the lower left corner of the display over the dynamic label “Vol”. In order to get an accurate volumetric flow rate, the gas being measured must be selected (see Gas Select below). This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities.

Gas viscosity, and thus gas composition, can be very important to the accuracy of the meter. Anything that has an effect on the gas viscosity (e.g. water vapor, odorant additives, etc.) will have a direct proportional effect on the accuracy. Selecting methane and measuring natural gas for instance, will result in a fairly decent reading, but it is not highly accurate because natural gas contains small and varying amounts of other gases

such as butane and propane that result in a viscosity that is somewhat different than pure methane.

Absolute viscosity changes very little with pressure therefore a true volumetric reading does not require a correction for pressure. Changes in gas temperature do affect viscosity. For this reason, the Flow Tracker utilizes the temperature sensor to internally compensate for this change and no outside temperature correction is required for volumetric measurement.

Other Gases: Flow Tracker Series Flow Meters can easily be used to measure the flow rate of gases other than those listed as long as “non-corrosive” gas compatibility is observed. For example, a flow meter that has been set for air can be used to measure the flow of oxygen.

The conversion factor needed for measuring the flow of different gases is linear and is simply determined by the ratio of the absolute viscosity of the gases. This factor can be calculated as follows:

$$Q_{og} = Q_1 [\eta_1/\eta_{og}]$$

Where:

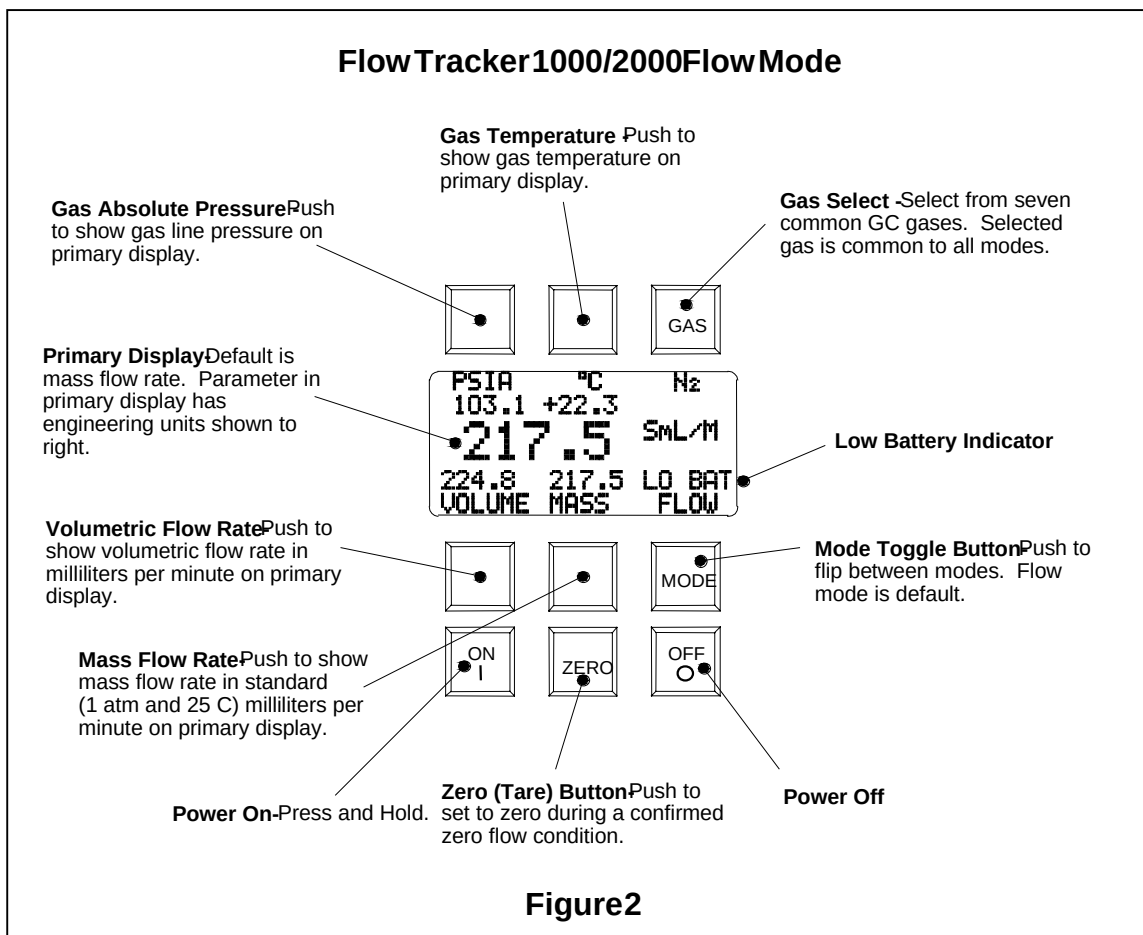
- Q_1 = Flow rate indicated by the flow meter
- η_1 = Viscosity of the calibrated gas at the measured temp.
- Q_{og} = Flow rate of the alternate gas
- η_{og} = Viscosity of the alternate gas at the measured temp.

A good rule of thumb is “at a given flow rate, the higher the viscosity, the higher the indicated flow”

Mass Flow Rate: The mass flow rate is the volumetric flow rate corrected to a standard temperature and pressure (14.695 psia and 25°C). This parameter is located in the lower middle portion of the display over the dynamic label “Mass”. The engineering unit associated with the mass flow rate is called a standard milliliter per minute (SmL/min). The meter uses the measured temperature and the measured absolute pressure to calculate what the flow rate would be if the gas pressure was a 1 atmosphere and the gas temperature was 25°C. This allows a solid reference point for comparing one flow to another.

Volume Flow vs. Mass Flow: At room temperature and low pressures the volumetric and mass flow rate will be nearly identical, however, these rates can vary drastically with changes in temperature and/or pressure because temperature and pressure of the gas directly affects the volume. For example, assume a volumetric flow reading was used to fill balloons with 250 mL of helium, but the incoming line ran near a furnace that cycled on and off, intermittently heating the incoming helium. Because the volumetric meter simply measures the volume of gas flow, all of the balloons would initially be the same

size. However, if all the balloons are placed in a room and allowed to come to an equilibrium temperature, they would generally all come out to be different sizes. If, on the other hand, a mass flow reading were used to fill the balloons with 250 standard mL of helium, the resulting balloons would initially be different sizes, but when allowed to come to an equilibrium temperature, they would all turn out to be the same size.



This parameter is called corrected mass flow because the resulting reading has been compensated for temperature and pressure and can therefore be tied to the mass of the gas. Without knowing the temperature and pressure of the gas and thus the density, the mass of the gas cannot be determined.

Volumetric and Mass Flow Conversion: In order to convert volume to mass, the density of the gas must be known. The relationship between volume and mass is as follows:

$$\text{Mass} = \text{Volume} \times \text{Density}$$

The density of the gas changes with temperature and pressure and therefore the conversion of volumetric flow rate to mass flow rate requires knowledge of density change. Using ideal gas laws, the effect of temperature on density is:

$$\rho_a / \rho_s = T_s / T_a$$

Where:

- ρ_a = density @ ambient condition
- T_a = absolute temp @ ambient condition in °Kelvin
- ρ_s = density @ standard (reference) condition
- T_s = absolute temp @ standard (reference) condition in °Kelvin
- °K = °C + 273.15 Note: °K=°Kelvin

The change in density with pressure can also be described as:

$$\rho_a / \rho_s = P_a / P_s$$

Where:

- ρ_a = density @ ambient condition
- P_a = ambient absolute pressure
- ρ_s = density @ standard (reference) condition
- P_s = Absolute pressure @ standard (reference) condition

Therefore, in order to determine mass flow rate, two correction factors must be applied to volumetric rate: temperature effect on density and pressure effect on density.

Although the correct units for mass are expressed in grams, kilograms, etc. it has become standard that mass flow rate is specified in SLPM (standard liters / minute), SCCM (standard cubic centimeters / minute) or SmL/M (standard milliliters / minute).

This means that mass flow rate is calculated by normalizing the volumetric flow rate to some standard temperature and pressure (STP). By knowing the density at that STP, one can determine the mass flow rate in grams per minute, kilograms per hour, etc.

STP is usually specified as the sea level conditions, however, no single standard exists for this convention. Examples of common reference conditions include:

0°C	and	14.695 PSIA
25°C	and	14.695 PSIA
0°C	and	760 torr (mmHG)
70°F	and	14.695 PSIA
68°F	and	29.92 inHG
20°C	and	760 torr (mmHG)

Flow Tracker Series Flow Meters reference 25°C and 14.695 PSIA (101.32 kPa).

Gas Select: The selected gas is shown in the upper right hand corner of the display. There are seven different gases commonly used for gas chromatography that can be selected. The gas can be changed by pushing the button labeled “GAS” until the desired gas is displayed. The selected gas is common to all operating modes and can be changed at any time in any operating mode. The gases are:

- | | |
|--------------------------------------|--------------------------------|
| 1. Air | Air |
| 2. N₂ | Nitrogen |
| 3. CO₂ | Carbon Dioxide |
| 4. CH₄ | Methane |
| 5. H₂ | Hydrogen |
| 6. 95% Ar – 5% CH₄ | 95% Argon – 5% Methane Mixture |
| 7. He | Helium |

LO BAT: This indicator is located on the lower right corner of the display just above the mode indicator and is displayed only if the batteries run below a certain voltage level that can affect the accuracy of the meter. Caution: To avoid inaccurate readings, change the batteries when the LO BAT indicator is displayed! Low power can result in inflated temperature sensor readings, which affects the expected gas viscosity and mass flow calculations.

FLOW mode indicator: This indicator is located in the lower right corner of the display and simply indicates that the unit is in the “Flow” mode. The operating mode can be changed by pushing the button labeled “MODE”. Available operating modes are Flow and GC (Gas Chromatography) in the Flow Tracker 1000, and Flow, GC, and Leak in the Flow Tracker 2000.

GC (Gas Chromatography) Mode

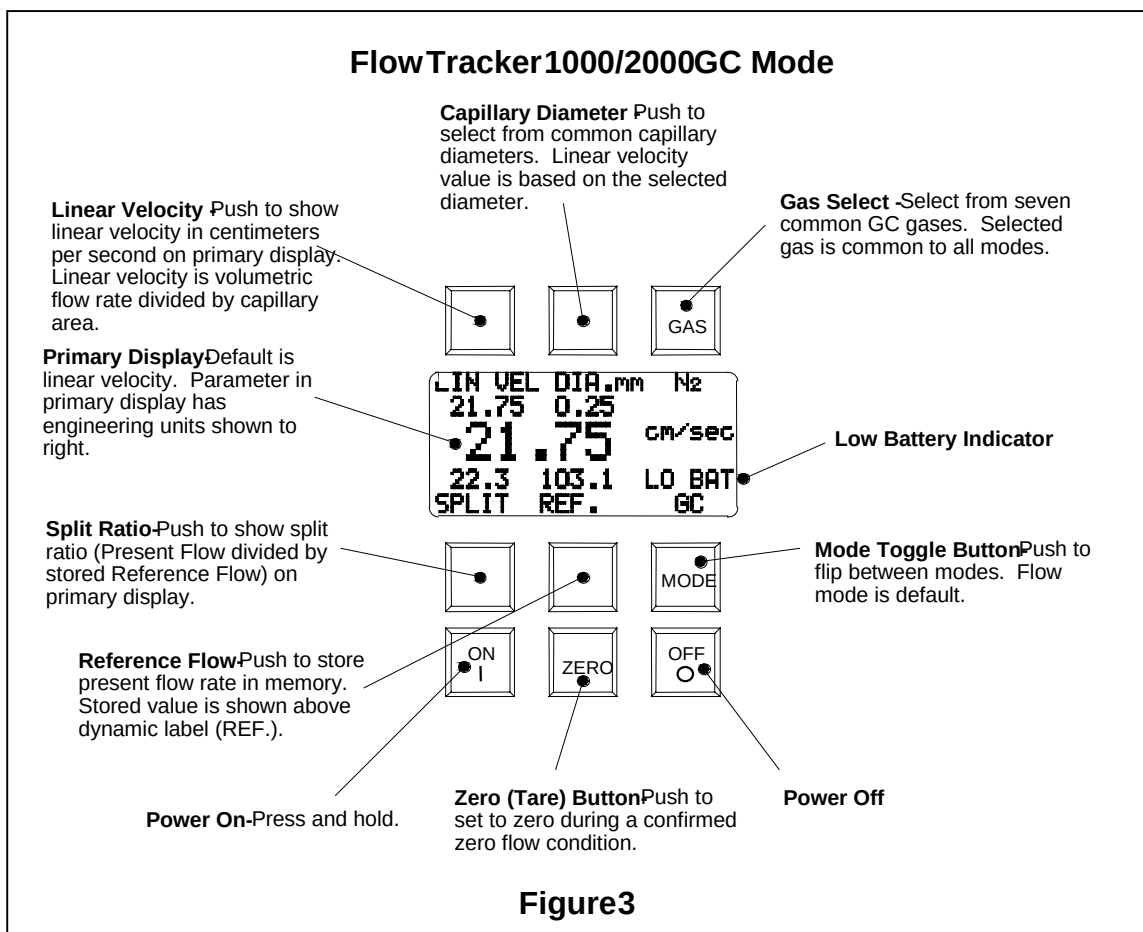
The GC mode screen shown in **Figure 3** displays the following parameters:

Linear Velocity: The Flow Tracker Series Flow Meters utilize the volumetric flow rate and the selected capillary diameter (inside diameter) to calculate the average velocity of the selected gas through the capillary. This parameter is located in the upper left portion of the display under the dynamic label “LinVel”. The engineering unit associated with the linear velocity is centimeters per second (cm/sec). The calculation is as follows:

$$\text{Linear Velocity} = \text{Volumetric Flow Rate} / \text{Capillary Area}$$

Capillary Diameter: The selected capillary diameter in millimeters (mm) is shown in the upper middle portion of the screen under the dynamic label “Dia. mm”. Pushing the button located above this dynamic label scrolls through the list of available capillary diameters. The capillary diameters are:

1. 0.10 mm (Inside Diameter)
2. 0.18 mm (Inside Diameter)
3. 0.25 mm (Inside Diameter)
4. 0.32 mm (Inside Diameter)
5. 0.53 mm (Inside Diameter)
6. 0.75 mm (Inside Diameter)



Reference Flow: The reference flow allows the user to store a volumetric flow rate in memory. This parameter, located in the lower middle portion of the display above the dynamic label “Ref.”, is defaulted to zero. When the button under this dynamic label is pushed, the current volumetric flow rate is stored in memory and the fixed value is shown above the dynamic label. The engineering unit associated with this parameter is milliliters per minute (mL/min). In gas chromatography, this is normally used to store the main column flow rate prior to attaching the flow meter to the split vent, so that a running split ratio can be calculated and displayed. *Note: When the power is turned off, the stored reference flow returns to the default zero.*

Split Ratio: The split ratio is the ratio of the present volumetric flow rate to the stored Reference flow rate detailed above. This parameter is located in the lower left corner of the display over the dynamic label “Split”. The split ratio is a flow divided by a flow, and is thus dimensionless:

$$\text{Split Ratio} = \text{Present Volumetric Flow Rate} / \text{Reference Flow Rate}$$

In gas chromatography, the reference flow rate is normally the main column flow rate, and the present flow rate is normally the split vent flow:

$$\text{Split Ratio} = \text{Split Vent Flow Rate} / \text{Main Column Flow Rate}$$

Note: This parameter reads “DIV0”, denoting “Division by Zero Error” until a value is stored in the reference flow buffer as described in the section labeled Reference Flow above.

Note: This parameter will read “OVRFLO”, denoting “Over Flow” if the resulting ratio is too large to display. The maximum value that can be displayed here is 655.35. This can occur if the stored reference flow is very near zero and/or the present flow is high.

Gas Select: The selected gas is shown in the upper right hand corner of the display. Available gases are detailed in the Flow Mode description.

LO BAT: This indicator is located on the lower right corner of the display just above the mode indicator and is displayed only if the batteries run below a certain voltage level that can affect the accuracy of the meter. Caution: To avoid inaccurate readings, change the batteries when the LO BAT indicator is displayed! Low power can result in inflated temperature sensor readings, which affects the expected gas viscosity and mass flow calculations.

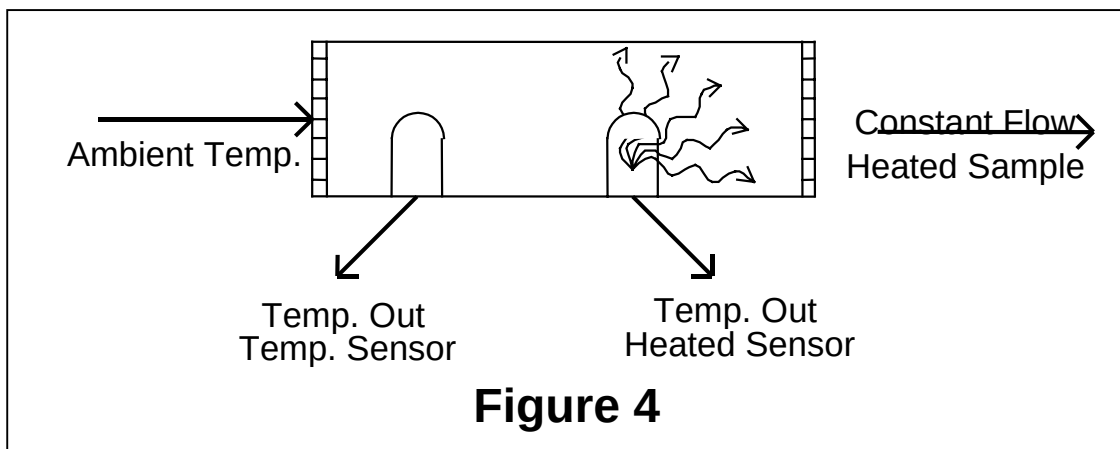
GC mode indicator: This indicator is located in the lower right corner of the display and simply indicates that the unit is in the “GC” (Gas Chromatography) mode. The operating mode can be changed by pushing the button labeled “MODE”. Available operating modes are Flow and GC (Gas Chromatography) in the Flow Tracker 1000, and Flow, GC, and Leak in the Flow Tracker 2000.

Leak Mode (Flow Tracker 2000)

The Agilent Flow Tracker 2000 GC Flow Meters utilize the thermal conductivity property of gases to detect leaks. The mechanism for detecting leaks is entirely separate from the main flow metering portion of the device. It consists of a sample suction probe, internal flow channel with thermal conductivity sensors, an internal suction pump, and an exhaust port.

Operating Principle: The thermal conductivity of a gas is a measure of its ability to conduct heat. The presence of a gas (leak) other than air is determined by a change in the current required to keep a sensor at a constant temperature while the sampled gas flows over the sensor at a constant rate. Ambient air carries heat away from the sensor at a particular rate, and gases other than air (that have substantially different thermal conductivity properties) carry heat away at different rates. The leak detector measures this difference as a difference in the temperature of the sensor being heated by a constant current and a second unheated sensor located upstream of the heated sensor as shown in

Figure 4. If the identity, and thus the thermal conductivity of the gas being sought are known, then a leak rate can be *inferred* from the known constant flow rate and the temperature difference measured between the two sensors.



This rate is subject to several limitations. For instance, if the leak is large enough that the sample is pure leak, the rate will show approximately the sample rate of the pump (approx. 30 ml/min), which may be considerably smaller than the actual leak. If the geometry of the leaking area prevents all of the leaking gas from entering the sample suction probe, the leak rate inferred will also be smaller than the actual leak rate. For these reasons, the accuracy of the reported leak rate can be quite subjective, and should be regarded appropriately. A good rule of thumb is that the actual leak rate is *at least* the rate indicated if the appropriate gas is selected.

Generally, only gases with thermal conductivities substantially different, either higher or lower, than air can be detected with this method. The absolute thermal conductivity (at 80 °F, 26.7 °C) of the gases that are selectable in the Flow Tracker 2000 are:

Gas	Absolute Thermal Conductivity cal/(sec)(cm ²)(°C/cm) X 10 ⁻⁶	Detectable	Temp 80 °F, 26.7 °C
Air	62.20	No	80 °F, 26.7 °C
Nitrogen	62.40	No	80 °F, 26.7 °C
Carbon Dioxide	39.67	Yes	80 °F, 26.7 °C
Methane*	81.83	*	80 °F, 26.7 °C
Hydrogen*	433.92	*	80 °F, 26.7 °C
95-5 Argon-Methane		Yes	80 °F, 26.7 °C
Helium	360.36	Yes	80 °F, 26.7 °C

***CAUTION-** These gases are technically detectable, however this device is not rated for use in hazardous areas.

Note: If it is deemed necessary and the temperature of the gas leak is known, the leak rate and conductivity can be compensated for temperature. The thermal conductivity of gases changes in direct proportion to the temperature of the gas. This change is relatively

small and approximately linear at 0.27% per degree Celsius (greater temp = greater conductivity).

Operating the Leak Detector: To operate the Flow Tracker 2000 in Leak Mode, the unit must be turned on and cycled to the Leak Mode by pressing the MODE button three times. The word “Leak” will appear in the mode indicator position on the display and the main display will default to “WarmUp”. In addition, if the selected gas happens to be an undetectable gas as denoted in the table above, the Rate, Conductivity, and Relative will read “gas?” to prompt the user to select a detectable gas.

Leak Detector Operating Steps

1. Insert the suction probe into the probe receptacle on the top of the unit as shown in figure 1. If desired, a length of inert tubing can be substituted for the included sampling probe. Simply remove the probe from the brass hose barb and install an appropriate length of tubing in its place.
2. Turn on the unit and cycle the mode indicator to “Leak” by pressing the MODE button three times.
3. Let the detector warm up its sensors for approximately 1 to 2 minutes. The “WarmUp” will disappear from the primary display and the suction pump will power up (this can usually be heard as a faint squeaking sound) when the device is ready to make gross leak measurements. If a precise reading of a very small leak is required, it is recommended that the unit be allowed to run for several more minutes until all displayed parameters stabilize.
4. Making sure that the device is well away from the suspected leak area, press the “ZERO” button. This sets a relative zero, which in turn sets the conductivity to 62.20, the conductivity of air. If the unit has been allowed to completely warm up, the conductivity will remain nearly constant. If the unit is not completely warmed up, the displayed parameters will begin a slow drift. For gross leak detections this can generally be ignored, as any substantial leak will rapidly outpace the drift.
5. Select the gas to be detected. The detector will use the conductivity of the selected gas, along with the conductivity detected and the constant flow rate to infer a leakage rate.
6. If desired, the sound can be toggled on at this point. Normal no leakage conditions are indicated by a constant high pitch sound. As the conductivity varies from that of air (either higher or lower), the pitch becomes proportionately lower. If the unit is not completely warmed up the pitch will become progressively lower as the conductivity parameter drifts from that of air. If the unit is completely warmed up, it will remain at a high pitch.
7. When a satisfactory zero has been obtained, the end of the suction probe can be moved to the point of the suspected leak. With the probe in place it may take 1-2 seconds for the sample to reach the sensors. If tubing is used in place of the probe, the response time will vary with the length of the tubing.
8. It is good practice to allow the detector to purge away from the suspected leak for a minute or two between leak detections. If the unit is fully warmed up, it will

return to approximately zero condition parameters (Cond. = approximately 62.20) when it is completely purged.

The Flow Tracker 2000 Leak Mode displays the following parameters:

Leak Rate: The leak rate for the selected gas is inferred from the conductivity of the gas being sampled, the known conductivity of the selected gas, and the known constant flow rate provided by the sampling pump. This parameter is located in the upper left corner of the display below the dynamic label “Rate”. The engineering unit associated with this parameter is cubic centimeters per second (cc/sec).

Thermal Conductivity: The thermal conductivity of a gas is a measure of its ability to conduct heat. The absolute thermal conductivity of the gas presently being sampled is located in the upper middle of the display under the dynamic label “Cond.” The engineering units associated with the thermal conductivity shown are the value $\times 10^{-6}$ (cal/(sec)(cm²)(°C/cm)). Because of the excessive length of the units, they are not shown on the display. The thermal conductivity of air is given as 62.2×10^{-6} (cal/(sec)(cm²)(°C/cm)) in the CRC Handbook of Chemistry and Physics.

Relative Conductivity Indicator: The relative conductivity indicator is a dimensionless value reflecting the raw sensor measurement of the difference in temperature between the heated and unheated sensors. This parameter is located in the lower left corner of the display above the dynamic label “Rel.”. It can be signed plus or minus with zero being the state at which the device was last zeroed, which is nominally in ambient air. This value can be roughly interpreted as:

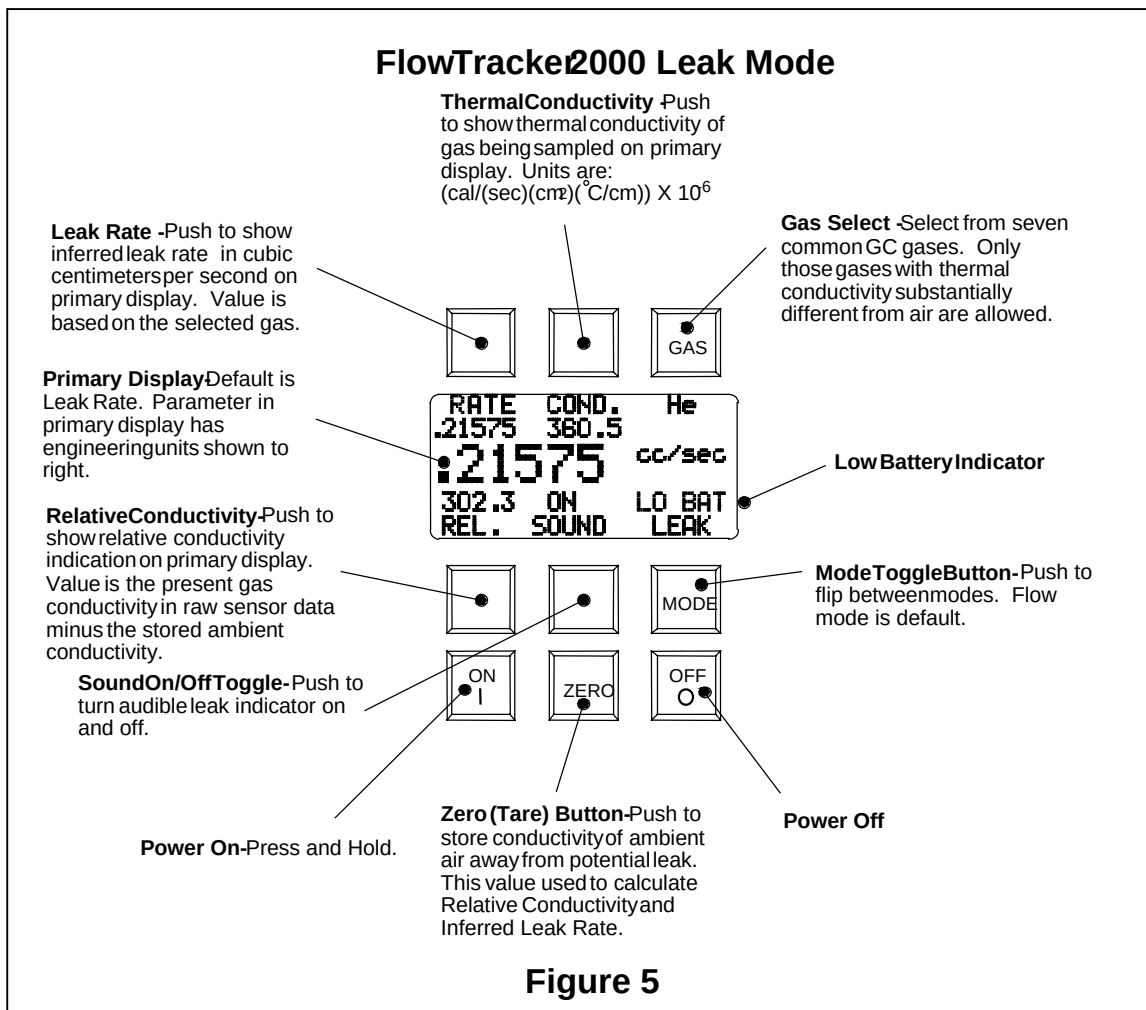
$$\text{Rel.} = (\text{Temperature difference between the two sensors when last zeroed}) - (\text{Present temperature difference between the two sensors})$$

Thus, if the unit is completely warmed up and zeroed in air, the Relative Conductivity Indicator will read approximately zero until a leak is detected. If a gas with a greater conductivity than air is introduced, more current will be required and the Rel. reading will increase positively. If a gas with a lower conductivity than air is introduced, less current will be required and the Rel. reading will go negative.

Sound On / Off Toggle: This indicator is located in the bottom center of the display above the dynamic label “Sound”. The unit defaults in sound off. The sound can be toggled on and off simply by pushing the button located under the dynamic label. The sound is normally high in pitch and decreases with a change (either positive or negative) in the thermal conductivity from air. Small changes in high pitches are easier for the human ear to detect than small changes in lower frequencies. If the sound is turned on and the unit zeroed prior to a complete warm up, the slow drift in the parameters will cause a slow drop in the pitch of the sound similar to the sound made by a falling bomb. If the unit is completely warmed up the sound will remain a steady high pitch.

Gas Select: The selected gas is shown in the upper right hand corner of the display. Available gases are detailed in the Flow Mode description.

LO BAT: This indicator is located on the lower right corner of the display just above the mode indicator and is displayed only if the batteries run below a certain voltage level that can affect the accuracy of the meter. Caution: To avoid inaccurate readings, change the batteries when the LO BAT indicator is displayed! Low power can result in inflated temperature sensor readings, which affects the expected gas viscosity and mass flow calculations.



Leak Mode Indicator: This indicator is located in the lower right corner of the display and simply indicates that the unit is in the “Leak” mode. The operating mode can be changed by pushing the button labeled “MODE”. Available operating modes are Flow and GC (Gas Chromatography) in the Flow Tracker 1000, and Flow, GC, and Leak in the Flow Tracker 2000.

RS-232 Output

Connecting to the Computer: The Flow Tracker Series Flow Meters have robust RS-232 serial output capabilities. If the serial port on your computer is female, the flow meter can simply be plugged into your serial port via the 8 Pin Mini-DIN to DB-9 serial adapter cable included with the Flow Tracker. If the serial port on your computer is male, you will need a common double ended female adapter cable.

Configuring HyperTerminal®:

1. Open your HyperTerminal® RS-232 terminal program (installed under the “Accessories” menu on all Microsoft Windows operating systems).
2. Select “Properties” from the file menu.
3. Click on the “Configure” button under the “Connect To” tab. Be sure the program is set for: 19,200 baud and an 8-N-1-None (8 Data Bits, No Parity, 1 Stop Bit, and no Flow Control) protocol.
4. Under the “Settings” tab, make sure the Terminal Emulation is set to ANSI.
5. Click on the “ASCII Setup” button and be sure the “Send Line Ends with Line Feeds” box is not checked, and that the “Append Line Feeds to Incoming Lines” box is checked. Those settings not mentioned here are normally okay in the default position.
6. If the meter is connected to the serial port on the computer, data should begin streaming to the window. If not, try hitting the “Enter” key several times to clear any extraneous information. If data still does not appear, check all the connections and com port assignments.

Data Format: The data stream on the screen represents the parameters of the operating mode presently selected in the units shown on the display. A column header is displayed when the unit is turned on or off, or the operating mode is changed. Examples are:

Flow Mode:

Flow	Air		
PSIA	°C	Vol	Mass
13.37	+25.78	+2.0	+2.0
13.37	+25.78	+2.0	+2.0
13.37	+25.78	+2.0	+2.0

GC Mode (in LO BAT condition):

GC	Air			
LinVel	Dia.mm	Split	Ref.	
1.1	0.10	DIV0	+0	LO BAT
1.1	0.10	DIV0	+0	LO BAT
.9	0.10	DIV0	+0	LO BAT

Leak Mode:

Leak	Air		
Rate	Cond.	Rel.	Sound
.00004	+62.4	+0	Off
.00004	+62.4	+0	Off
.00004	+62.4	+0	Off

Collecting Data: The RS-232 output updates to the screen on the order of 50 lines per second. Very short-term events can be captured simply by disconnecting (there are two telephone symbol icons at the top of the HyperTerminal® screen for disconnecting and connecting) immediately after the event in question. The scroll bar can be driven up to the event and all of the data associated with the event can be selected, copied, and pasted into Microsoft® Excel® or other spreadsheet program as described below.

For longer term data, it is useful to capture the data in a text file. With the desired data streaming to the screen, select “Capture Text” from the Transfer Menu. Type in the path and file name you wish to use. Push the start button. When the data collection period is complete, simply select “Capture Text” from the Transfer Menu and select “Stop” from the sub-menu that appears.

Data that is selected and copied, either directly from HyperTerminal® or from a text file can be pasted directly into Excel®. When the data is pasted it will all be in the selected column. Select “Text to Columns...” under the Data menu in Excel® and a Text to Columns Wizard (dialog box) will appear. Make sure that “Fixed Width” is selected under Original Data Type in the first dialog box and click “Next”. In the second dialog box, set the column widths as desired, but the default is usually acceptable. Click on “Next” again. In the third dialog box, make sure the column data format is set to “General”, and click “Finish”. This separates the data into columns for manipulation and removes symbols such as the plus signs from the numbers. Once the data is in this format, it can be graphed or manipulated as desired.

Maintenance and Recalibration

General: The Flow Tracker requires very minimal maintenance. With the exception of the sampling pump in the 2000 Series, the Flow Tracker has no moving parts. The single most important thing that affects the life and accuracy of this device is the quality of the gas being measured. It is designed to measure CLEAN, DRY, NON-CORROSIVE gases. A 20 micron filter mounted upstream of the meter is highly recommended. Moisture, oil, and other contaminants can affect the laminar flow elements and/or reduce the area that is used to calculate the flow rate. This directly affects the accuracy.

Recalibration: The recommended period for recalibration is every two years. Providing the CLEAN, DRY, and NON_CORROSIVE mantra is observed, this periodic recalibration is quite sufficient. A label located on the back of the meter (under the flexible cover) lists the recalibration due date. The meter should be returned to Agilent Technologies for recalibration near the listed due date. Before calling to schedule a recalibration, please note the serial number on the back of the meter.

Cleaning: The Flow Tracker requires no periodic cleaning. If required, the outside of the meter can be cleaned with a soft dry rag. Avoid excess moisture or solvents.

For repairs, re-calibrations, or recycling of this product, contact:

Agilent Technologies
Little Falls Analytical Division
2850 Centerville Road
Wilmington, DE 19808
302-633-8000

Notes: _____

Warranty

This product is warranted to the original purchaser for a period of one year from the date of purchase to be free of defects in material or workmanship. Under this warranty the product will be repaired or replaced at manufacturers option, without charge for parts or labor when the product is carried or shipped prepaid to the factory together with proof of purchase. This warranty does not apply to cosmetic items, nor to products that are damaged, defaced or otherwise misused or subjected to abnormal use. Where consistent with state law, the manufacturer shall not be liable for consequential economic, property, or personal injury damages.

Flow Tracker 1000 and 2000 Flow Measurement Specifications:

Flow Range:	0-500 ml/min
Accuracy:	Flow: +/- 2% of reading (+/- 0.2 ml/min) linear through zero. Temp: +/- 0.5 °Celsius Press: +/- 0.5% of reading
Sensor Type:	Flow: Solid state piezoresistive differential pressure sensor with measurement in the laminar flow region. No heated elements. Temp: Integrated circuit absolute temperature sensor. No RTD's. Press: Solid State Absolute Pressure Sensor
Calibration:	NIST traceable Multipoint Calibration Certificate included.
Calibrated Gases:	Nitrogen, Hydrogen, Helium, Air, Carbon Dioxide, Methane, 95% Argon / 5% Methane Blend
Modes:	Flow, Gas Chromatography, Leak Detection (2000 Only)
Display:	Dynamically labeled multi-function 7 line LCD with 99 chars.
Power:	Six AA Batteries (included) or optional universal AC/DC Adapter.
Dimensions:	8.3"(h) x 3.75"(w) x 1.9"(d)
Certification:	CE Marked
Operating Pressure:	100 PSI (690 kPa) Maximum
Output:	RS-232 output for all variables for selected mode, no special software required.
Weight:	Approx. 2.4 lbs (1.1 kg)
Inlet and Outlet:	1/8" NPT(Female) Threads
Accessories:	RS-232 cable, stand, batteries, 1/8" and 1/16" barbed fittings.

Flow Tracker 2000 Leak Detector Specifications:

Sensor Type:	Solid state thermal conductivity detector, low power consumption for extended battery life.
Response Time:	1 second*
Sensitivity:	1×10^{-5} ml/sec for He
Gases:	All calibrated gases (as above) with a thermal conductivity significantly different than air.**
Detection:	Thermal conductivity, relative conductivity, inferred leak rate, audible signal.

* Gross detection in 1-2 seconds, leak rate quantification may take 1-2 minutes.

** Other gases are detectable but not quantifiable.