TARGAS-1

Portable Photosynthesis System

Operation Manual

Version 1.01

4th November 2016

PP Systems
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Contents

Welcome

Thank you very much for purchasing our **TARGAS-1 Portable Photosynthesis System.** Although the majority of customers will be using this system for measurement of leaf gas exchange using our PLC5 Leaf Cuvette, it can also be used with a number of additional chambers and accessories for measurement of soil respiration, net canopy flux, PAR, soil temperature, soil moisture and soil temperature and temperature/PAR. The TARGAS-1 can also be used as a stand-alone CO_2/H_2O gas analyzer in both absolute and differential mode. We greatly appreciate your business and we look forward to working with you and your research team for many years to come.

For applications where failure of this equipment to function correctly would lead to consequential damage, the equipment must be checked for correct operation and calibration at intervals appropriate to the circumstances. The PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

This manual is provided to help you install and operate the equipment. Every effort has been made to ensure that the information it contains is accurate and complete. PP Systems does not accept any liability for losses or damages resulting from the use of this information.

It is the operator's responsibility to review this information prior to installation and operation of the equipment. Otherwise, damage may be caused which is not covered under our normal warranty policy.

User Registration

It is very important that ALL new customers register themselves with us to ensure that our user's list is kept up-to-date. If you are a PP Systems' user, please go to www.ppsystems.com and click on Customer Registration in the upper left hand corner.

Only **REGISTERED** users will be allowed access to the protected "Users" section of our web site. This section will contain important product information including hardware/software updates, application notes, newsletters, etc.

Thank you in advance for your cooperation.

Service & Warranty

PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

The equipment is covered under warranty for one complete year, parts and labor included. This, of course, is provided that the equipment is properly installed, operated and maintained in accordance with written instructions (i.e. Operator's Guide).

The warranty excludes all defects in equipment caused by incorrect installation, operation or maintenance, misuse, alteration, and/or accident.

If for some reason, a fault is covered under warranty, it is the responsibility of the customer to return the goods to PP Systems or an authorized agent for repair or replacement of the defective part(s).

Prior to returning equipment to PP Systems for service, you must first get in contact with our Service Manager (service@ppsystems.com) to request a case number for reference and tracking purposes.

Contact Information

PP Systems, Inc.
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Amesbury, MA 01913 USA
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Sales: sales@ppsystems.com
Support: support@ppsystems.com
Service: service@ppsystems.com
URL: www.ppsystems.com

Unpacking and Storage of Your Equipment

It is extremely important that you check the contents of your equipment immediately upon receipt to ensure that your order is complete and that it has arrived safely. Please refer to the packing list to show all items that are included with your order. **DO NOT DISCARD ANY OF THE PACKAGING MATERIAL UNTIL ALL OF THE ITEMS LISTED ARE ACCOUNTED FOR. WE RECOMMEND THAT YOU RETAIN THE ORIGINAL PACKING FOR FUTURE USE.** If you suspect that any of the items listed on the packing list are not included or damaged, you must contact PP Systems or your authorized distributor immediately.

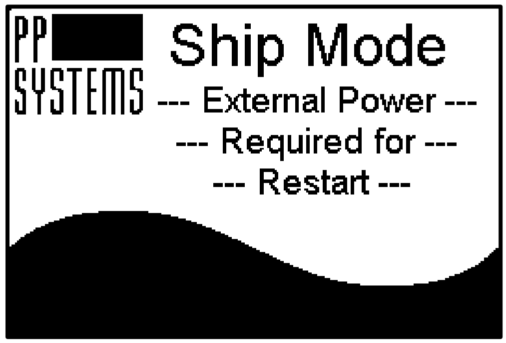
Storage – Transport Case

We highly recommend storing your equipment in a safe, dry location. Every system is supplied with a custom designed transport case which is ideal for both transporting and storage of your system. The transport case allows for storage of:

- TARGAS-1 Console
- PLC5 Leaf Cuvette and Light Unit
- Air Supply Intake Unit
- Extra compartment for spares

Powering up the TARGAS-1 for the First Time

When you first receive your new TARGAS-1 from PP Systems you will need to first connect it up to the external power supply/charger prior to powering up the instrument. To avoid accidental power up during shipment we put the instrument into “Ship Mode” (see Ship Mode Settings on page 66 for more information).



Therefore, when you are ready to begin:

1. Locate the power supply/charger and power cord inside the packing box.
2. Connect the AC power cord to the mains and the barrel connector into the EXT Power socket on the back of the TARGAS-1.
3. Press the ON/OFF switch to power up the instrument. The power switch should now have an illuminating blue ring indicating power is on.
4. Allow 10-15 minutes to achieve warm-up.

You are ready to go!

Data Storage

For convenience and ease it is very important to note that all TARGAS-1 system data is recorded and saved directly to a USB flash drive (i.e. memory stick or thumb drive). A USB flash drive is included in the spares kit (Part No. 43034-1) with every new system. Most commercially available flash drives are compatible with the TARGAS-1.

THEREFORE IT IS IMPERATIVE THAT YOU HAVE A USB FLASH DRIVE WITH YOU AT ALL TIMES IF YOU WANT TO RECORD DATA WITH YOUR TARGAS-1. OTHERWISE DATA WILL HAVE TO BE RECORDED MANUALLY.

Technical Specification

TARGAS-1 CO_2/H_2O Gas Analyzer (Main Console)

Analysis Method	Two non-dispersive infrared, configured as an absolute absorptiometer with microprocessor control of linearization for both CO_2 and H_2O. All readings are automatically corrected for temperature, pressure and foreign gas broadening.
CO_2 Measurement Ranges	0 - 10000 µmol mol^{-1} Precision: 1 µmol mol^{-1}
H_2O Range	0-75 mb Precision: 0.1 mb
Pressure Compensation Range	80-115 kPa
Absolute Accuracy	< 1% of span concentration over the calibrated range but limited by the accuracy of the calibration mixture.
Differential Accuracy	± 1 µmol mol^{-1} for CO_2 differential up to 50 µmol mol^{-1}
Linearity	< 1% throughout the range
Stability	Auto-zero at regular intervals corrects for sample cell contamination, source and detector ageing and changes in electronics.
Calibration	User programmable calibration (if required)
Warm-up Time	Approximately 15 minutes
Sampling Rate	10 Hz. Sample data is averaged and output every 1.0 seconds.
Sample Flow Rate	50-200 cc/min. An internal, electronic flow sensor monitors flow rate.
Air Supply Unit	Integral pump for supply of reference air to the leaf cuvette Range: 200-500 cc/min
CO_2 and H_2O Control	User adjustable from 0-100% of ambient.
Sampling Pump	Integral pump for sample (analysis) air Range: 50-200 cc/min An internal electronic flow sensor monitors flow rate.
Sampling Rate	10 Hz. Sample data is averaged and output every 1.0 second.
Digital Output	USB
Gas Flow Rate	200-500 cc/min (280-340 cc/min is optimal). An electronic flow sensor monitors flow rate.
Terminal Block	10 pin terminal block for system inputs and outputs
Analog Output	0-2.5V (CO_2 range selectable)
Digital Output	One mini USB for connection to external PC
Environmental Sensor Inputs	2 inputs available for use with external chambers and environmental sensors
Alarm	Visual and audible alarm/warnings
Data Storage (USB)	USB flash drive port for data storage
Mini USB	For connection to external PC
Touch Display	2.7" electronic paper touch display with 264 x 176 pixel resolution
Power	Internal, rechargeable 7.2 V, 8.7Ah Li-Ion battery providing up to 10 hours continuous operation.

Power Consumption	Warm up: 15W (12V @ 1.2A) Normal operation: 7.2W (12V @ 0.6A)
Enclosure	Rugged, ergonomic, lightweight aluminum with polyurethane base.
Gas Connections	Four quick disconnect style fittings for use with 1/8" (.125") ID tubing
Operating Temperature	0-50 ^oC, non-condensing. External filtration may be required in dirty environments.
Dimensions	20 cm (L) x 23 cm (H) 10 cm (W) (Enclosure only)
Weight	2.1 kg

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- PP Systems is continuously updating its products and reserves the right to amend product specifications without notice.
- All brand names are trademarks or registered trademarks of their respective owners.

PLC5 Leaf Cuvette

Cuvette Materials	The materials of construction are carefully selected to ensure maximum accuracy and repeatability of gas exchange measurements.
Stirring Fan	High speed fan provides efficient mixing of the air inside the leaf chamber for rapid measurement and minimal boundary layer resistance.
Cuvette Window	18 mm x 25 mm (4.5 cm^2)
Air Temperature Sensor	Precision Thermistor · Range: 0-50 ^oC · Accuracy: ± 0.3 ^oC at 25 ^oC
PAR Sensor (External)	Cosine corrected · Response: 400-700 nm · Range: 0-3000 µmol m^{-2} s^{-1} · Accuracy: 10 µmol m^{-2} s^{-1}
Dimensions	30 cm (L) x 3 cm (Handle Diameter)
Weight	0.7 kg

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Light Unit (Optional)

Type	Low power LED light unit (White LEDs) easily mounts to the PLC5 Broad Leaf Cuvette.
Control Range	0-2500 µmol m^{-2} s^{-1}
Dimensions	6 cm (L) x 6 cm (H) x 5 cm (W)
Weight	0.1 kg

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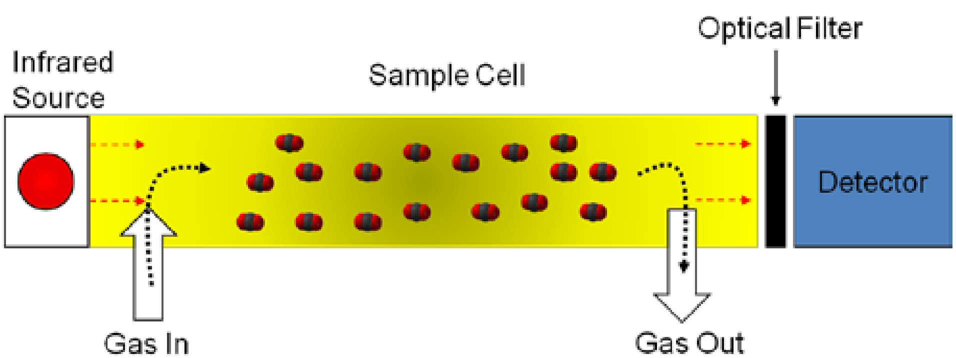
Summary of System Design

Overview and Theory

The CO_2/H_2O gas analyzer is a major part of any portable photosynthesis system. The TARGAS-1 Portable Photosynthesis System features a very accurate, precise and robust CO_2/H_2O Gas Analyzer that can be used as part of a powerful leaf gas exchange system (with leaf cuvette) or as a self-contained instrument for continuous measurement of CO_2 and H_2O in air. Its open-path design allows for continuous, unattended air sampling, as the pump introduces fresh sample gas to the essential component, the IRGA (infrared gas analyzer). It can also be used as an absolute gas analyzer in "closed" mode for measurement of soil CO_2 efflux and net canopy CO_2 flux using chambers supplied by PP Systems as well as for use with commercially available sensors for environmental monitoring applications (PAR, soil temperature, etc.).

The IRGAs form the core of the TARGAS-1 Portable Photosynthesis System for measurement of both CO_2 and H_2O. Non-dispersive infra-red (NDIR) refers to the transmission of a broad-band infra-red wavelength from the IRGA source lamps. A single IRGA consists of four basic components:

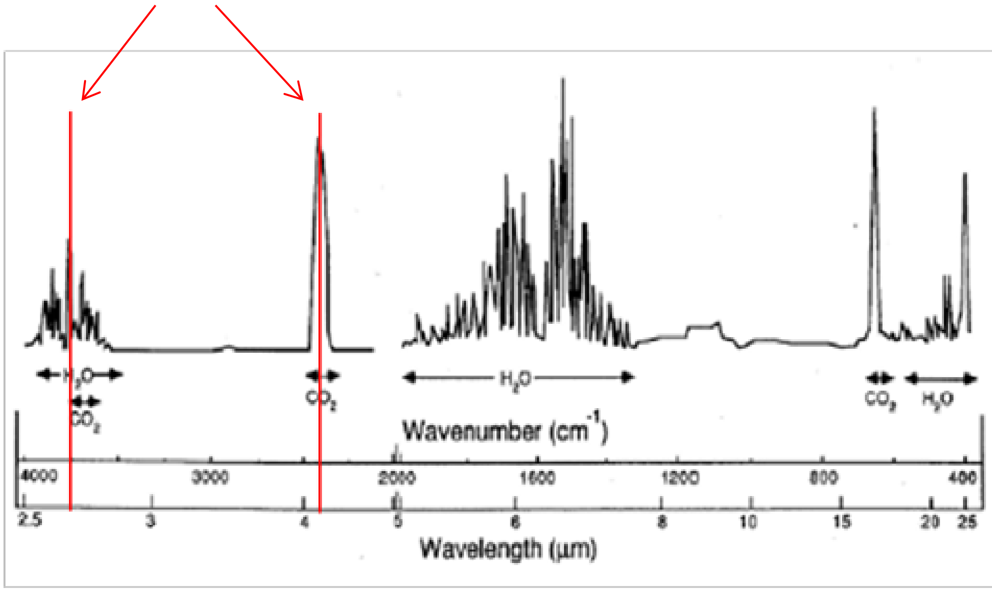
- Infra-red source
- Sample cell of known path length and volume
- Optical interference filter
- Infra-red detector



The theory itself is quite simple – light from mid-infra-red wavelengths is produced by the source and pulsed through a gold plated cell. The interference filter narrows the bandwidth of the IR source received by the detector to the signature wavelength absorbed by the target gas molecule, e.g. CO_2. The CO_2 and H_2O cells each employ a unique optical filter. As the sample gas fills the cell, it absorbs IR, and the reduction in IR source strength is measured instantaneously by the detector. The *higher* the target gas concentration, the *lower* the infra-red signal received at the detector, as defined by the Lambert-Beer Law of Attenuation.

Both H_2O and CO_2 molecules have diverse absorption spectra, so we use two prominent absorption peaks, seen below at 2.60 and 4.26 µm, respectively. The TARGAS-1 electronics could be considered the fifth component, which processes raw analog-to-digital (A/D) information from the IRGAs detectors, accurately translating this information into gas concentrations.

The TARGAS-1 detectors are optimized for these wavebands for H_2O (2.60 µm) and CO_2 (4.26 µm)



The gas sample is of course a mixture of gas molecules, and this can present problems in terms of accurate detection of concentrations of a specific gas, such carbon dioxide. This effect, *foreign gas broadening* (FGB), must be corrected to ensure accurate measurement of gas concentrations. With FGB, the CO_2 gas in the IRGA cell is somewhat diluted by the increased air volume induced by water vapor. This effect is about 0.1 µmol mol^{-1} CO_2 mb^{-1} H_2O. The presence of water vapor also causes an increase in infra-red absorption, which is detected as an apparent increase in [CO_2]. This is of a similar magnitude, but opposite to the dilution effect, and TARGAS-1 automatically corrects these FGB effects.

The TARGAS-1 IRGAs are quite stable owing to their construction, calibration and thermal environment, but various circumstances can cause apparent changes over time. Some changes may require recalibration, although one of the strengths of TARGAS-1 is that recalibration is not a routine (annual) maintenance task. The factory calibration ranges of 0-10000 µmol mol^{-1} CO_2 and 0-75 mb water vapor are ideally suited for most typical applications.

The TARGAS-1 features an Auto-Zero function that corrects for nearly all changes that result in calibration drifts. Auto-Zero minimizes effects on span (gas sensitivity), of sample cell contamination, lamp ageing, changes in detector sensitivity, amplifier gains and reference voltages. Measurements are ratioed to the Zero reading before IR absorbance is determined. From the relationship between absorbance and concentration determined in the factory for each instrument, and the current calibration factor, the sample concentration is determined.

System Components for Measurement of Leaf Gas Exchange

There are 3 main components that make up the TARGAS-1 Portable Photosynthesis System as follows:

TARGAS-1 CO_2/H_2O Gas Analyzer

The TARGAS-1 console (2.1 kg) features two, non-dispersive infrared gas analyzers for CO_2 and H_2O. It is constructed out of rugged aluminum with polyurethane, shock absorbing base making it extremely robust and reliable for use in harsh environmental conditions. An internal air supply unit provides accurately controlled reference air to the leaf cuvette and another pump draws the sample air (analysis) air to the analyzer. Both pumps are user controlled and accuracy is ensured by two internal electronic flow sensors. It is powered by a powerful, internal rechargeable Li-Ion battery providing up to 10 hour continuous operation in the field.

The gas analyzers should not require frequent calibration, although we do recommend frequent checks to confirm system integrity.

PLC5 Leaf Cuvette

The PLC5 Leaf Cuvette is extremely versatile and light weight (0.7 kg) making it ideal for measurement on a wide variety of vegetation including broad leaves, narrow leaves, grasses and small needle conifers. It includes sensors for measurement of air temperature and PAR. All cuvette materials are carefully selected to minimize influences such as infrared radiation, water sorption, CO_2 effects and leaks. The leaf gaskets provide an air-tight seal without causing damage to vegetation.

Light Unit (*Optional*)

The light unit is a low power LED based source for light control (light response curves) or for use on cloudy days. The light unit clips onto the PLC5 Leaf Cuvette head and can easily be removed for measurement under ambient conditions.

- Type: LED (white)
- Measurement Range: 0-2500 µmol m^{-2} s^{-1}

External Sensors/Chambers for Use with TARGAS-1

The following sensors/chambers are external to the TARGAS-1 and electrical connection is made to the Probe Ports (Probe 1 and/or Probe 2) located on the back of the TARGAS-1. See Probe Port Settings on page 60 for more information for proper connection. Gas connections are made to the "Gas In" and "Gas Out" ports on the back of the TARGAS-1 as described for each chamber and sensor below.

Quantum Sensor

An optional quantum sensor (Apogee Instruments) is available for use with the TARGAS-1 for accurate measurement of PAR (Photosynthetically Active Radiation) and it is specifically calibrated for use in sunlight conditions. The sensor housing features a fully potted, dome-shaped head, making the sensor fully weatherproof for self-cleaning. **Never use an abrasive material or cleaner on the diffuser**.

- Range: 0-3000 µmol m^{-2} s^{-1}
- Calibration Uncertainty: ± 5%
- Measurement Repeatability < 1%
- Long Term Drift: < 2% per year
- Cable Length: 5 meters

An optional leveling unit (ACS039) is also available for use with the quantum sensor. We highly recommend that you mount the sensor on a horizontal surface and that it is level for best results. To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1%, but is easy to minimize by proper cable orientation. This sensor connects to Probe Port 1 only.

We recommend recalibration of the quantum sensor every 2 years.

TRP-3 Temperature/PAR Probe

An optional probe can be used with the TARGAS-1 for measurement of temperature and PAR. It consists of a rugged, aluminum housing with black foam cover. It also includes a standard tripod thread mount for use with commercially available tripods. The single gas connection for this probe is made to the "Gas In" port on the TARGAS-1. This sensor can be used on Probe Port 1 or 2.

Temperature Sensor (Precision Thermistor)

- Range: 0-50 ^{o}C
- Accuracy: ± 0.3 ^{o}C at 25 ^{o}C

PAR Sensor

- Fully cosine corrected
- Range: 0-3000 µmol m^{-2} s^{-1}
- Accuracy: ± 10 µmol m^{-2} s^{-1}

Cable Length: 1.5 meters

We recommend recalibration of the PAR sensor every 2 years. The temperature sensor should not require recalibration.

SRC-2 Soil Respiration Chamber

Our SRC-2 Soil Respiration Chamber is available for use with the TARGAS-1 for measurement of closed system, soil CO_2 efflux. There are two gas connections required, one to the **GAS IN** port, and the other to the **GAS OUT** port on the TARGAS-1. It is constructed out of rugged PVC with a convenient handle for placement on the soil surface. An aluminum ring provides a good seal on the soil surface or on collars.

- Dimensions: 150 mm (Height) x 100 mm (Diameter)
- Volume: 1171 ml
- Area: 78 cm^2
- Cable Length: 1.5 meters

It includes a temperature sensor for measurement of air temperature near the soil surface. This chamber can be used on Probe Port 1 or 2

Temperature Sensor (Precision Thermistor)

- Range: 0-50 ^oC
- Accuracy: ± 0.3 ^oC at 25 ^oC

CPY-5 Canopy Assimilation Chamber

Our CPY-5 Canopy Assimilation Chamber is available for use with the TARGAS-1 for measurement of closed system, net canopy CO_2 flux. It is transparent and constructed out of rugged polycarbonate with an aluminum ring, which provides a good seal on the soil surface or on collars. It also includes sensors for measurement of air temperature and PAR within the chamber. There are two gas connections required, one to the **GAS IN** port and the other to the **GAS OUT** port on the TARGAS-1. This sensor can be used on Probe Port 1 or 2.

- Dimensions: 145 mm (Height) x 146 mm (Diameter)
- Area: 167 cm^2
- Cable Length: 1.5 meters

Temperature Sensor (Precision Thermistor)

- Range: 0-50 ^oC
- Accuracy: ± 0.3 ^oC at 25 ^oC

PAR Sensor

- Fully cosine corrected
- Range: 0-3000 µmol m^{-2} s^{-1}
- Accuracy: ± 10 µmol m^{-2} s^{-1}

We recommend recalibration of the PAR sensor every 2 years. The temperature sensor should not require recalibration.

STP-2 Soil Temperature Probe

An optional soil temperature sensor can be used with the TARGAS-1 for measurement of soil temperature. It is commonly used with the SRC-2 Soil Respiration Chamber and CPY-5 Canopy Assimilation Chamber. This sensor connects to Probe Port 1 only.

It is a rugged sensor with electronics housed in an anodized aluminum enclosure with stainless steel tip.

- Dimensions: Handle: 200 mm (Length) x 18.7 mm (Diameter)
  Tip: 125mm Length
- Cable Length: 1.5 meters

Temperature Sensor (Precision Thermistor)

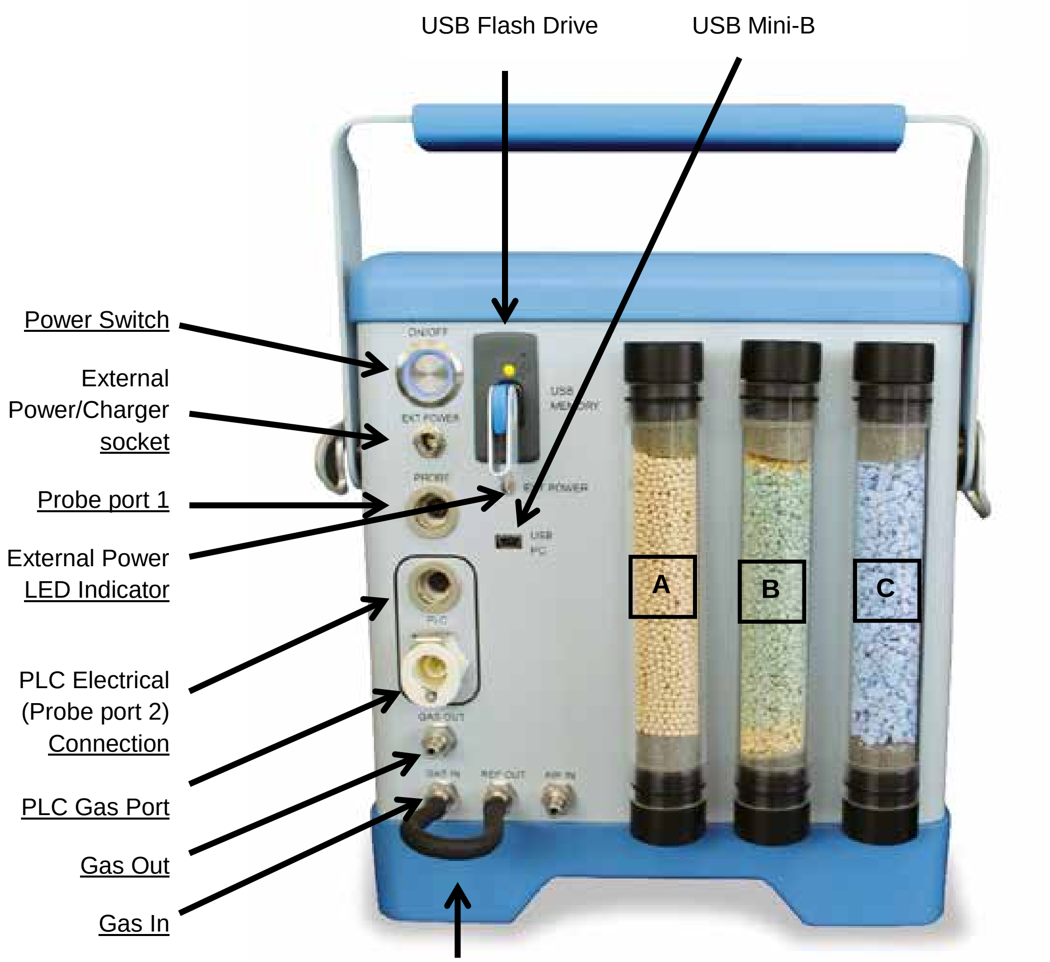
- Range: 0-50 °C
- Accuracy: ± 0.3 °C at 25 °C

The soil temperature sensor should not require recalibration.

Getting Familiar with the TARGAS-1 Portable Photosynthesis System

TARGAS-1 Portable CO_2/H_2O Gas Analyzer (Main Console)

Back of TARGAS-1



Link Tube

Must be in place for use with leaf cuvette

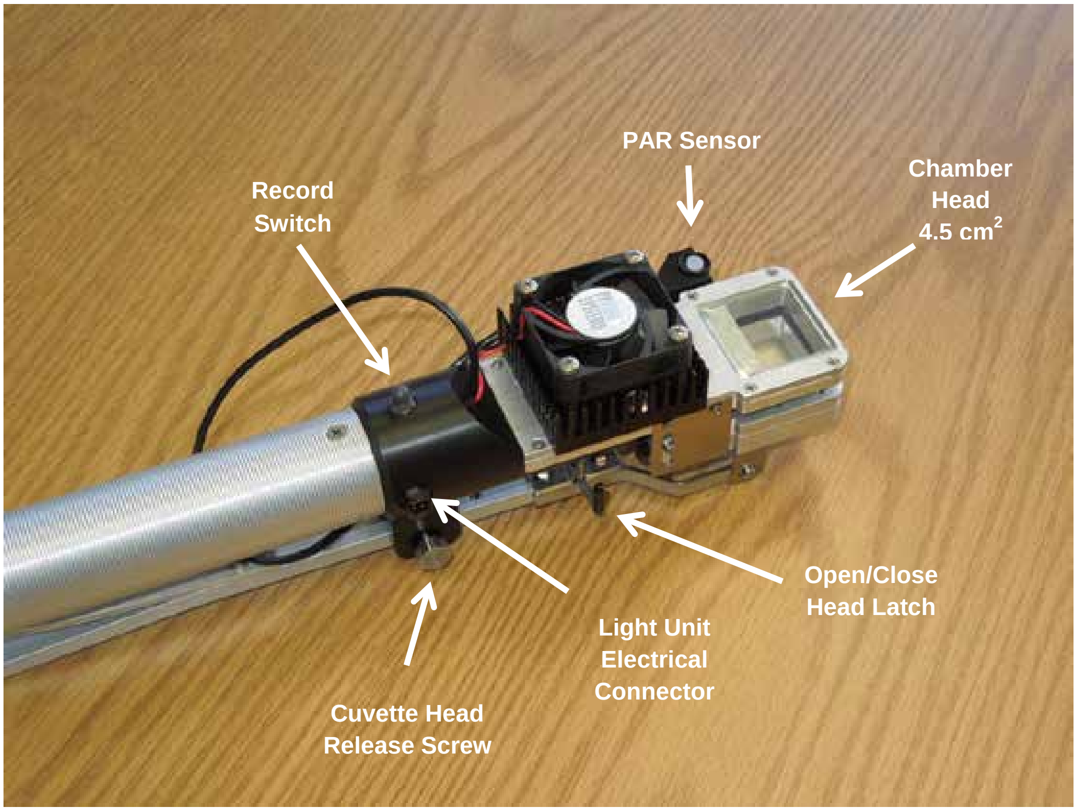
A. Auto-Zero (Molecular Sieve)
B. CO_2 Scrubber (Sofnolime)
C. H_2O Scrubber(Drierite)

External Air Filter

An air filter is included with each system and we recommend fitting it to the **AIR IN** port to keep dirt and dust from entering the analyzer. See External Air Filter on page 127 for more information.

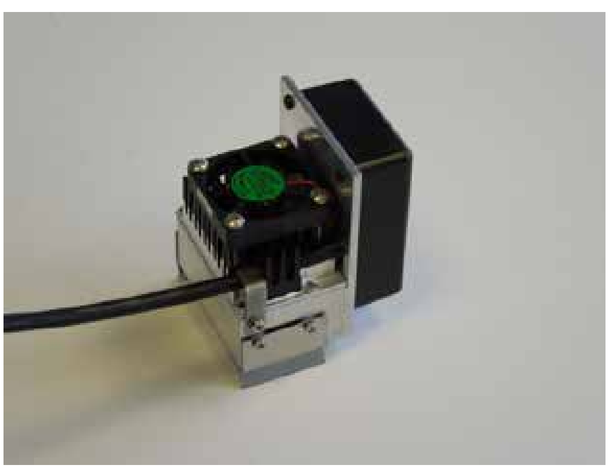
PLC5 Leaf Cuvette

The PLC5 Leaf Cuvette is designed to work with the TARGAS-1 Portable CO_2/H_2O Analyzer for measurement of leaf gas exchange on a wide variety of plants including broad leaves, narrow leaves, grasses and small needle conifers.



When the PLC5 Leaf Cuvette is not in use or being stored away make sure that the Open/Close Head Latch is secure in place to keep the cuvette head open to avoid problems associated with compressed leaf gaskets which is a common source for leaks.

Light Unit (*Optional*)



The optional light unit can be used with the PLC5 Leaf Cuvette for use on cloudy days or for light response curves. It easily clips onto the PLC5 Leaf Cuvette head and provides control of light intensity up to 2500 µmol m^{-2} s^{-1}. The electrical connection is on the side of cuvette handle as shown above.

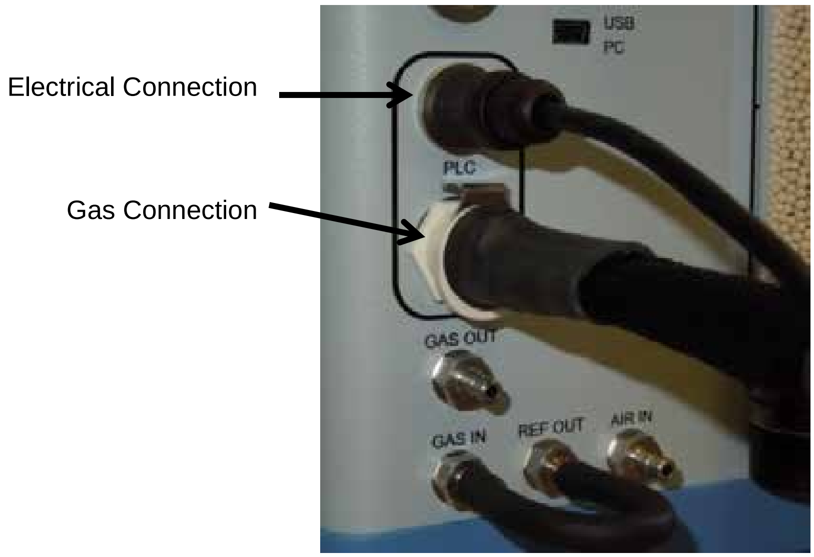
- Type: LED (white)
- Measurement Range: 0-2500 µmol m^{-2} s^{-1}

Quick Start

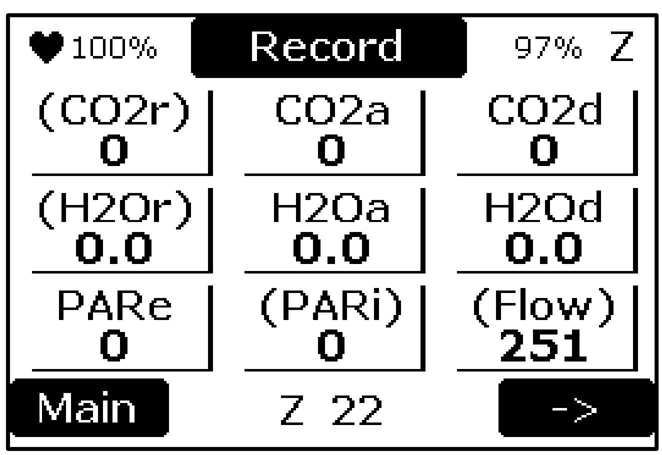
For measurement of leaf gas exchange using the PLC5 Leaf Cuvette.

We highly recommend that you take a few moments to run this simple test to familiarize yourself with the basic TARGAS-1 set-up and to ensure that the system is performing perfectly before starting a measurement campaign.

1. Connect the PLC5 Leaf Cuvette gas and signal connectors to the TARGAS-1 console as shown below and close the cuvette head.

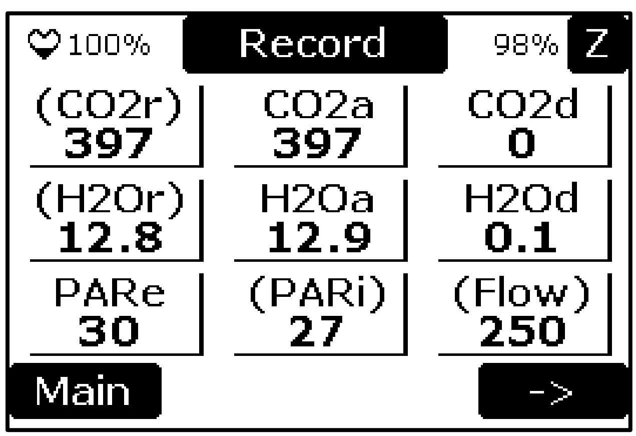


2. Connect the TARGAS-1 to the power supply provided by PP Systems (to conserve power) and power up the TARGAS-1 console and allow it to warm-up. Prior to performing actual photosynthesis measurements, it is recommended to wait an additional 15 minutes. This will allow the system to achieve stabilization of the IRGAs and perform system ZEROs. During warm-up, the main measurement screen will show 0 readings for most measured parameters similar to this:



3. Connect the sampling tubing to the **AIR IN** port on the back of the TARGAS-1 console. Remember to make sure the external air filter is fitted to the **AIR IN** port (see External Air Filter on page 127). This will be your reference air. We strongly recommend that your reference air is as far away from any local CO_2 disturbances such as people breathing, ventilation, automobiles, parking lots, etc. This can be as easy as running a long piece of tubing outside the window in your lab or away from where you are taking measurements in the field. If in the field you could also use the "**fresh air intake unit**" supplied with the system which will help to provide steady reference air. It is very important that you establish a very steady reference air supply to ensure that your system is working properly and to make measurements easier and quicker.
4. Make sure you set the rb value (boundary layer resistance) and RS factor for your cuvette correctly. Settings associated with rb and RS Factor are located in the Settings 1 menu (press **Main, Settings, RB or RS Fact**). The rb value is measured at the factory and is programmed into your TARGAS-1 console when supplied as a new instrument. This value is also written on the "Tested" label on your leaf cuvette for additional reference purposes (See RB Setting on page 53 for more information). The RS Factor is set to 0.50 as default on the assumption that you have 50% stomata on the upper and lower side of your leaf. You should enter the value associated with your leaf (See RS Factor Setting on page 54 for more information).

5. Make sure the cuvette flow rate **(Flow)** located in the bottom right hand corner of the main measure display is set to our recommended rate of 250 cc/min. If not, press the **(Flow)** button and set it to 250. Also make sure that the sample flow rate is set to 150 cc/min (see Sample Flow Setting on page 62). Settings associated with sample flow are located in the Settings 3 menu (press **Main, Settings, right arrow, right arrow, Flow**). With the leaf cuvette head closed, all readings should be stable and you should see something similar to this displayed:



- Stable CO2r and CO2a at ambient levels (~ 400 ppm)
- Stable H2Or and H2Oa at ambient levels
- CO2d should be stable and near 0 (± 1 ppm) and H2Od should also be stable and near 0 (± 0.5 mb)
- PARe and PARi should be at ambient light levels (Typically less than 50 µmol m^{-2} s^{-1} indoors)
- Flow rate should be approximately 250 cc/min

If everything looks similar to the above you should be good to go. Good luck!

Leaf Gas Exchange Measurements – Recommended Set-up

When performing leaf gas exchange measurements in the lab or field, calculations are based on the changes in CO_2 and H_2O gas concentrations between the reference and analysis (sample) air streams. The reference air source is normally outside air (ambient) which contains both CO_2 and H_2O and is the air that is supplied to the leaf cuvette. The analysis air is the air containing the sample CO_2 and H_2O gas coming from the leaf cuvette.

For healthy plants you would expect that the analysis CO_2 concentration (CO2a) will be less than the reference CO_2 concentration (CO2r) as the plant will be taking up CO_2. Initially the CO_2 analysis concentration (CO2a) may increase when the cuvette head is open to enclose the leaf (normally due to local breathing by the user) but it will fairly rapidly begin to decrease and slowly drop after closing the head on the leaf. On the H_2O side, the analysis H_2O concentration (H2Oa) should be higher than the reference H_2O concentration (H2Or) as the leaf will be adding moisture to the air and commonly referred to as "transpiration". For best results you want to make sure that your reference air is as stable as possible especially when working on plants that have low rates of assimilation. Therefore we strongly recommend that your source of reference air is drawn from a stable source away from any CO_2 influences or disturbances such as people breathing, ventilation systems, parking lots or highways, automobiles, etc. This can be achieved by using a homemade buffer volume (i.e. 20 liter bucket, large water container, etc.) or using the air supply intake unit provided by PP Systems. The air supply intake unit draws ambient air from about 2.3 meters above the ground and should help to smooth the reference air allowing for rapid and accurate measurement of leaf gas exchange. On windy days additional smoothing may be required but for most conditions the air supply intake unit should work well.

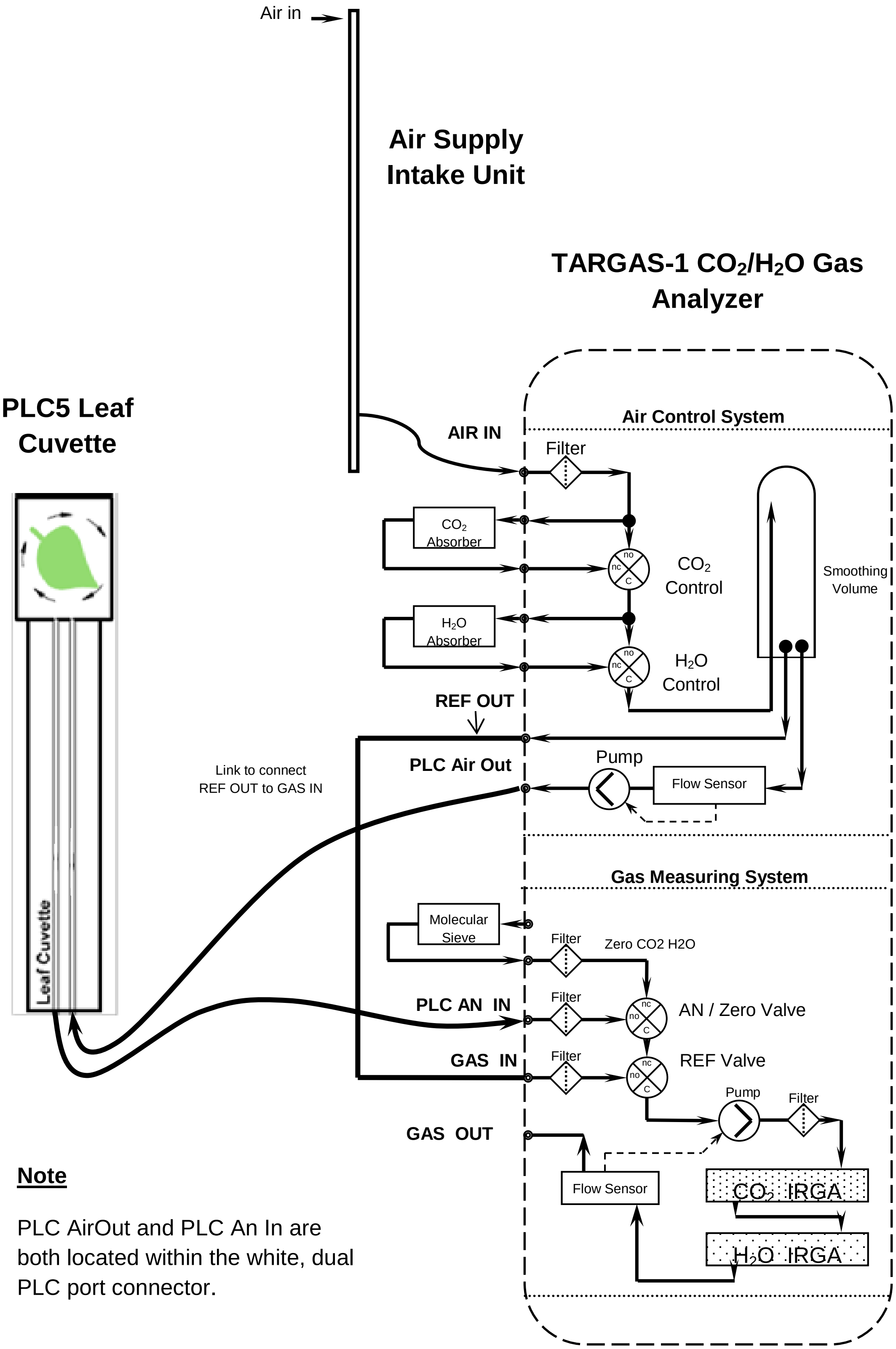
When should I record a measurement?

This is a very good question. Generally speaking it really depends on the biological state of the plant and local environmental conditions. For many healthy plants under sunny conditions you could expect the plant to reach equilibrium in approximately 60 seconds. For plants that are not as healthy and experiencing stress conditions (i.e. drought, heat, salinity, etc.) it may take longer up to several minutes. After placement of the leaf inside the chamber we recommend monitoring either the CO2d value (Measure Screen 1) or A value (Measure Screen 2) and when it stabilizes then it is time to record the measurement. Measurements can be recorded by pressing the RECORD button on the console display or by pressing the record switch located on the PLC handle.

Important Note. It is not unusual to see fluctuating or unrealistic "calculated" parameters (i.e. A, gs, Ci, etc.) with an empty chamber and the head closed. Do not be concerned by this. What is important is that your measured data is stable and CO2d and H2Od values close to 0 as described on the previous page. The calculated parameters become relevant only after enclosing a leaf in the chamber and during actual leaf gas exchange measurements.

For more information related to photosynthesis measurements and equations see Appendix 1. Photosynthesis Equations Used in TARGAS-1 on page 137.

Schematic of TARGAS-1 Portable Photosynthesis System Air Supply System



Note

PLC AirOut and PLC An In are both located within the white, dual PLC port connector.

Routine System Checks Before Starting

The TARGAS-1 is designed to operate with minimal maintenance. The basic routine system checks are as follows:

- **Absorber Columns -** Check the absorber columns on the back and make sure that they are properly seated in the correct location (See Back of TARGAS-1 on page 21). You should periodically lubricate all O-rings associated with the columns (black end caps) with silicone grease to ensure good seal and to avoid problems associated with cracks and leaks. Also ensure that the gray foam filters are in good shape and replace when worn.
- **Desiccants -** Check the condition of each desiccant to ensure that they are fresh. Pay special attention to the soda lime and molecular sieve which visually do not change color like the Drierite. If you are unsure then you should replace all desiccants to ensure stability and calibration.
- **Zero -**. If the Zero reading in the upper right hand corner of display is 20% or lower you should change it. Pay special attention to the Molecular Sieve desiccant as this is non-indicating and if unsure change it out with fresh Molecular Sieve. Reset the absorber column life after replacing the Molecular Sieve. See Reset Zero Absorber on page 56.
- **rb (boundary layer resistance) and RS Factor –** Make sure both are set properly for your leaf cuvette and vegetation type.
- **Cuvette Flow rate and Sample rate –** For most plant types and when the chamber head is filled with vegetation we recommend a cuvette flow rate of 250 cc/min and sample flow rate of 150 cc/min. Cuvette flow rate and sample flow rate can be adjusted by the user as required and usually based on leaf area and biological state of the plant.
- **System Power -** Make sure that the heart symbol is flashing in the upper left hand corner after the instrument is powered on. Also check the battery capacity next to the heart to ensure that you have plenty of power to get you through your measurements. We recommend that you keep the charger connected to the TARGAS-1 during warm-up to save on battery life.
- **USB Flash Drive –** You must make sure that you have a USB flash drive (also commonly referred to as a memory stick or thumb drive) plugged into the USB Memory port on the TARGAS-1 console for data storage. **If you do not have this you will be unable to save data and it will have to be recorded manually.**
- **Status** – Inspect periodically for error messages/warnings **AND DO NOT IGNORE THEM**. They are appearing for a reason.

System Power

The TARGAS-1 has an internal, rechargeable lithium ion battery pack capable of providing continuous power to the instrument for up to 10 hours. The TARGAS-1 is supplied with an external AC power adapter to charge and/or power the TARGAS-1.

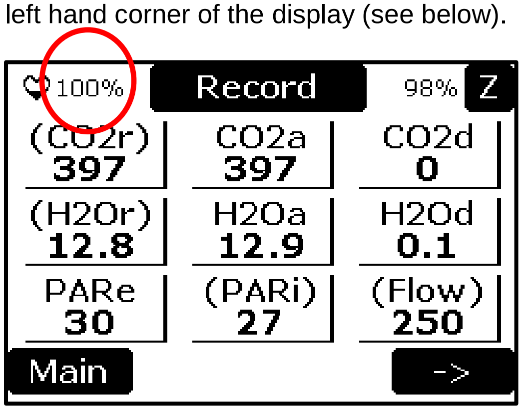
Battery Specification

- **Type:** Rechargeable Smart Lithium Ion Battery Pack
- **Power**: 7.2V, 8.7Ahr, 63Whr

Note, if the TARGAS-1 is used with external sensors/chambers it will reduce the battery life depending on the probe connected.

A discharged battery (0% capacity) can be fully recharged in approximately 4-5 hours using the power supply/charger supplied by PP Systems.

To check the battery status, simply power up the instrument and observe the battery capacity next to the flashing heartbeat in the upper left hand corner of the display (see below).



Power Supply/AC Adapter Rating:

- **Input:** 100-240 VAC, 50-60 Hz, 1.0A
- **Output:** 12 VDC, 3.3A

Re-Order Information	
Part Number	**Description**
STD561	Mains Charger/Power Supply

TARGAS-1 Main Console Components

Touch Display

The TARGAS-1 features a 2.7" a-Si, active matrix TFT, Electronic Paper Display (EPD) touch panel. The panel has such high resolution (117 dpi) that it is able to easily display fine patterns with excellent readability under sunlight conditions. Due to its bi-stable nature, the EPD panel requires very little power to update and needs no power to maintain an image.

Features

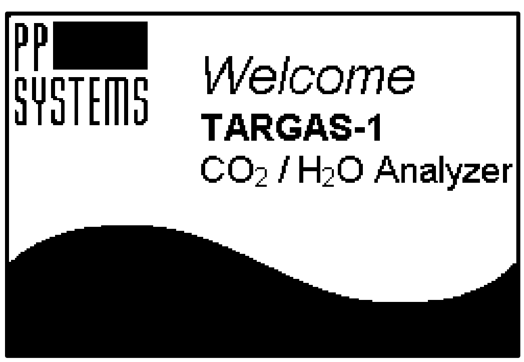
- a-Si TFT active matrix Electronic Paper Display(EPD)
- Resolution: 264 x 176 pixel
- Ultra-low power consumption
- Super Wide Viewing Angle - near 180°
- Slim & lightweight enclosure
- SPI interface
- RoHS compliant

Navigation using the Touch Display

Navigating through the system is simple and easy by pressing black buttons where applicable. Whenever you see white text inside a black box we refer to this as a button (i.e. Main). Pressing on these buttons will allow you to set up, navigate and operate the TARGAS-1. Whenever a numeric value is required, a keypad will appear allowing you to enter the desired values.

Power Switch

The power switch is located in the upper left hand corner of the back panel. To power on the TARGAS-1 simply push in the switch. When power is on the illumination ring around the switch will turn blue. To turn off, simply press the switch again bringing it back to the flush position. When powered off, the Splash Screen will be displayed as follows:



When the TARGAS-1 is turned off you must wait at **least 5 seconds** before powering on the instrument. If you do not wait long enough the system will not power up properly.

Please note that a warning message is displayed when the battery capacity is less than 10%. When the battery capacity of the TARGAS-1 reaches 0% it will turn off. If this happens we recommend connecting up to the charger to recharge the internal battery

If the TARGAS-1 was put into ship mode, it **will not power on until external power is applied**. To bring the TARGAS-1 out of ship mode, first connect external power to the instrument, and then turn it on by pressing the “ON/OFF” button. See Ship Mode Settings on page 66 for more information.

Ext Power Jack

When external power is present, the system will charge the internal battery. A power supply/charger is supplied with the TARGAS-1 as standard. When the power supply/charger is connected to the TARGAS-1 it will both operate the instrument continuously and recharge the internal battery when the TARGAS-1 is powered on. If connected to the TARGAS-1 with power off it will recharge the internal battery faster.

Ext Power LED

The amber LED is illuminated whenever the power supply/charger is connected to the **EXT POWER** jack on the back panel.

Probe Ports

There are 2 digital **PROBE PORTS** available for powering chambers and sensors.

Probe port 1 supported probes/sensors include:

- Quantum Sensor (Apogee Instruments)
- TRP-3 Temperature & PAR Probe
- STP-2 Soil Temperature Probe
- SRC-2 Soil Respiration Chamber
- CPY-5 Canopy Assimilation Chamber

Probe Port 2 (PLC) supported probes:

- PLC5 Leaf Cuvette
- PLC3 Leaf Cuvette
- TRP-3 Temperature & PAR Probe
- SRC-2 Soil Respiration Chamber
- CPY-5 Canopy Assimilation Chamber

Up to two different probes can be used at the same time, for example, the SRC-2 Soil Respiration Chamber and the STP-2 Soil Temperature Probe. Note that some combinations of the above probes will not be possible, for example, the PLC5 and the PLC3 will not work with other probes.

PLC Gas Ports

This port connection is for the PLC5 or a PLC3 leaf cuvette for measurement of leaf gas exchange. The port provides both the supply air (reference) and the analysis (sample) air through this single gas connection.

Gas Ports

There are 4 gas ports on the TARGAS-1. Each port is designed for use with 1/8" (.125") ID tubing or a mating quick disconnect.

- **GAS OUT**: Exhaust air from the IRGAs
- **GAS IN**: Reference air entering the IRGAs (when PLC5 is used) or sample air when in absolute or closed modes
- **REF OUT**: The (conditioned) air from the TARGAS-1 (when PLC5 is used) or exhaust air when in absolute or closed modes
- **AIR IN**: The air that is drawn in from the ambient and used by the TARGAS-1 for the PLC sample air (Reference)

NOTE: the **REF OUT** must be linked to the **GAS IN** when using a PLC5 or PLC3 leaf cuvettes for measurement of leaf gas exchange. See Back of TARGAS-1 on page 21. The link pipe must be removed when using the SRC-2 Soil Respiration Chamber or the CPY-5 Canopy Assimilation Chamber. When using these accessories both the **GAS IN** and **GAS OUT** ports are used and the link pipe is not required.

When using the TARGAS-1 as a stand-alone CO_2/H_2O analyzer, the sampling line should be fitted to the **GAS IN** port and the **GAS OUT** port should be left open to atmosphere to allow the sample air to exhaust without restriction. This does not apply when using some optional accessories (e.g., the SRC-2 Soil Respiration Chamber or the CPY-5 Canopy Assimilation Chamber).

Flow Rate

The TARGAS-1 features an internal electronic flow sensor for controlling flow rates.

Important Note

If the flow rate cannot be maintained, a "low flow" error message will be displayed in the status box. Typically this is the result of flow restriction caused by either the external air filter (if applicable) or a blocked internal hydrophobic filter located inside the TARGAS-1 enclosure. First, replace the external air filter (if applicable) connected to the **GAS IN** port to see if this corrects the problem. If it doesn't then the likely problem is a blocked internal hydrophobic filter See Hydrophobic Filter on page 132 for information related to changing this filter.

USB Flash Drive Port

A USB Flash Drive Port is available on the back panel to allow users to save data directly to a USB flash drive (also commonly referred to as a "thumb drive" or "memory stick"). When a USB flash drive is inserted into the USB port, the LED indicator will first turn red in recognition of the USB flash drive and then it will flash green indicating that data is being saved to it automatically. If the indicating LED is a steady green then data is not being saved because the "Interval (sec)" is likely set to 0 under Interval Settings.

USB PC Port

The USB PC Port (USB Mini-B) can be used to connect the TARGAS-1 to a PC. Measured data is continuously sent through this port. The PP Systems' GAS software or a terminal emulation program (i.e. HyperTerminal) can then monitor the measured data. GAS software is supplied on the USB flash drive supplied with the TARGAS-1 and it is also available for free download from our website. See GAS (Gas

Analysis Software) on page 123 for more information. When using a terminal emulator, the COM port settings to communicate with the EGM-5 are: 19200 baud, 8 bit, 1 stop, no parity, no flow control.

Absorber Columns

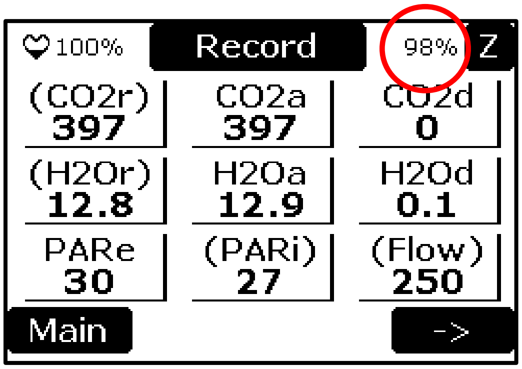
There are 3 absorber columns used with the TARGAS-1. One column is for Auto-Zero and the other two columns are for CO_2 and H_2O control.

Auto-Zero Column

The Auto-Zero column contains a CO_2 and H_2O scrubbing desiccant called “Molecular Sieve”. When air passes through this column, it removes all of the CO_2 and H_2O from the air stream. The “Auto-Zero” function built into the TARGAS-1 periodically switches the flow of gas from the analyzer through this column to check the analyzer zero. This routine ensures long term stability and accuracy of the CO_2 and H_2O gas analyzers. It automatically corrects for such things as sample cell contamination, source aging, detector sensitivity and changes in electronics. The default Auto-Zero interval is 20 minutes, but this can be changed if required. See Zero Settings on page 54.

Important Note

It is critical that the Molecular Sieve is fresh to ensure that the TARGAS-1 receives a good zero for long term calibration and stability of the CO_2 and H_2O gas analyzers. We recommend changing out the Molecular Sieve Desiccant at least once per week or when the scrubber value in the upper right hand corner of the display is at 20% or lower (see below). When the display is less than 10% a warning is displayed.



See Reset Zero Absorber on page 56 for information on resetting the scrubber after refreshing the desiccant.

Molecular Sieve

Molecular Sieve is used to remove CO_2 and H_2O from the air supply during analyzer Auto-Zero to ensure system stability and accuracy for CO_2 and H_2O. Unfortunately, Molecular Sieve is not self-indicating and there is no obvious way to see that it is exhausted. **It is therefore best to always change the Molecular Sieve at least once per week regardless of use.**

Molecular Sieve can easily become contaminated through absorption of CO_2 and H_2O from atmospheric air. It is therefore **strongly recommended and advised** that when you open the Molecular Sieve container for the very first time you decant it into small air-tight, glass containers sealed by electrical tape to minimize any exposure to air (See Molecular Sieve Repackaging on page 33).

- Type: Molecular Sieve, 13X 1/16, 1.25 lb. container
- Manufacturer: AGM Container. (www.agmcontainer.com)
- For the latest Material Safety Data Sheet, please visit www.agmcontainer.com and request the latest MSDS or contact PP Systems.

Take caution to wash your hands completely after handling Molecular Sieve.

Re-Order Information	
Part Number	**Description**
STD006	Molecular Sieve, 1.25 lb.

Molecular Sieve Repackaging

The Molecular Sieve is originally supplied by PP Systems in tin packaging. After initial opening, we strongly urge all users to repackage the Molecular Sieve in small glass containers with a screw top to seal the desiccant from room air. This desiccant saturates very quickly in room air and if not properly stored it will cause it to go bad and subsequently affect CO_2 readings and calibration.

To ensure a good seal, we also recommend putting some electrical tape around the screw top as shown here. If you have any questions, get in contact with PP Systems.

Tip

Always change the molecular sieve at least once per week when the TARGAS-1 is in use regardless of operation time.

CO_2 & H_2O Control Columns

There are two columns used for CO_2 and H_2O control. One column contains soda lime (CO_2 scrubber) and the other contains Drierite (H_2O scrubber).

Soda Lime

Soda lime (calcium hydroxide, sodium hydroxide, water) is used to remove CO_2 from air entering the TARGAS-1. Both self-indicting (white to violet) and non-indicating Soda Lime can be can be used with the TARGAS-1. Soda Lime cannot be regenerated and should be discarded after exhaustion.

- Type: Sofnolime, 1.0-2.5 mm, self-indicating white to violet), 1 kg
- Manufacturer: Molecular Products. (www.molecularproducts.com)

- For the latest Material Safety Data Sheet, please visit www.molecularproducts.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of soda lime, please contact the manufacturer directly or contact PP Systems.

Take caution to wash your hands completely after handling soda lime.

Re-Order Information	
Part Number	**Description**
STD007W	Sofnolime, white to violet (1 kg)

Important Note

The Soda Lime provided by PP Systems is self-indicating and this desiccant changes from white to violet during operation. However it will revert back to white when the instrument is powered off and not in use. Therefore it is best practice to replace this desiccant regularly (at least once per week) for best results and controlling capability.

Drierite

Drierite (anhydrous 97% calcium sulfate ($CaSO_4$) and 3% cobalt chloride) is an excellent H_2O absorber making it an ideal choice for analyzer ZERO and for controlling H_2O. Both self-indicting (blue to pink) and non-indicating Drierite can be can be used with the TARGAS-1. It can be regenerated easily by simply spreading out the granules one layer deep and placed in a preheated oven for 90 minutes at 230 °C or 425 °F. The regenerated material should be returned to the original glass container and sealed while hot. The color of the self-indicating Drierite may become less distinct on successive regenerations due to the migration of the indicator into the interior of the granule and sublimation of the indicator.

- Type: 8 mesh, self-indicating (blue to pink) or non-indicating, 1 lb. Jar
- Manufacturer: W.A. Hammond Drierite Company Ltd. (www.DRIERITE.com)
- For the latest Material Safety Data Sheet, please visit www.DRIERITE.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of Drierite, please contact the manufacturer directly or contact PP Systems.

Take caution to wash your hands completely after handling Drierite.

Re-Order Information	
Part Number	**Description**
STD008	Drierite, 1 Lb Jar

When changing out all desiccants, the user must take care to ensure that the columns are properly seated in the correct manifolds, the proper desiccant is used in appropriate columns which are clearly marked and that all "O" rings are in place and slightly lubricated with silicone grease. Any leakage of ambient air into the gas circuit generally results in error messages during ZERO or fluctuating CO2r values during measurement.

Each absorber column includes the following items which should be checked periodically and replaced when necessary:

Foam Filters

The gray foam filters used inside the absorber columns become worn over time and should be inspected regularly and replaced when torn or reduced in size. The foam must be of an open celled type, such as packing foam. The foam filters at the bottom of each column will likely require more frequent changes versus the upper foam filters.

Re-Order Information	
Part Number	**Description**
30118-1	Filter Foam

Absorber Filters

Each absorber column end cap contains a white plastic filter disk. Generally these do not need to be replaced but should be checked periodically. However, they must be present to prevent any of the column contents being drawn with the gas stream causing damage to the instrument.

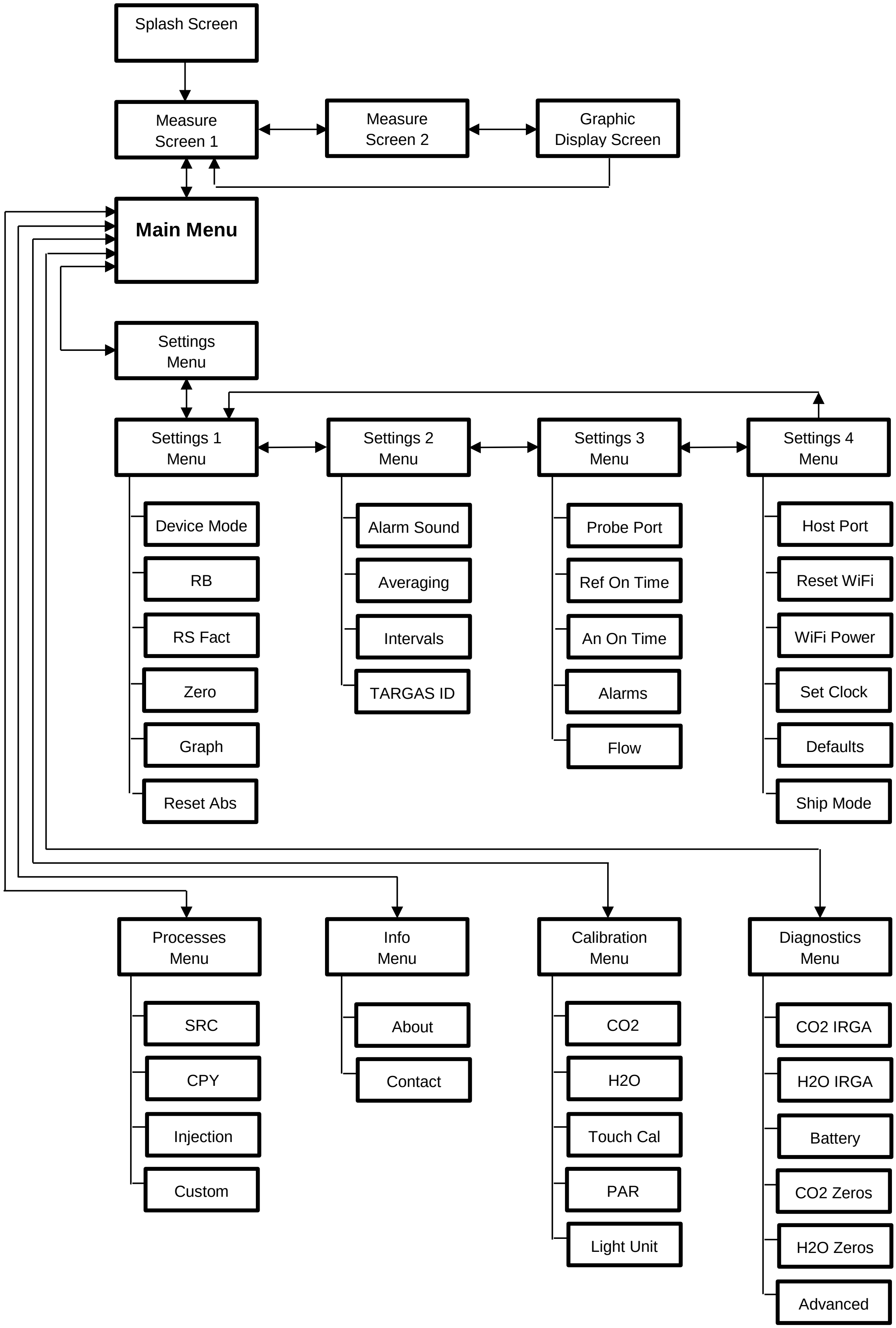
"O" Rings

All "O" Rings on the absorber columns should periodically (every couple of weeks) receive a slight smear of silicone grease to aid ease of fitting, improve the seal and extend the life of the "O" rings and to keep them from cracking or breaking. Once sealed, end fittings should be checked to ensure that the O-rings are seated correctly in their groove and that they are not trapped or pinched resulting in system leaks.

Re-Order Information	
Part Number	**Description**
30013-1	O-ring 4.76 x 1.78
30013-19	O-ring 20.8 x 2.4

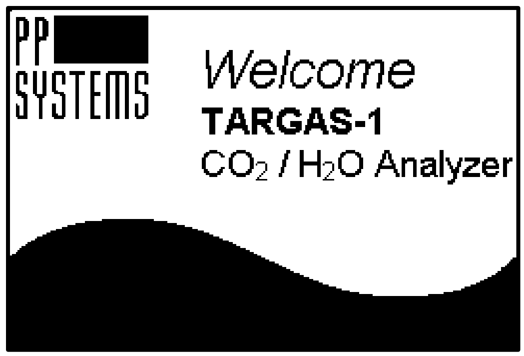
TARGAS-1 Menu Overview (Flow Chart)

The flowchart on the next page describes an overview of the touch display for the TARGAS-1. When the instrument is first powered up, there is a brief period where the Splash screen is shown. After this time, the instrument goes into the warm-up period which is approximately 10-15 minutes and the Measure screen is displayed. During and after the warm-up period, the user has the ability to navigate through the menus as shown in the flowchart below. The following sections describe each screen and its functionality.


Splash Screen
Measure Screen 1
Measure Screen 2
Graphic Display Screen
Main Menu
Settings Menu
Settings 1 Menu
Settings 2 Menu
Settings 3 Menu
Settings 4 Menu
Device Mode
RB
RS Fact
Zero
Graph
Reset Abs
Alarm Sound
Averaging
Intervals
TARGAS ID
Probe Port
Ref On Time
An On Time
Alarms
Flow
Host Port
Reset WiFi
WiFi Power
Set Clock
Defaults
Ship Mode
Processes Menu
Info Menu
Calibration Menu
Diagnostics Menu
SRC
CPY
Injection
Custom
About
Contact
CO2
H2O
Touch Cal
PAR
Light Unit
CO2 IRGA
H2O IRGA
Battery
CO2 Zeros
H2O Zeros
Advanced

Splash Screen

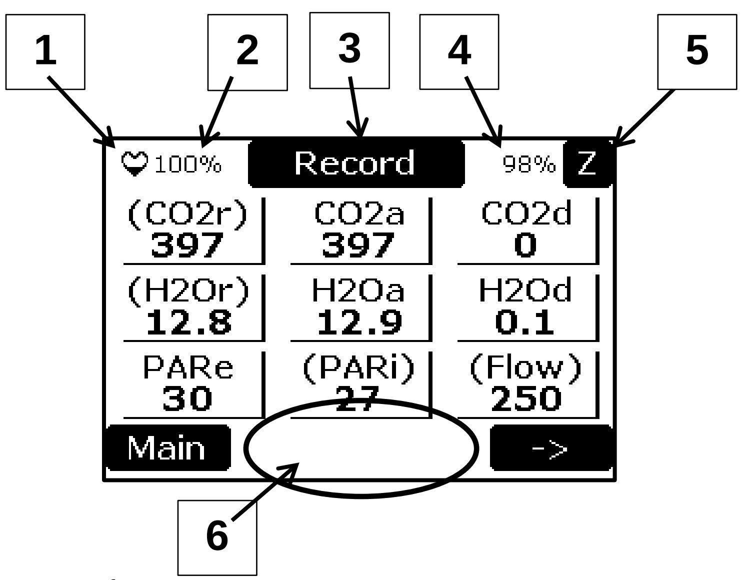
The Splash screen is always shown on the display when the TARGAS-1 is off. When the instrument is first powered up, the Splash screen is refreshed and displayed momentarily followed by the Measure screen.



General Screen Info

New screens are displayed by the user selecting either the lower left or the lower right buttons. Generally speaking, the left button brings you back to the previous screen and the right button to the next available screen.

Measure Screen Info



Each screen contains common features.

1. There is a pulsing ♥ icon to confirm that the TARGAS-1 display is actively on.
2. The percentage value in the top left corner is the percentage of battery charge remaining. If proceeded by a '+', it means the battery is being charged.
3. The Record button saves data as a marked record in the USB memory stick, and also sends the record to the host and WiFi ports. Data can also be recorded by pressing the recording switch on the PLC leaf cuvette handle.

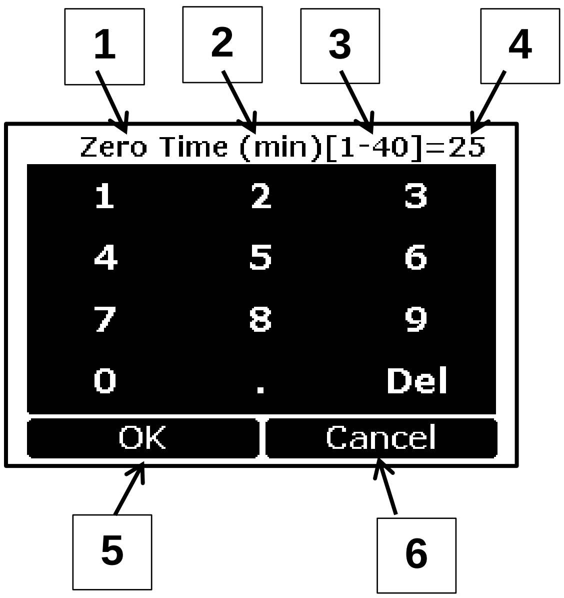
4. The percentage value in the top right corner is the estimated percentage of Auto-zero absorber column capacity remaining based on the number of zeros performed since the last time the counter was reset by the user (See Reset Zero Absorber on page 56).
5. The ‘Z’ button is used to initiate a manual zero.
6. A status or error message can be displayed in the Status Area.

Parameters in Parenthesis

Any parameter (i.e. Flow) that has a parenthesis is an active button that gives a direct link to a user adjustable setting that can be changed. On completion of the setting, it returns to the measurement screen from where it started.

Data Entry Screen

The Data Entry Screen is used to enter new numerical values. The screen is displayed whenever a new value is required.



1. The name of the parameter.
2. The units associated with the parameter.
3. The acceptable range of values.
4. The value being entered.
5. The OK button selects the entered value. If the entered value is out of range, it is set to the minimum or maximum value. It then returns to the previous screen.
6. The Cancel button returns to previous screen without changing the initial value.

Measurement Mode

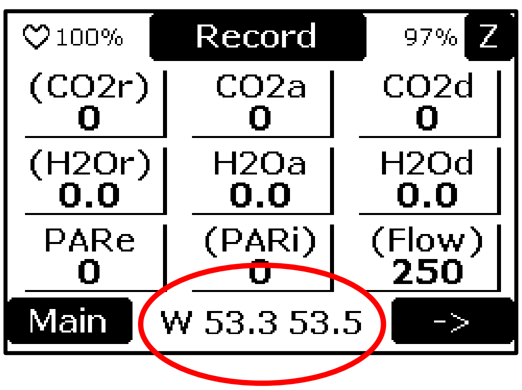
The Measurement Mode is comprised of three screens:

1. Measure Screen 1 - The initial screen is the Measure Screen 1 which displays the values of CO_2 and H_20 concentrations.
2. Measure Screen 2 - The next screen is the Measure Screen 2 which displays device relevant data.
3. Graphic Display Screen – The third screen is the Graphic Display Screen which displays graphical information over time.

Measure Screen 1

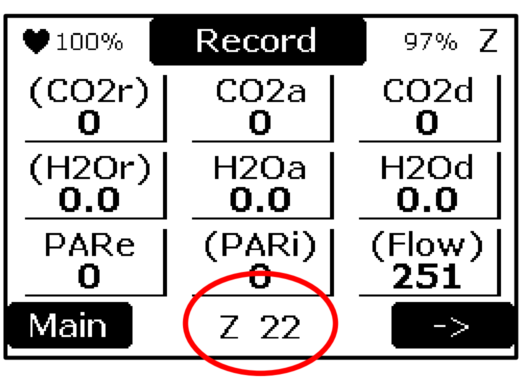
The Measure Screen 1 is displayed after the Splash screen once the TARGAS-1 is powered up. For the first 10-15 minutes, the TARGAS-1 goes into a warm-up period until it achieves its final temperature of 55°C and an Auto-Zero is performed. During this time, messages are displayed in the Status Area that indicate that the instrument is in the warm-up stage. We recommend that you have the TARGAS-1 connected to the charger to preserve the internal battery during the initial warm-up period. The buttons are operational during the warm-up period.

Warming Up



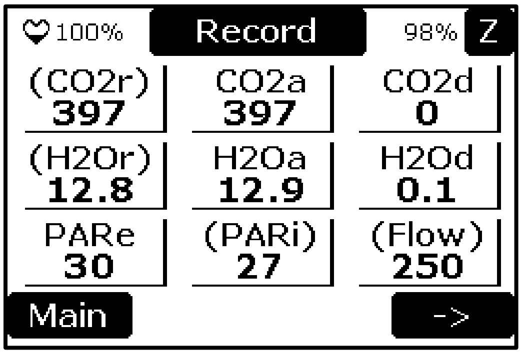
The status of '**W 53.3 53.5**' means the TARGAS-1 is warming and the CO_2 IRGA temperature is 53.3°C and the H_2O IRGA temperature is 53.5°C. During warm-up, the CO_2 and H_2O values are displayed as 0.

Performing a Zero



The status of '**Z 22**' means the TARGAS-1 is performing a zero. The number is how many seconds it will take to complete the sequence. A normal zero starts at 25 seconds. During a Zero, the CO_2 and H_2O values are displayed as 0 as the readings are not valid during the Zero sequence.

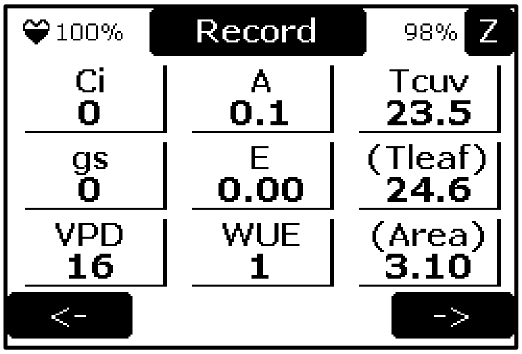
At the completion of the warm-up and the first Zero, valid readings are displayed.



Measure Screen 1	
CO2r	CO_2 Reference (ppm) · This parameter is user adjustable from 0 to ambient
CO2a	CO_2 Analysis or sample (ppm)
CO2d	CO_2 Differential (ppm)
H2Or	H_2O Reference (mb) · This parameter is user adjustable from 0 to ambient
H2Oa	H_2O Analysis or sample (mb)
H2Od	H_2O Differential (mb)
PARe	PAR External (µmol m^{-2} s^{-1})
PARi	PAR Internal (µmol m^{-2} s^{-1}) · This parameter is user adjustable up to 2500 µmol m^{-2} s^{-1} if a light unit is used
Flow	Cuvette Flow Rate (cc/min) · This parameter is user adjustable from 200-500 cc/min and it is associated with the flow of air to the leaf cuvette. The cuvette flow rate should always be at least 100 cc/min higher than the sample flow rate (see Sample Flow Setting on page 62). · The recommended flow rate is 250 cc/min. However, the cuvette flow rate can be increased if you are working with healthy plants and expecting higher rates of photosynthesis. It can be reduced if you are expecting lower rates of photosynthesis or if the leaf sample is small and not filling the entire chamber window. Note that lower cuvette flow rates will result in longer equilibration times so be a bit more patient before recording a measurement.
Main Button	The Main screen is displayed when this button is selected. See Direct Link Settings on 48.
Right Arrow	Selects the next measurement screen (Measure Screen 2).

Measure Screen 2

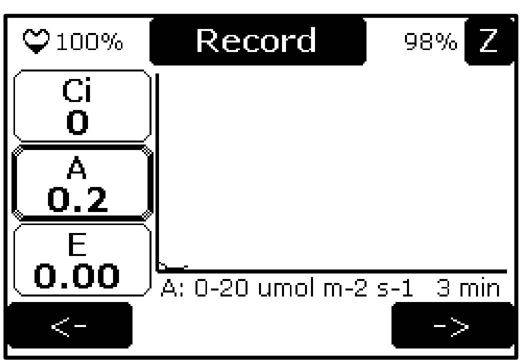
The Measure Screen 2 displays the values of nine parameters in real time.



Measure Screen 2	
Ci	Leaf internal CO_2 concentration (µmol mol^{-1})
A	Assimilation (µmol (CO_2) m^{-2} S^{-1})
Tcuv	Cuvette air temperature (^{o}C)
gs	Stomatal Conductance (mmol (H_2O) m^{-2} S^{-1})
E	Transpiration, (mmol (H_2O) m^{-2} S^{-1})
Tleaf	Leaf surface temperature (^{o}C) · This parameter is user adjustable
VPD	Vapor Pressure Deficit
WUE	Water Use Efficiency(A/E)
Area	Exposed area of the leaf (cm^2) · This parameter is user adjustable
Left Arrow	Goes back the previous screen (Measure Screen 1).
Right Arrow	Selects the next measurement screen (Graph Screen).

Graphic Display Screen

The Graphic display screen shows a real-time display of the calculated parameters Ci, A or E.



Graphical Display Screen	
Ci Button	Internal or substomatal CO_2 concentration. Fixed range: 0 – 1000 ppm
A Button	Assimilation. Fixed range: 0 - 20 µmol (CO_2) m^{-2} s^{-1}
E Button	Transpiration (Evaporation). Fixed range: 0 - 10 mmols (H_2O) m^{-2} s^{-1}
Y-axis	Range and units are located under the graph on left side
X-axis	X-axis time; fixed value of 3 minutes.
Left Arrow	Goes back the previous screen (Measure Screen 2).
Right Arrow	Selects the next measurement screen (Measure Screen 1).

To display one of the 3 calculated parameters simply press the corresponding button. Only one parameter can be displayed at a time. When selected it will be have a dark border around it.

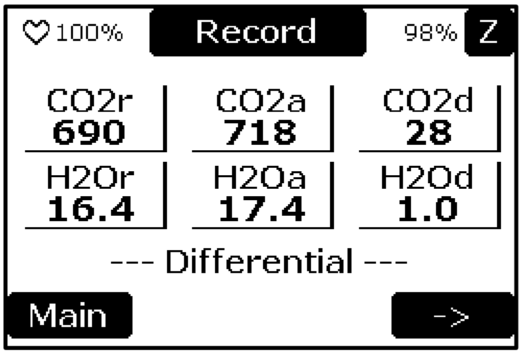
Alternative Measurement Screens

Depending on the Device Mode selection of the TARGAS-1, the Measurement screens may be different. To learn more, see Device Mode Settings on page 52 for more information.

Diff Mode

Measure Screen 1

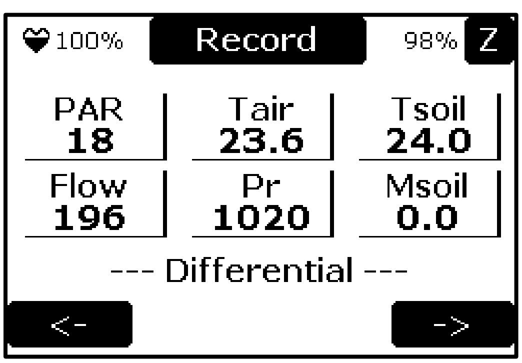
The Measure Screen 1 displays the values of six parameters in real time.



Measure Screen 1	
CO2r	CO_2 Reference reading (ppm)
CO2a	CO_2 Analysis reading (ppm)
CO2d	CO_2 Differential (ppm)
H2Or	H_2O Reference reading (mb)
H2Oa	H_2O Analysis reading (mb)
H2Od	H_2O Differential (mb)
--- Differential ---	Indicates the machine is in Differential mode
Main Button	The Main screen is displayed when this button is selected. See Direct Link Settings on 48.
Right Arrow	Selects the next measurement screen (Measure Screen 2).

Measure Screen 2

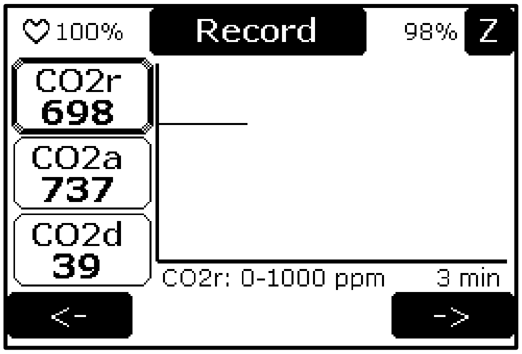
The Measure Screen 2 displays the values of six parameters in real time.



Measure Screen 2	
PARi	PAR reading from sensor (µmol m^{-2} s^{-1})
Tair	Air temperature (°C)
Tsoil	Soil temperature (°C)
Flow	Sample gas flow (cc/min)
Pr	Air pressure in IRGAs (mb)
Msoil	Soil moisture content (%)
--- Differential ---	Indicates the machine is in Differential mode
Left Arrow	Goes back the previous screen (Measure Screen 1).
Right Arrow	Selects the next measurement screen (Graph Screen).

Graphic Display Screen

The Graphic display screen shows a real-time display of CO2r, CO2a or CO2d.



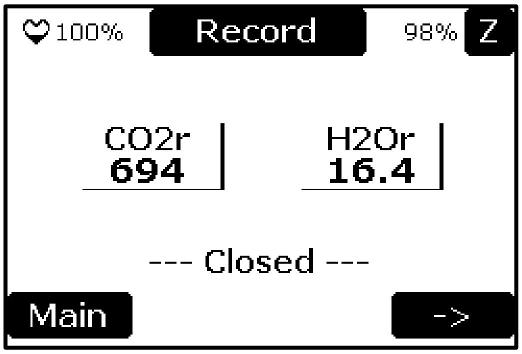
Graphical Display Screen	
CO2r Button	CO_2 Reference. Fixed range: 0 – 1000 ppm
CO2a Button	CO_2 Analysis. Fixed range: 0 – 1000 ppm
CO2d Button	CO_2 Differential. Fixed range: -50 – +50 ppm
Y-axis	Range and units
X-axis	X-axis time (range 3 minutes)
Left Arrow	Goes back the previous screen (Measure Screen 2).
Right Arrow	Selects the next measurement screen (Measure Screen 1).

To display one of the 3 parameters simply press the corresponding button. Only one parameter can be displayed at a time. When selected it will be have a dark border around it.

Closed or Absolute Mode

Measure Screen 1

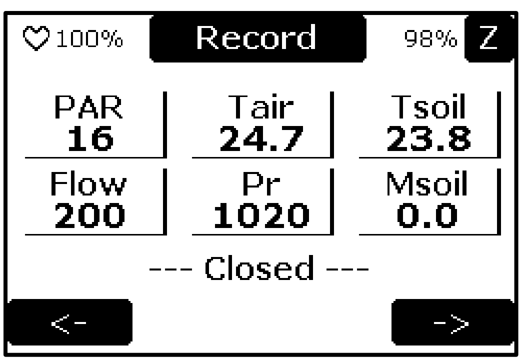
The Measure Screen 1 displays the values of 2 parameters in real time.



Measure Screen 1	
CO2r	CO_2 Reference (ppm)
H2Or	H_2O Reference (mb)
--- Closed ---	Indicates the machine is in Closed mode
Main Button	The Main screen is displayed when this button is selected. See Direct Link Settings on page 48.
Right Arrow	Selects the next measurement screen (Measure Screen 2).

Measure Screen 2

The Measure Screen 2 displays the values of six parameters in real time.

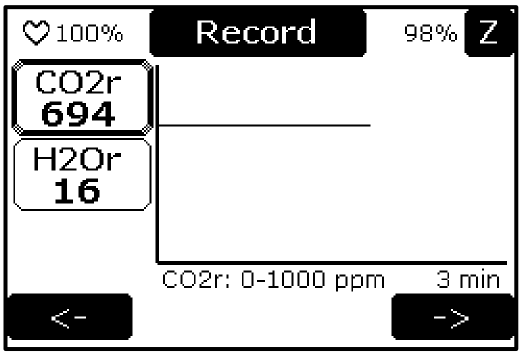


Measure Screen 2	
PARi	PAR reading from sensor (μmol m^{-2} s^{-1})
Tair	Air temperature (^oC)
Tsoil	Soil temperature (^oC)
Flow	Sample gas flow (cc/min)

Pr	Air pressure in IRGAs (mb)
Msoil	Soil moisture content (%)
--- Closed ---	Indicates the machine is in Closed mode
Left Arrow	Goes back the previous screen (Measure Screen 1).
Right Arrow	Selects the next measurement screen (Graph Screen).

Graphic Display Screen

The Graphic display screen shows a real-time display of CO2r or H2Or.



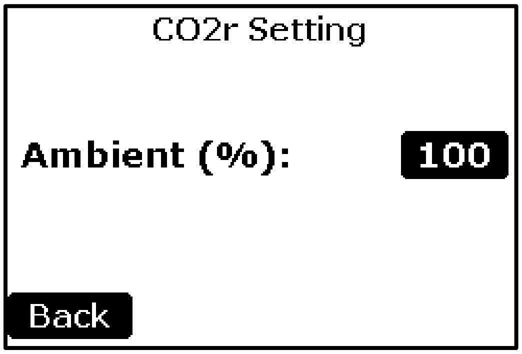
Graphical Display Screen	
CO2r Button	CO_2 Reference: Fixed range: 0 – 1000 ppm
H2Or Button	H2O Reference: Fixed range: 0 – 20 mb
Y-axis	Range and units
X-axis	X-axis time (range 3 minutes)
Left Arrow	Goes back the previous screen (Measure Screen 2).
Right Arrow	Selects the next measurement screen (Measure Screen 1).

To display one of the 2 parameters simply press the corresponding button. Only one parameter can be displayed at a time. When selected it will be have a dark border around it.

Direct Link Settings

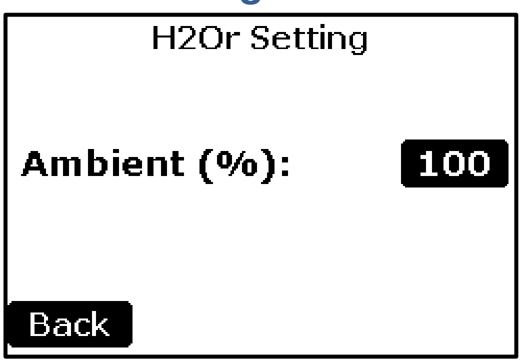
These are settings that are associated with any parameter with parenthesis around them on the 3 Measure Screens. They directly link to fields within the Measurement Screens and are user adjustable.

CO2r Setting



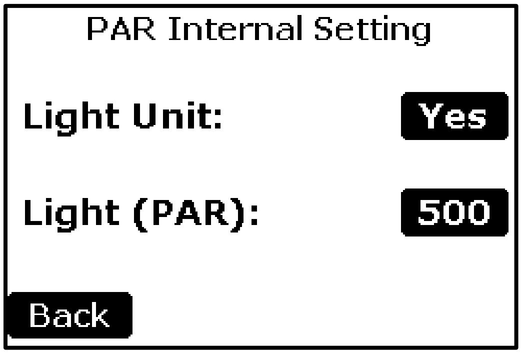
CO2r Setting	
Ambient Button	Controls the amount of CO_2 based on current ambient level. The range is from 0 to 100% of Ambient. (Default is 100%)
Back Button	Goes back to Measure Screen 1

H2Or Setting



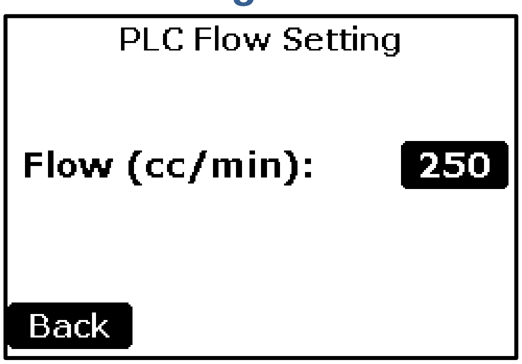
H2Or Setting	
Ambient Button	Controls the amount of H_2O based on current ambient level. The range is from 0 to 100% of ambient. (Default is 100%) Note: when Reducing CO_2 it increases the H_2O due to the absorption process.
Back Button	Goes back to Measure Screen 1

PARi Setting



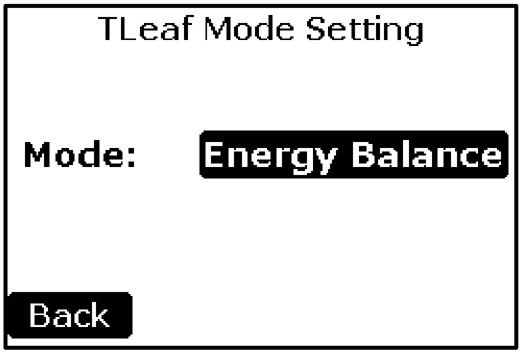
PARi Setting	
Light Unit Button	The Selection is Yes/ No Yes – Indicates that a light unit is being used. No – Indicates no light unit is being used and ambient light is your source. The PARe sensor is used to determine ambient PAR.
Light (PAR) Button	If a light unit is being used, this value then appears and is used to control the light unit. (Range is 0 - 2500 μmol m^{-2} s^{-1})
Back Button	Goes back to Measure Screen 1

Flow Setting



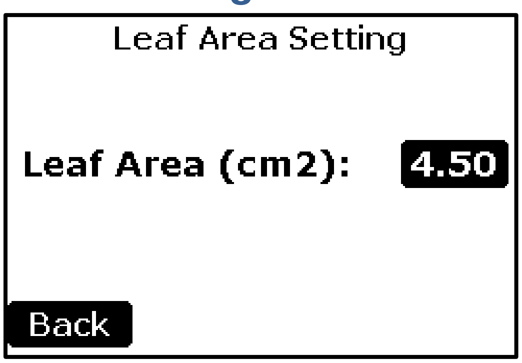
Flow Setting	
Flow Button	Sets the flow rate (cc/min) to the PLC (Range 200 - 500). The default and recommended value is 250 cc/min. However, the cuvette flow rate can be increased if you are working with healthy plants and expecting higher rates of photosynthesis. It can be reduced if you are expecting lower rates of photosynthesis or if the leaf sample is small and not filling the entire chamber window. Note that lower cuvette flow rates will result in longer equilibration times so be a bit more patient before recording a measurement.
Back Button	Goes back to Measure Screen 1

TLeaf Setting



TLeaf Setting	
Mode Button	Select the leaf temperature measurement method (Energy Balance or Chamber Temperature)
Back Button	Goes back to Measure Screen 2

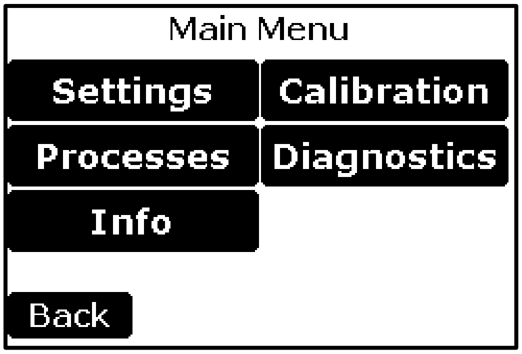
Area Setting



Area Setting	
Leaf Area Button	Sets the Leaf Area (cm^2) used in the photosynthesis calculations. (Range 0.5 – 4.50). If the leaf cuvette is filled completely then 4.50 is the proper value.
Back Button	Goes back to Measure Screen 2

Main Menu

This Main Menu screen is the top level menu for all settings and user functionality of the system.



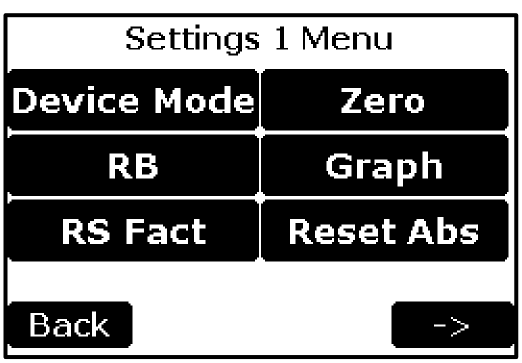
Main Menu	
Settings	Controls major settings of the TARGAS-1. There are four sub menus under Settings. See Settings on page 51.
Processes	Performs the TARGAS-1 Processes available depending on probe/sensor used with the TARGAS-1. See Processes on page 68 for more details.
Calibration	Used to calibrate the CO_2 gas analyzer, H_2O gas analyzer, PLC PAR Sensor, PLC light Unit, and the Touch Screen. See Calibration on page 92.
Diagnostics	Performs system diagnostics for troubleshooting purposes. See Diagnostics on page 102 for more details.
Info	To obtain version information and contact info
Back Button	Goes back to Measure screen 1

Settings

There are four settings menus; Settings 1-4. Generally, the settings have been grouped related to their frequency of change and common functionality.

Settings 1 Menu

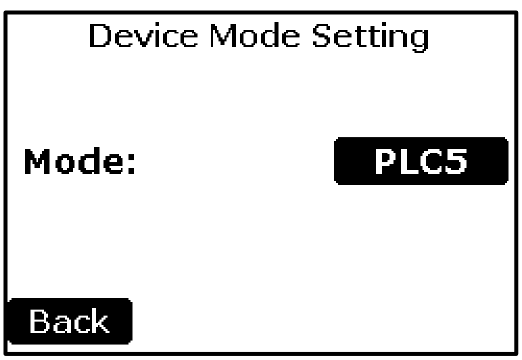
This menu contains the first tier and most common settings for the TARGAS-1 including the Device Mode, Zero, RB value of PLC, Graph settings, RS factor to use, and Reset Abs (Reset Absorber Column).

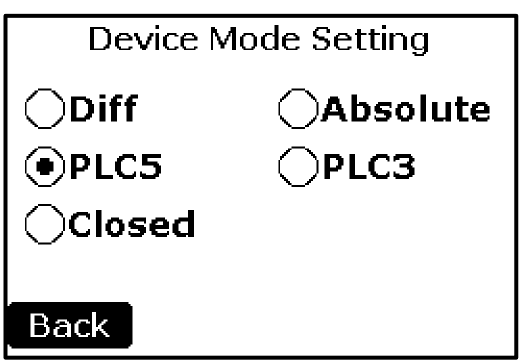


Settings 1 Menu	
Device Mode	To select the operational mode of the TARGAS-1
RB	To set the r_b factor for cuvette. The initial value recorded at the PP Systems' factory is written on the "Tested" label affixed to the PLC handle.
RS Fact	To set the RS factor for leaf photosynthesis
Zero	Change/view the settings associated with the zero (zero type and time interval for performing zeros).
Graph	To set the range Y Axis for the graph in the Injection Process.
Reset Abs	To indicate that absorber material has been replaced and reset.
Back Button	Returns to the Main Menu.
Right Arrow	Continues to the Settings 2 Menu screen.

Device Mode Settings

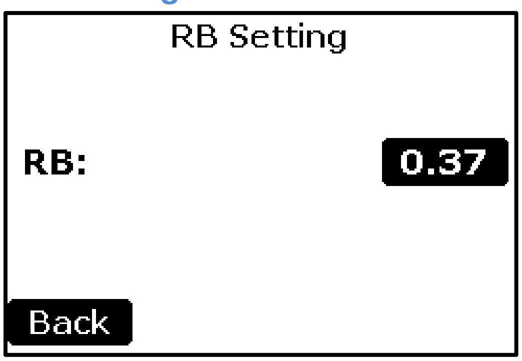
This function allows the user to change/view the Device Mode used by the TARGAS-1. The TARGAS-1 has one CO_2 IRGA and one H_2O IRGA. In Absolute mode and Closed mode, gas is sampled continuously from the GAS IN port and CO_2 and H_2O concentration is updated every 1.0 second. In the Differential mode and the PLC modes, gas is sampled alternately from the GAS IN port which represents the reference gas, and the PLC port which represents the analysis gas. At the default gas switching frequency of 5 seconds, the reference readings CO2r and H2Or will be updated every 10 seconds; the analysis readings CO2a and H2Oa will also be updated every 10 seconds, but at 5 seconds after the reference values are updated. Other values such as temperature, flow and calculations are always updated every 1.0 second. The switching frequency can be adjusted in the Settings 3 menu as Ref On Time and An On Time.





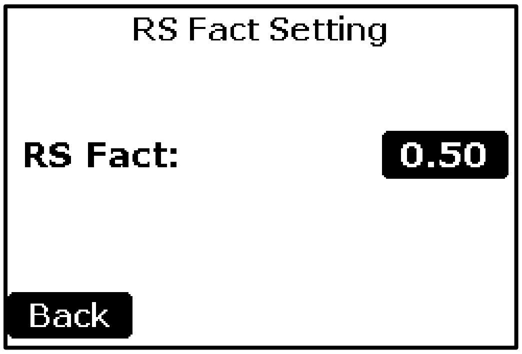
Device Mode Settings	
Diff Button	Sets the TARGAS-1 to operate as a Differential Analyzer
Absolute Button	Sets the TARGAS-1 to operate as an Absolute Analyzer (recommended for using the TARGAS-1 as a stand-alone CO_2/H_2O gas analyzer)
PLC5 Button	Sets the TARGAS-1 to operate as a photosynthesis system with a PLC5 style leaf cuvette
PLC3 Button	Sets the TARGAS-1 to operate as a photosynthesis system with a PLC3 style leaf cuvette
Closed Button	Sets the TARGAS-1 to operate as an Absolute Analyzer for closed system measurements (normally for use with the SRC-2 Soil Respiration Chamber and CPY-5 Canopy Assimilation Chamber)
Back Button	Returns to the Settings 1 Menu.

RB Setting



RB Setting	
RB Value Button	To set the r_b factor (boundary layer resistance) for the PLC5 or PLC3 leaf cuvette. The initial value recorded at the PP Systems' factory is stored in your TARGAS-1 console when supplied as a new instrument and it is also written on the "Tested" label affixed to the PLC handle (m^2 s mol^{-1}). The factory set value should remain consistent during normal use. If you have any questions about r_b please contact PP Systems for more information.
Back Button	Returns to the Settings 1 Menu.

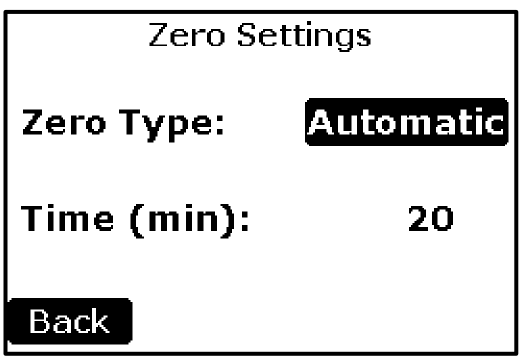
RS Factor Setting



RS Factor Setting	
RS Factor Value Button	To set the RS factor (stomata ratio) for your plant type. Enter a known or estimated fraction of upper leaf surface stomata for your leaf sample. 0.50 represents equal stomata on upper and lower leaf surfaces, 0.0 represents stomata on the lower leaf surface only, 1.0 represents stomata on the upper leaf surface only.
Back Button	Returns to the Settings 1 Menu.

Zero Settings

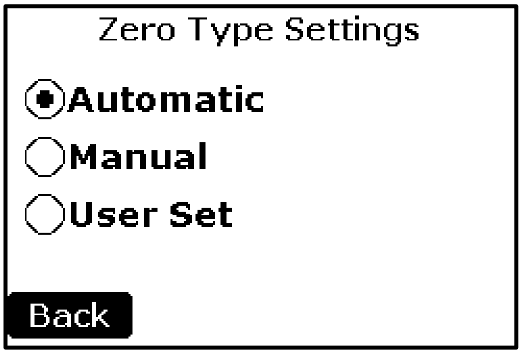
This function allows the user to change/view the zero parameters used by the TARGAS-1.



Zero Settings	
Zero Type Button	There are three types of zeros that can be performed; Automatic, Manual and User Set. **WE RECOMMEND AUTOMATIC.**
Time Button	Zero time is the interval between zeros in minutes. Time is always 20 minutes for Automatic. When Zero Type is set to User Set, the time can be selected and set.
Back Button	Returns to the Settings 1 Menu.

Zero Type Settings

Press the desired setting either directly on the radio button or on the text to the right of the radio button. Then select the Back button to return to the Zero Settings screen. The Zero Settings screen will return with the updated Zero Type value in the button box.

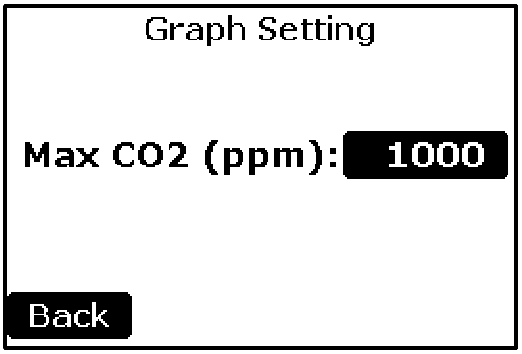


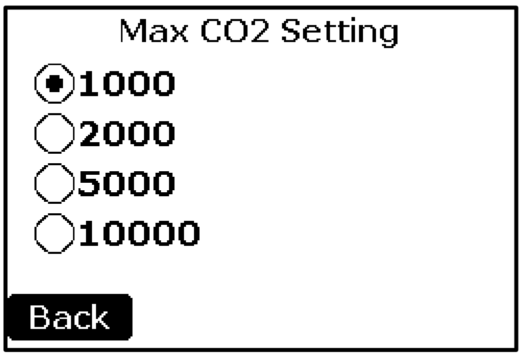
Zero Type Settings	
Automatic	This is the default and recommended Zero Type. The TARGAS-1 performs a zero more frequently initially after achieving the IRGA warm-up temperature (55 ^{o}C). At completion of warm-up it will perform an initial zero, then again after 3 minutes, then again after 6 more minutes, then after 12 minutes, then every 20 minutes thereafter. The Zero Time interval is fixed at 20 minutes.
Manual	A zero can be initiated at any time and regardless of the Zero Type Setting by pressing the Z button in the upper right hand corner of the display.
User Set	When selected, the TARGAS-1 performs a zero on start up, then again after 3 minutes, then again after 6 more minutes, then after 12 minutes, then finally after 20 minutes. It then performs zeros at the user-specified interval. It can be set from 1 to 40 minutes.
Back Button	Returns to the Zero Settings screen.

Important Notes

A Zero can be performed at any time either automatically or using the “Z" button in the Measure Screens. In this case, the timer resets back to zero and will perform another zero when the Zero Time interval has elapsed.

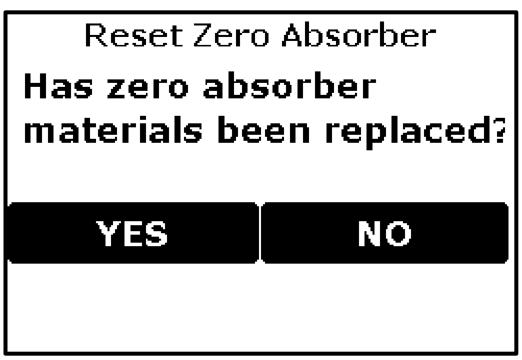
Graph Setting





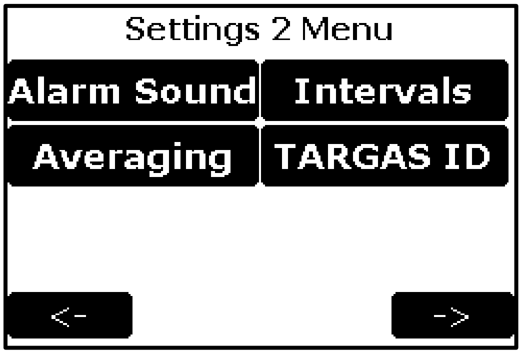
Max CO2 Setting	
Radio Buttons	To set the CO2 Y-axis range for the graph associated with the Injection Process.
Back Button	Returns to the Graph Settings screen.

Reset Zero Absorber



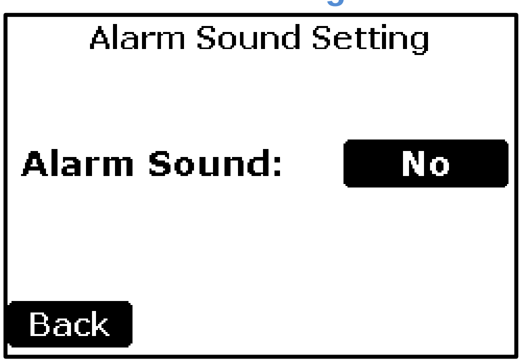
Reset Zero Absorber	
Yes Button	Reset the Zero Absorber capacity gauge to 100%. This should be set every time the molecular sieve is changed in the Auto-Zero column to ensure reporting accuracy.
No Button	Returns to the Settings 1 Menu with resetting the Zero Absorber capacity gauge.

Settings 2 Menu



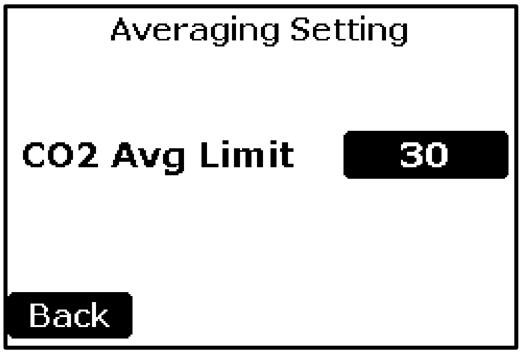
Settings 2 Menu	
Alarm Sound	To enable or disable the alarm sounds
Averaging	Sets the CO_2 averaging value range
Intervals	To control the frequency that data is sent
TARGAS ID	To select an ID number of the TARGAS-1
Back Button	Returns to the Settings 1 Menu screen.
Right Arrow	Continues to the Settings 3 Menu screen.

Alarm Sound Setting



Zero Settings	
Alarm Sound Button	To Select Yes or No (enable or disable the Alarm Sound)
Back Button	Returns to the Settings 2 Menu.

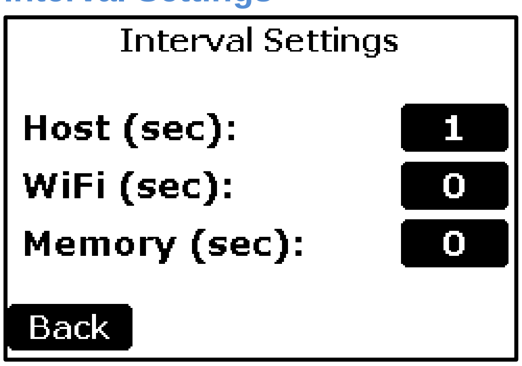
Averaging Setting



Averaging Setting	
CO2 Avg Limit Value Button	To select the CO_2 limit in which the CO_2 is being averaged. This only applies to Absolute Mode.
Back Button	Returns to the Settings 2 Menu.

Running Average: When in absolute mode only, an exponential running average filter can be applied to smooth out small fluctuations while remaining sensitive to larger differences by using an Average Limit value. Whenever a new reading differs from the current running average by more than the CO_2 Avg Limit value, a new running average begins. Thus, when the CO_2 concentration is changing rapidly, averaging is suspended and the instrument can track changes at the basic instrument data rate of 1 second. When the CO_2 Avg Limit is set to 0, no running average is performed. The running average filter response time is 3.5 seconds to reach 66% of a new value, and 16 seconds to reach 99%. In other words, if Avg Limit is set above 100 ppm and the inlet sample gas concentration instantaneously changed by 100 ppm, it would take 4 seconds for the CO_2 reading to change by 66 ppm; then after 16 seconds, the measured value would change by 99 ppm.

Interval Settings

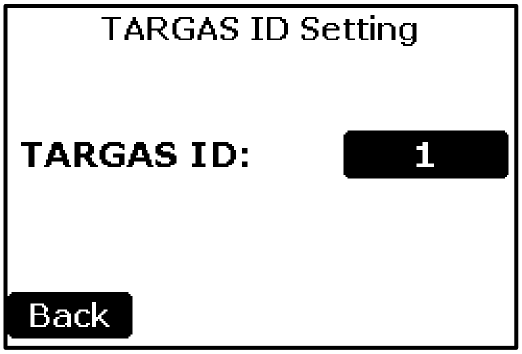


Interval Settings	
Host Button	To set the time interval between data writes to the Host Port (normally the USB connection to an external PC). Time is in Seconds and the value 0 turns off data writes. The default is 1.
Wifi Button	To set the time interval between data writes to the Wifi Port. Time is in Seconds and the value 0 turns off data writes. The default is 0.

Memory Button	To set the time interval between data writes to the USB Memory Stick. Time is in Seconds and the value 0 turns off data writes. The default is 0.
Back Button	Returns to the Settings 2 Menu.

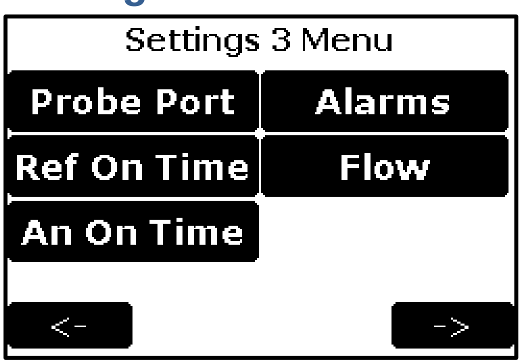
Note: A manual record initiated by hitting **RECORD** on the touchscreen always sends data to the devices.

TARGAS ID Setting



Averaging Setting	
TARGAS ID Button	To Select device ID Range 0-9 (the Default is 1)
Back Button	Returns to the Settings 2 Menu.

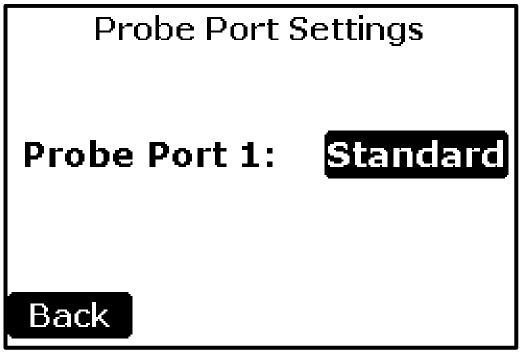
Settings 3 Menu



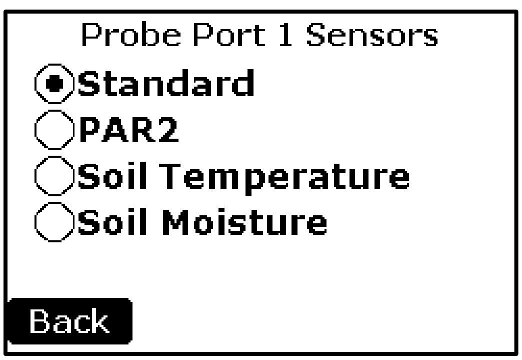
Settings 3 Menu	
Probe Port	To select the probe type being used in Port 1
Ref On Time	To set the time duration of the Reference sample time (seconds)
An On Time	To set the time duration of the Analysis sample time (seconds)
Alarm	To set the CO_2 limits low and high which will cause an alarm

Flow	To set sample flow
Back Button	Returns to the Settings 2 Menu screen.
Right Arrow	Continues to the Settings 4 Menu screen.

Probe Port Settings



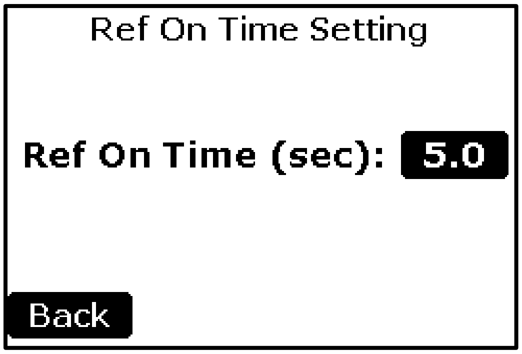
Probe Port Settings	
Probe Port 1 Button	To Select Probe Type
Back Button	Returns to the Settings 3 Menu.



Interval Setting	
Standard	For use with the following probes manufactured by PP Systems: · SRC-2 Soil Respiration Chamber · CPY-5 Canopy Assimilation Chamber · TRP-3 Temperature/PAR Probe
Quantum	For use with the Apogee Quantum Sensor.
Soil Temperature	For use with the STP-2 Soil Temperature Probe.

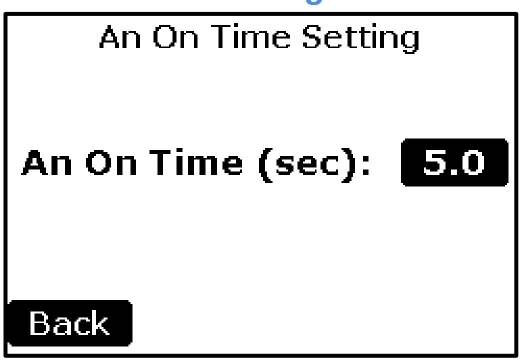
Soil Moisture	For use with the Stevens Soil Moisture Sensor.
Back Button	Returns to the Probe Port Settings screen.

Ref On Time Setting



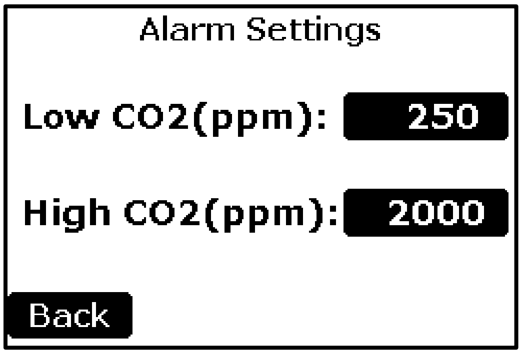
Ref On Time Settings	
Ref On Time Button	To set the duration of the Reference time in seconds (range 3-15). This is used in Differential and Photosynthesis Modes (default is 5)
Back Button	Returns to the Settings 3 Menu.

An On Time Setting



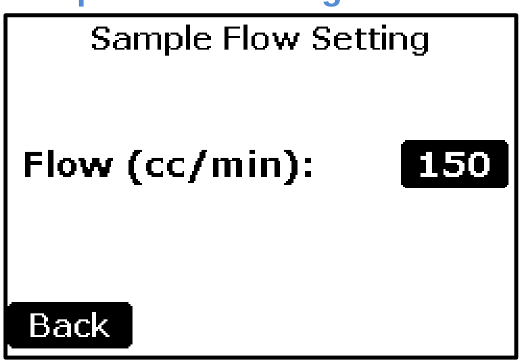
An On Time Settings	
AN On Time Button	To set the duration of the Analysis time in Seconds (range 3-15). This is used in Differential and Photosynthesis Modes (default is 5)
Back Button	Returns to the Settings 3 Menu.

Alarm Settings



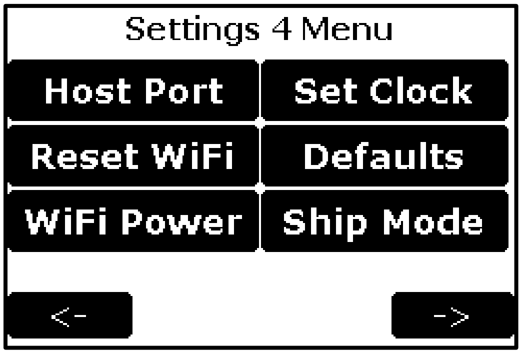
Alarm Settings	
Low CO2 (ppm) Button	To set the low CO_2 limit value at which an error is generated.
High CO2 (ppm) Button	To set the high CO_2 limit value at which an error is generated.
Back Button	Returns to the Settings 3 Menu.

Sample Flow Setting



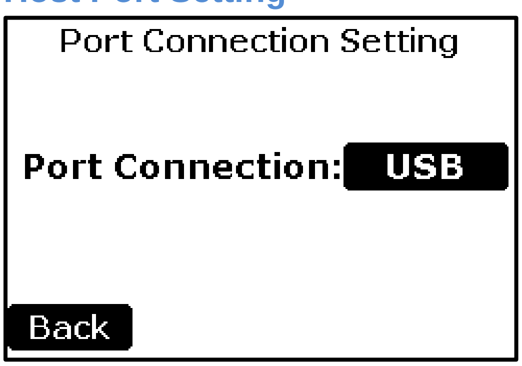
Sample Flow Settings	
Flow (cc/min) Button	To set the sample flow rate (cc/min). Range: 50 -200 cc/min. It is user adjustable but the default value and recommended value is 150 cc/min. This parameter represents the flow rate of the sample air by the analyzer. **Note:** when selecting Device Mode, it sets the sample flow to the correct values.
Back Button	Returns to the Settings 3 Menu.

Settings 4 Menu



Settings 4 Menu	
Host Port	**Not implemented and available for potential future use.** To select which Port to connect Host.
Reset WiFi	**Not implemented and available for potential future use.** To reset Wi-Fi to Factory Settings (if installed)
WiFi Power	**Not implemented and available for potential future use.** To Enable Wi-Fi (if installed)
Set Clock	To set the time and date of the TARGAS-1
Defaults	To reset all parameters to factory defaults This function allows the user to initialize the TARGAS-1 to its factory default values. This feature may be needed to correct an erroneous calibration, or to simply undo undesirable configuration changes.
Ship Mode	To Put the TARGAS-1 into a state to prevent the batteries from being used. This is used when shipping the machine.
Back Button	Returns to the Settings 3 Menu screen.
Right Arrow	Continues to the Settings 1 Menu screen.

Host Port Setting

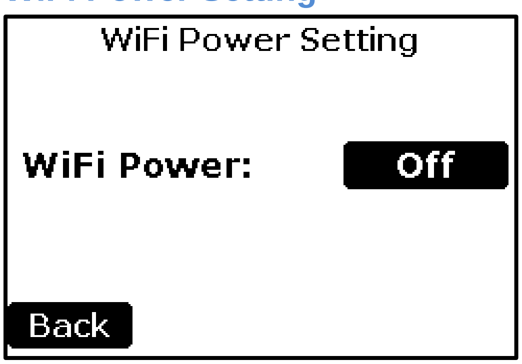


Host Port Setting	
Port Connection Button	To select which Port to connect Host. · USB · Wi-Fi
Back Button	Returns to the Settings 4 Menu.

Reset WiFi Settings

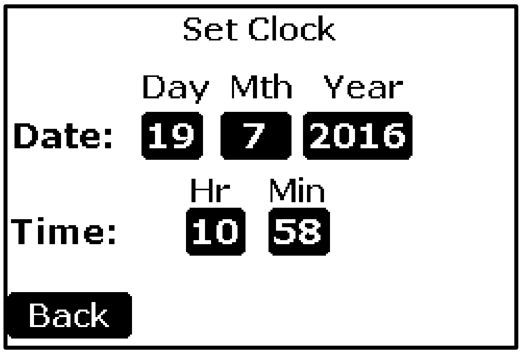
Reset WiFi Settings	
Yes	Reset Wi-Fi to original Factory Settings then returns to Settings 4 Menu
No	Returns to the Settings 4 Menu without resetting Wi-Fi

WiFi Power Setting



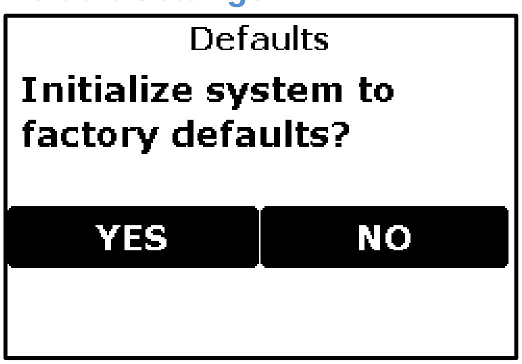
WiFi Power Settings	
WiFi Power Button	To enable or disable the Wi-Fi (if installed)
Back Button	Returns to the Settings 4 Menu.

Set Clock Settings



Set Clock Settings	
Day Button	To set the day (1 – 31)
Mth Button	To set the month (1 -12)
Year Button	To set the year (20XX)
Hr Button	To set the hour (0 – 23) (24 hour format)
Min Button	To set the minutes (0 – 59)
Back Button	Returns to the Settings 4 Menu.

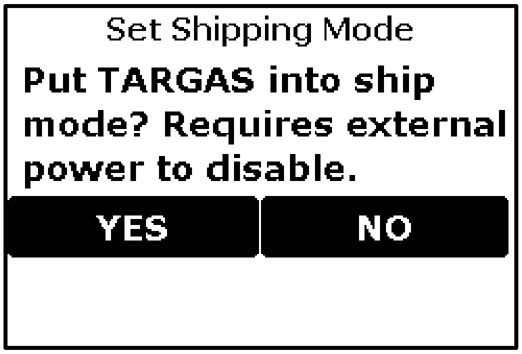
Default Settings



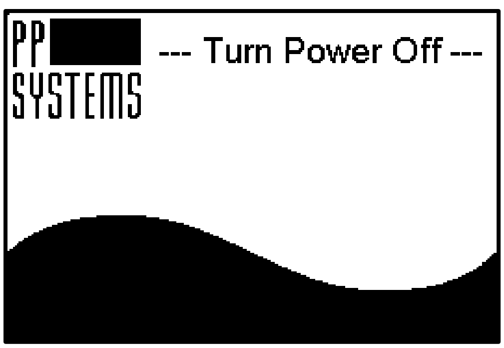
Default Settings	
Yes	Resets TARGAS-1 to original factory settings then returns to Settings 4 Menu
No	Returns to the Settings 4 Menu with no changes.

Ship Mode Settings

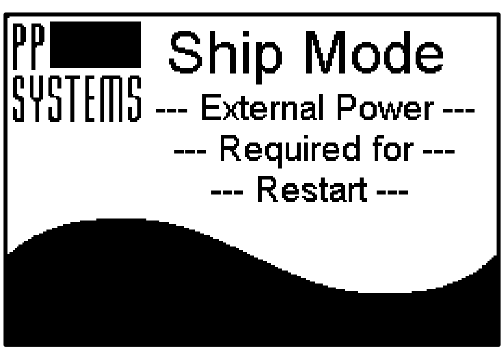
We recommend that you put the instrument into Ship Mode any time you are transporting the instrument in order to keep the instrument from accidental power up.



Ship Mode Settings	
Yes	To put the TARGAS-1 into a state to prevent the batteries from being used. Note: After selecting Yes the power switch must be turned off to complete the action. A new Splash Screen will appear.
No	Returns to the Settings 4 Menu with no changes.



Turn the power switch to the off position. Once the power is off it advances to the next screen, which will remain until the system is powered up using the external power supply/charger supplied by PP Systems.

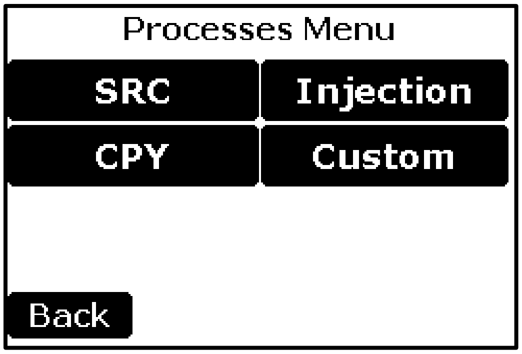


Important Note

In order to get the TARGAS-1 out of “Ship Mode” you must first connect the power supply/charger to the EXT POWER jack before turning the instrument on. If you do not have the power supply/charger connected, you will not be able to power up the instrument.

Processes

This menu handles the various processes of the TARGAS-1.



Information Menu	
SRC Button	Starts the Soil Respiration Chamber (SRC) process.
CPY Button	Starts the Canopy Assimilation Chamber (CPY) process.
Injection Button	Starts the Injection process using the “Sample Injection Kit” from PP Systems.
Custom Button	Starts the Custom process (for use with customer’s own chambers).
Back Button	Returns to the Main Menu.

SRC (Soil Respiration Chamber) Process

This process is used in conjunction with our SRC-2 Soil Respiration Chamber for measurement of closed system soil CO_2 efflux. In the SRC process, the respiration rate (g m^{-2} hr^{-1}) is calculated by measuring the rate of change (increase) in the chamber CO_2 concentration over a period of time. The TARGAS-1 calculates both a linear fit and a quadratic fit to the measured data. The data is checked in the quadratic fit to determine if the data is linear.

While the TARGAS-1 is in the SRC measuring mode, additional data is added to the output data string: change in CO_2 (dC), process time (dT), Linear respiration rate (L), and Quadratic respiration rate (Q).

Once the SRC Mode is entered, it correctly configures the TARGAS-1 settings for the process.

Connecting the SRC-2 Soil Respiration Chamber to the TARGAS-1

The SRC-2 Soil Respiration Chamber has one electrical connection and two pneumatic connections. The electrical connection is made to the socket labeled **PLC** on the TARGAS-1 and the pneumatic connections are to the **GAS IN** and **GAS OUT** connectors as shown here. The tubing on the SRC-2 is labeled accordingly for gas connections. An air filter is also included on the **GAS IN** line on the SRC-2.

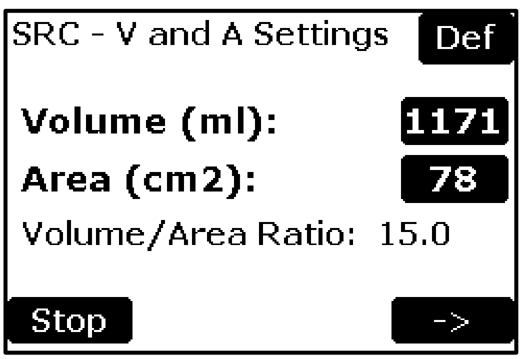
SRC – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the SRC process.

SRC – Start Process	
Back Button	Returns to the Processes Menu.
Right Arrow Button	Confirms and starts the SRC process by displaying the SRC – Volume and Area Settings screen (Step 2).

SRC – Volume and Area Settings (Step 2)

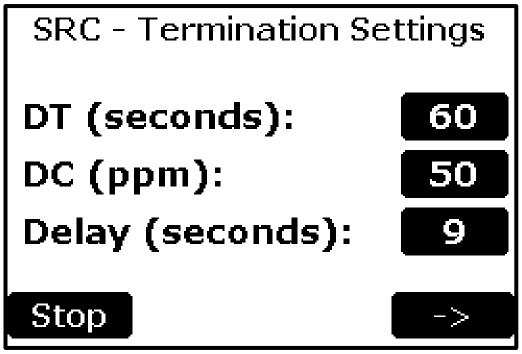
The volume and area settings are defined in this screen.



SRC – V and A Settings	
Def Button	Sets the volume and area values back to the defaults.
Volume Button	Sets the volume of the system. Entries between 1,000 and 2,000 ml are permitted. Default is 1171 ml.
Area Button	Sets the surface area of the chamber. Entries between 50 and 100 cm^2 are permitted. The default value is 78 cm^2.
Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop Button	Stops the SRC process and returns to the Processes Menu.
Right Arrow Button	Continues to SRC – Termination Settings screen (Step 3).

SRC – Termination Settings (Step 3)

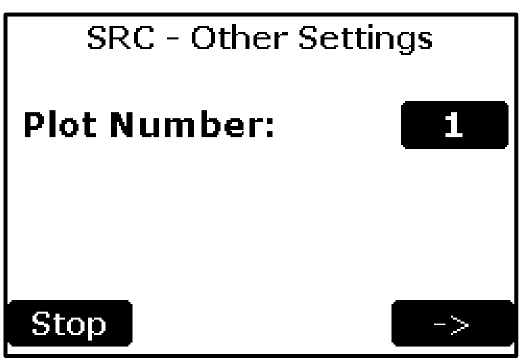
The Termination settings (DT, DC) as well as delay are defined in this screen. These settings define the end conditions for the SRC process. Each new measurement session will begin after the specified Delay, and will terminate when either the elapsed time reaches the DT value, or when the total change in CO_2 exceeds a specified threshold (DC), whichever occurs first.



SRC – Termination Settings	
DT Button	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC Button	Maximum positive change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value, the session will end. Valid entries are between 1 - 1000 ppm.
Delay Button	The amount of time the instrument waits at the start of each session before it starts calculating respiration. Valid entries are between 5 – 150 seconds.
Stop Button	Stops the SRC process and returns to the Processes Menu.
Right Arrow Button	Continues to SRC – Other Settings screen (Step 4).

SRC – Other Settings (Step 4)

The plot number is defined in this screen to allow the user to identify different sampling plots.



SRC - Other Settings	
Plot Number Button	Change/View plot number. Range: 0–1000.
Stop Button	Stops the SRC process and returns to the Processes Menu.
Right Arrow Button	Continues to SRC Flushing screen (Step 5).

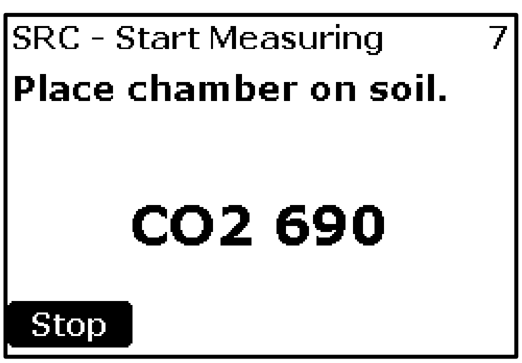
SRC Flushing (Step 5)

At this stage, the SRC chamber should be held in the air to allow it to flush out prior to placing it on the soil. During the flushing, the internal fan of the SRC is sped up to help flush. The number at the top right of the screen (23 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, SRC Step 6 will be displayed.

SRC – Prepare Chamber Menu (Step 5)	
CO2	Current CO_2 concentration (ppm).
23	Countdown in seconds (from 25 to 0).
Stop	Stops the SRC process and returns to SRC – Other Settings menu (Step 4).

SRC – Start Measuring (Step 6)

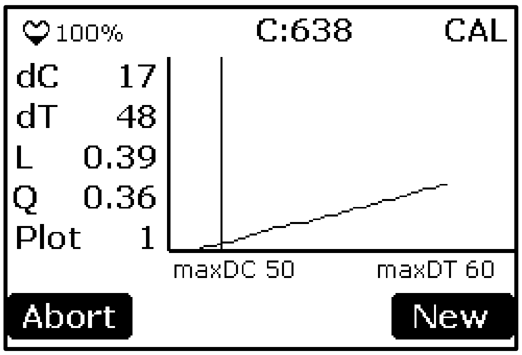
At this stage, the SRC chamber should be placed on the soil. The internal fan is set to a low speed to provide an even concentration of CO_2. The number at the top right of the screen (7 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, the Data Plot Screen will be displayed.



SRC – Start Measuring Menu	
CO2	Current CO_2 concentration (ppm).
7	Countdown in seconds (from 10 to 0)
Stop	Stops the SRC process and returns to SRC – Other Settings menu (Step 4).

Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.



SRC Data Plot Screen	
♥ (Heartbeat)	Pulses to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining (%).
C: 638	Current CO_2 concentration (ppm).
Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the delay value specified in SRC – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The difference in CO_2 concentration (ppm) from time = 0 seconds.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear respiration rate (g m^{-2} hr^{-1}).
Q	Quadratic respiration rate (g m^{-2} hr^{-1}).
Plot	Plot number defined by user in SRC – Other Settings (Step 4).
X-axis	Time (0 to maxDT seconds). Vertical line represents start of calculations.
Y-axis	dC (change in CO_2 concentration from start of measurement. 0 to maxDC (ppm)
maxDC	Maximum positive change in CO_2 concentration (ppm) allowed in a given session. This value is defined in SRC – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in SRC – Termination Settings (Step 3).

Abort	Stops the SRC process and returns to SRC – Other Settings (Step 4). Only the individual CO_2 measurements are saved to the USB flash drive. Process data is discarded.
New	Stops the SRC process and returns to SRC – Other Settings (Step 4). Results are saved to the USB flash drive.

The measurement sequence will terminate when the maxDC or maxDT is reached. If maxDT is reached first, the message “Time limit” will appear in the status box. If maxDC is reached first, the message “CO2 limit” will appear in the status box.

For more information on the theory and calculation of soil respiration/canopy assimilation, please refer to Appendix 2. Soil CO_2 Efflux and Net Canopy CO_2 Flux on page 144.

CPY (Canopy Assimilation Chamber) Process

This process is used in conjunction with our CPY-5 Canopy Assimilation Chamber for measurement of closed-system net canopy CO_2 flux. In the CPY process, the assimilation rate (µmol m^{-2} s^{-1}) is calculated by measuring the rate of change (decrease) in the chamber CO_2 concentration. The TARGAS-1 calculates both a linear fit and a quadratic fit to the measured data. The data is checked in the quadratic fit to determine if the data is linear.

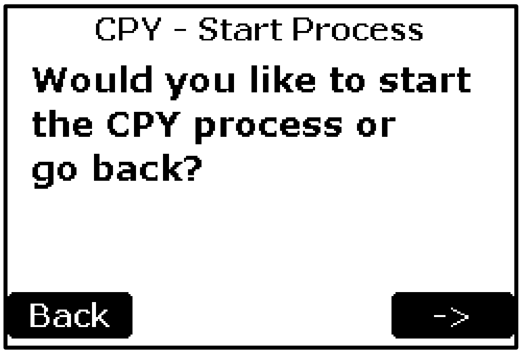
While the TARGAS-1 is in the CPY measurement mode, additional data is added to the output data string: change in CO_2 (dC), process time (dT), Linear respiration rate (L), and Quadratic respiration rate (Q).

Connecting the CPY-5 Canopy Assimilation Chamber to the TARGAS-1

The CPY-5 Canopy Assimilation Chamber has one electrical connection and two pneumatic connections. The electrical connection is made to the socket labeled **PLC** on the TARGAS-1 and the pneumatic connections are to the **GAS IN** and **GAS OUT** connectors as shown here. The tubing on the CPY-5 is labeled accordingly for gas connections. An air filter is also included on the **GAS IN** line on the CPY-5. For best results we also recommend using the H_2O equilibrator (Part No. 10049-2) on the **GAS IN** line as shown to assist with reducing the build-up of humidity in the gas stream.

CPY – Start Process (Step 1)

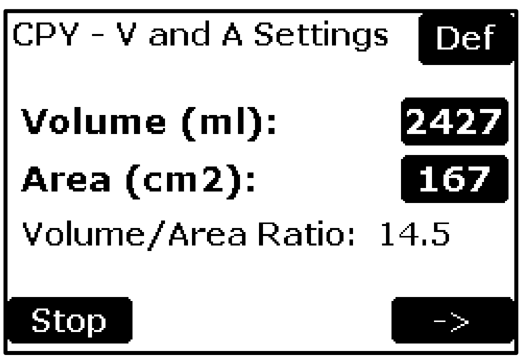
The first screen asks the user to confirm that they would like to start the CPY process.



CPY – Start Process Menu	
Back Button	Returns to the Processes Menu.
Right Arrow Button	Confirms and starts the CPY process by displaying the CPY – Volume and Area Settings menu (Step 2).

CPY – Volume and Area Settings (Step 2)

The volume and area settings are defined in this screen.



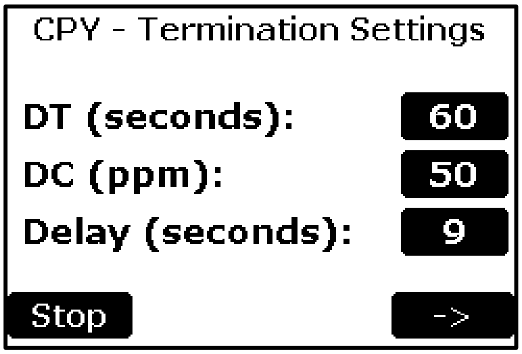
Important Note. The above values are based on the default volume for the CPY-5 Canopy Assimilation Chamber only. You must remember to account for any volume changes in order for the instrument to properly calculate assimilation rates. If using collars, please make sure that you adjust the volume accordingly.

CPY – Volume and Area Settings Menu	
Def Button	Sets the volume and area values back to the defaults.
Volume Button	Sets the volume of the system. Entries between 1,000 and 5,000 ml are permitted. Default is 2427 ml.
Area Button	Sets the surface area of the chamber in cm^2. Entries between 150 and 200 cm^2 are permitted. The default value is 167 cm^2.

Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop Button	Stops the CPY process and returns to the Processes Menu.
Right Arrow Button	Continues to CPY – Termination Settings menu (Step 3).

CPY – Termination Settings (Step 3)

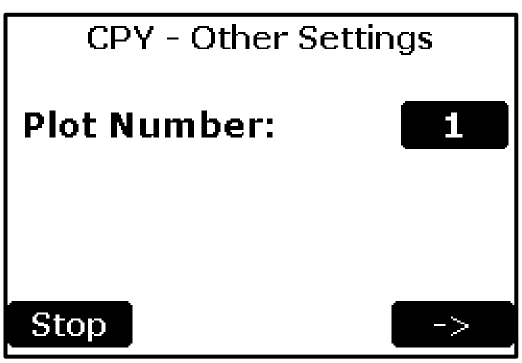
The Termination Settings (DT, DC) as well as Delay are defined in this screen.



CPY – Termination Settings Menu	
DT Button	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC Button	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value the session will end. Valid entries are between 1 - 1,000 ppm.
Delay Button	The amount of time the instrument waits at the start of each session before it starts calculating assimilation. Valid entries are between 5 – 150 seconds.
Stop Button	Stops the CPY process and returns to the Processes Menu.
Right Arrow Button	Continues to CPY – Other Settings Menu (Step 4).

CPY – Other Settings (Step 4)

The plot number is defined in this screen.



CPY – Other Settings Menu	
Plot Number Button	Change/View plot number. Range: 0–1000.
Stop Button	Stops the CPY process and returns to the Processes Menu.
Right Arrow Button	Continues to CPY – Prepare Chamber menu (Step 5).

CPY – Prepare Chamber (Step 5)

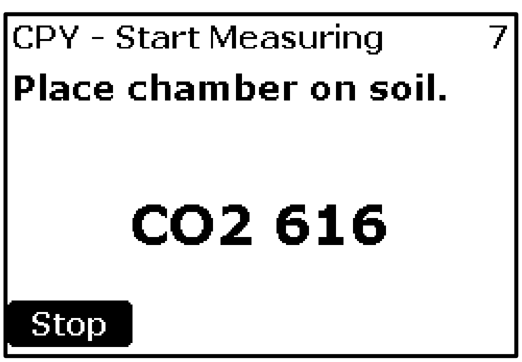
This screen instructs the user to prepare the chamber.

CPY – Prepare Chamber Menu	
CO2 (ppm)	Current measurement of CO_2 concentration (ppm).
23	Countdown in seconds (from 25 to 0)
Stop Button	Stops the CPY process and returns to CPY– Other Settings (Step 4).

At this stage, the CPY chamber should be held in the air to allow it to flush out prior to placing it on the soil. During this step, the internal fan of the CPY is sped up to help flush the chamber. The number at the top right of the screen (23 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, the process will proceed to the CPY – Start Measuring screen (Step 6).

CPY – Start Measuring (Step 6)

This screen instructs the user to place the chamber on the soil to commence measuring.

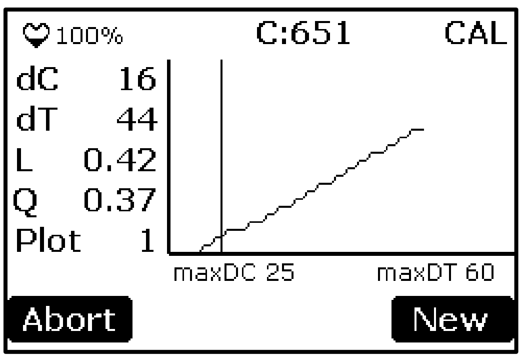


CPY – Start Measuring Menu	
CO2 (ppm)	Current measurement of CO_2 concentration (ppm).
7	Countdown in seconds (from 10 to 0)
Stop Button	Stops the CPY process and returns to CPY – Other Settings (Step 4).

At this stage, the CPY chamber should be placed on the soil. The internal fan is set to a low speed to provide an even concentration of CO_2. The number at the top right of the screen (7 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, CPY Data Plot Screen (Step 7) will be displayed.

CPY Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.



CPY Data Plot Screen	
♥ (Heartbeat)	Pulses to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining.
C: 651	Current measurement of CO_2 Concentration (ppm).
Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the delay value specified in CPY – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The current difference in CO_2 concentration (ppm) from time = 0 seconds. Normally in assimilation, CO_2 concentration is decreasing, but for display purposes the negative values are inverted.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear assimilation rate (μmol m^{-2} s^{-1}).
Q	Quadratic assimilation rate (μmol m^{-2} s^{-1}).
Plot	Plot number defined by user in CPY – Other Settings (Step 4).
X-axis	Time (0 to maxDT seconds). Vertical line represents start of calculations.

Y-axis	dC (change in CO_2 concentration from start of measurement. 0 to maxDC (ppm)
maxDC	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. This value is defined in CPY – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in CPY – Termination Settings (Step 3).
Abort Button	Stops the CPY process and returns to CPY – Other Settings (Step 4). Only the individual CO2 measurements are saved to the USB flash drive. Process data is discarded.
New Button	Stops the CPY process and returns to CPY – Other Settings (Step 4). Results are saved to the USB flash drive.

The measurement sequence will terminate when the maxDC or maxDT is reached. If maxDT is reached first, the message “Time limit” will appear in the status box. If maxDC is reached first, the message “CO2 limit” will appear in the status box.

For more information on the theory and calculation of soil respiration/canopy assimilation, please refer to Appendix 2. Soil CO_2 Efflux and Net Canopy CO_2 Flux on page 144.

Custom Process

This process is available for users that want to use their own custom chambers with the TARGAS-1. Since it is assumed that you are using your own chambers, there are no “defaults” built into the system. It is your responsibility to make sure that you enter the appropriate values where required in order to ensure proper calculations.

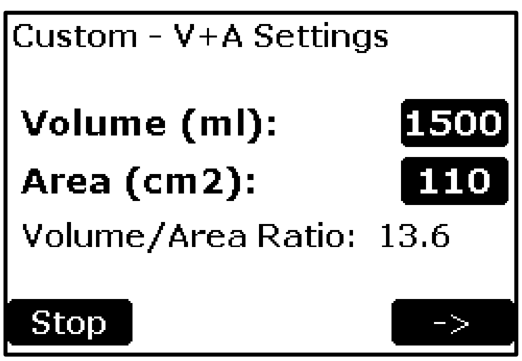
Custom – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the Custom process.

Custom – Start Process Menu	
Back Button	Returns to the Processes Menu.
Right Arrow Button	Confirms and starts the Custom process by displaying the Custom – Volume and Area Settings menu (Step 2).

Custom – Volume and Area Settings (Step 2)

The volume and area settings are defined in this screen.

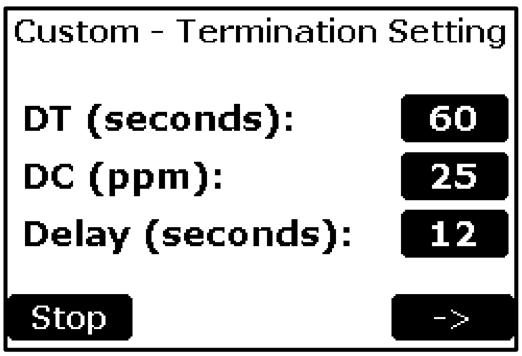


Important Note. You must remember to account for any volume changes in order for the instrument to properly calculate assimilation rates. If using collars, please make sure that you adjust the volume accordingly.

Custom Step 2 Menu	
Volume Button	Sets the volume of the system. Entries between 10 and 100,000 ml are permitted.
Area Button	Sets the surface area of the chamber in cm^2. Entries between 1 and 10,000 cm^2 are permitted.
Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Right Arrow Button	Continues to the Custom – Termination Settings menu (Step 3).

Custom – Termination Settings (Step 3)

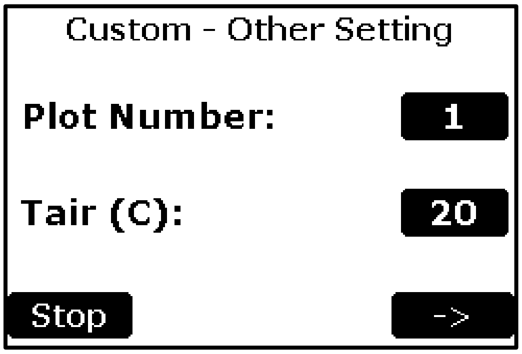
The Termination settings (DT, DC) and Delay are defined in this screen.



Custom – Termination Settings Menu	
DT Button	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC Button	Maximum change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value the session will end. Valid entries are between 1 - 1,000 ppm.
Delay Button	The amount of time the instrument waits at the start of each session before it starts calculating respiration. Valid entries are between 5 – 150 seconds.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Right Arrow Button	Continues to the Custom – Other Settings menu (Step 4).

Custom – Other Settings (Step 4)

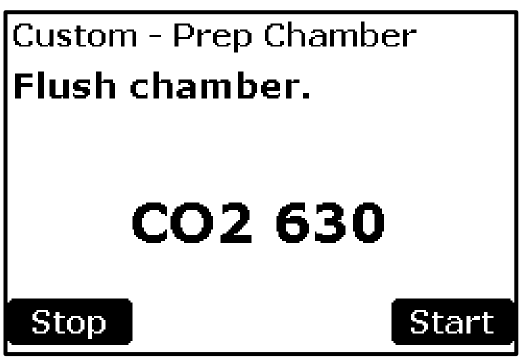
The plot number is defined and the Air Temperature is entered in this screen.



Custom – Other Settings Menu	
Plot Number Button	Change/View plot number. Range: 0–1000.
Tair Button	Air temperature inside chamber (^{o}C).
Stop Button	Stops the Custom process and returns to the Processes Menu.
Right Arrow Button	Continues to the Custom – Prepare Chamber screen (Step 5).

Custom – Prepare Chamber (Step 5)

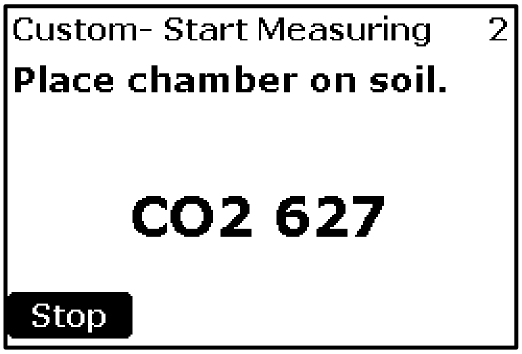
At this stage, the Custom probe should be held in the air to allow it to flush out prior to placing it on the soil. CO_2 concentration is displayed during this step. Unlike the SRC and CPY Processes, there is no countdown for flushing the chamber; it is up to the user to determine the amount of time required to flush a custom chamber. Once the chamber has been adequately flushed, pressing the Start button will allow the process to continue to the Custom – Start Measuring screen (Step 6)



Custom – Prepare Chamber Menu	
CO2 (ppm)	CO_2 concentration.
Stop Button	Stops the Custom process and returns to the Custom – Other Settings menu (Step 4).
Start Button	Continues to the Custom – Start Measuring screen (Step 6). Note: It is up to the user to determine the amount of time required to flush a custom chamber.

Custom – Start Measuring (Step 6)

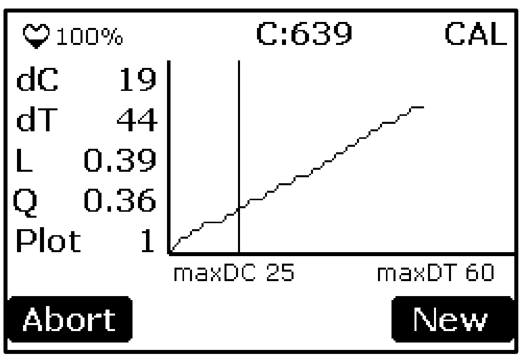
At this stage, the Custom probe should be placed on the soil. The number at the top right of the screen (2 in this case) is the count down from 5-0 seconds. CO_2 concentration is displayed during this step. When completed, the Custom Data Plot screen (Step 7) will be displayed.



Custom – Start Measuring Menu	
CO2 (ppm)	CO_2 concentration.
2	Countdown in seconds, from 5 to 0.
Stop Button	Stops the Custom process and returns to the Custom – Other Settings menu (Step 4).

Custom Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.



Custom Data Plot Menu	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining (%).
C: 639	Current measurement of CO_2 Concentration (ppm).

Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the Delay value specified in Custom – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The current difference in CO_2 concentration (ppm) from time = 0 seconds.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear respiration rate (g m^{-2} $hour^{-1}$).
Q	Quadratic respiration rate (g m^{-2} $hour^{-1}$).
Plot	Plot number defined by user in Custom – Other Settings (Step 4).
X-axis	Time (1 second interval)
Y-axis	dC (change in CO_2 concentration)(ppm)
maxDC	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. This value is defined in Custom – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in Custom – Termination Settings (Step 3).
Abort Button	Stops the Custom process and returns to Custom – Other Settings (Step 4). Only the individual CO2 measurements are saved to the USB flash drive. Process data is discarded.
New Button	Stops the Custom process and returns to Custom – Other Settings (Step 4). Results are saved to the USB flash drive.

Injection Process

The injection process is a technique used to measure the concentrations of small samples of gas, usually collected in sampling jars and transferred to the TARGAS-1 with a syringe. The injection process is an improvement over static sampling and yields more reliable and consistent results.

Measurement Principle

The concentration of CO_2 in a gas sample is calculated by injecting the sample into a fixed flow of gas with a known CO_2 concentration (the baseline CO_2 level) and integrating the resulting CO_2 measurements until they return to baseline. This is similar to the Pulse Tracer Gas Technique used for HVAC duct flow to infer the unknown flow rate by measuring the concentration of a known mass of tracer gas injected into the duct over time. In our case, the gas flow rate F is known, the syringe volume V is known, but the sample (or tracer gas) concentration is unknown.

The concentration in the syringe is calculated as:

$$CO_{2\,INT} = \int C(t)dt \cdot \frac{F}{V} = \sum \left(CO_{2\_m} - CO_{2\_b}\right) \cdot \frac{\Delta t}{60} \cdot \frac{F}{V}$$

Where

$CO_{2\ INT}$ (ppm) = calculated CO_2 concentration inside syringe (“integrated” CO_2)

CO_{2_b} (ppm) = baseline CO_2 readings before the measurement phase (averaged over 10 readings)

CO_{2_m} (ppm) = CO_2 readings during the measurement phase

Δt (s) = sample interval, typically 1 second

F (ml min^{-1}) = flow rate

V (ml) = syringe volume

The process consists of two phases: Baseline Phase and Measurement Phase. The Baseline Phase establishes a baseline measurement of CO_2 concentration by passing CO_2-free gas through the TARGAS-1 and calculating the average concentration over 10 measurements at a 1-second interval. Upon completion of the Baseline Phase, the instrument will enter the Measurement Phase. In this phase the sample is slowly injected, and the measured CO_2 concentrations are integrated over the duration of the Measurement Phase. Any gas with a known, constant CO_2 concentration can be used as a baseline, but a gas with zero CO_2 concentration can be readily produced with an absorber column filled with soda lime.

Sample Injection Kit (Part No. ACS037)

PP Systems offers a Sample Injection Kit (Part No. ACS037), which includes a fully assembled and leak-tested injection port with 4 spare septa, as well as an absorber column to establish a zero baseline.

The syringe is user supplied (not included with the kit) and the soda lime is not included with this part but it is included with the TARGAS-1 as standard.

The injection port includes a 9mm low-bleed septum that can withstand up to 50 injections (per the manufacturer's specification). For best results, we recommend changing the septum every 25 injections.

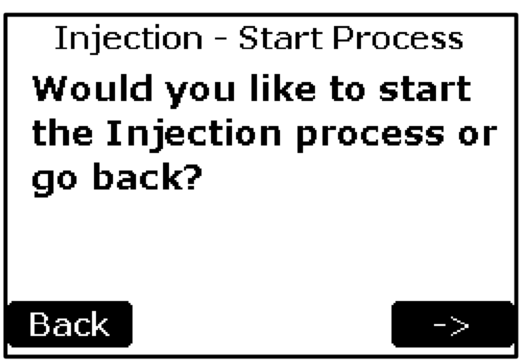
The septum has a guide hole and accommodates syringes up to 22 gauge. We recommend 18 gauge for best results. The syringe is not included in the kit and must be provided by the user. The injection technique is relatively insensitive to the volume of the syringe, but it should be at least a size where you could comfortably inject gas for at least 3 seconds continuously. For this reason alone, syringes with a volume of at least 10 ml (e.g. 10- and 25-ml syringes) are recommended. The injection rate should not exceed 3 ml/s, due to the risk of over-pressurizing the IRGA and causing damage to the instrument. We recommend glass syringes if available (e.g. typical GC syringes), but plastic (polypropylene) syringes will work as well.

The injection process works best for samples with concentrations greater than 100 ppm. The process will work at lower concentrations, but percent error will be significantly larger.

Injection – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the Injection process.

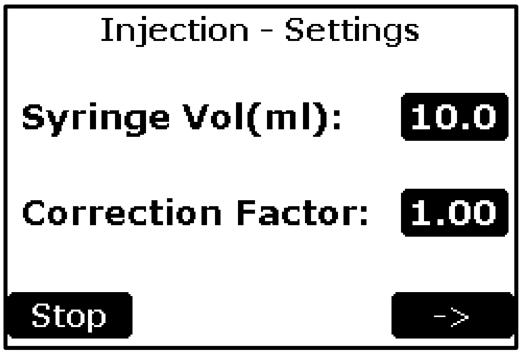
To begin a sample injection measurement, first fill the absorber column of the Sample Injection Kit with fresh soda lime and ensure it is oriented vertically throughout the process. Connect the open end of the kit to the **GAS IN** port on the back of the TARGAS-1.



Injection – Start Process Menu	
Back Button	Returns to the Processes Menu.
Right Arrow Button	Confirms and starts the Injection process by displaying the Injection – Settings screen (Step 2).

Injection – Settings (Step 2)

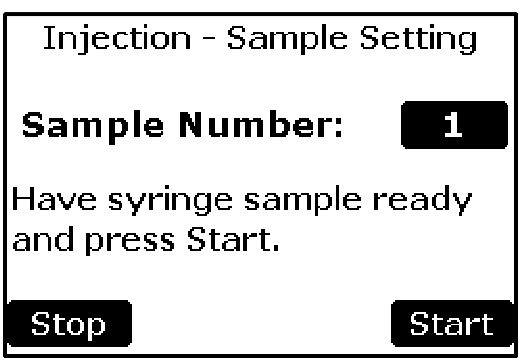
The syringe volume and correction factor settings are defined in this screen.



Injection – Settings Menu	
Syringe Volume Button	Volume of injection syringe. Valid entry range is between 1.0 – 1,000.0 ml.
Correction Factor Button	This user defined factor can be used to scale calculated gas concentrations to make them match a known reference gas standard. Range: 0.50 – 2.00.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Right Arrow Button	Continues the Injection process to Injection – Sample Setting screen (Step 3).

Injection – Sample Setting (Step 3)

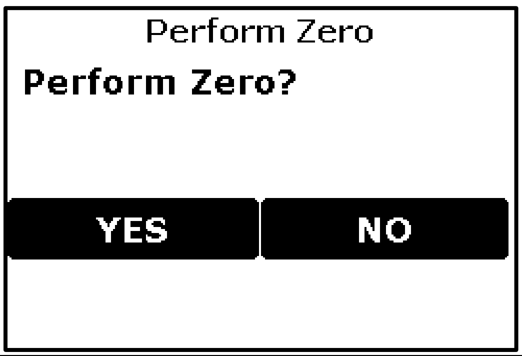
The sample number is defined in this screen. Once the Start button is pressed, the Injection process will begin. Before you press Start, take your syringe sample (e.g., from a chamber or airbag) if you have not done so already. We recommend that you draw more gas from your sample source than required, and then squeeze out excess. For example, for a 10 ml sample you should draw at least 11 ml into your syringe, and then slowly push the plunger to the 10 ml mark.



Injection – Sample Setting Menu	
Sample Number Button	Sample number of measurement.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Start Button	Starts the Injection Process and displays the Injection Zero screen (Step 4).

Injection - Zero (Step 4)

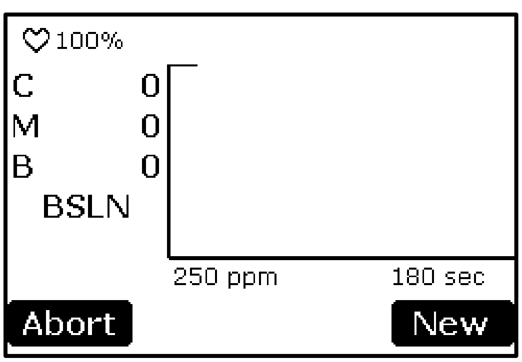
This allow the opportunity to do a zero prior to measuring sample



Perform Zero	
Yes Button	Does a Zero then proceeds to Measuring screen (Step 5).
No Button	Proceeds to Measuring screen (Step 5).

Injection – Baseline Phase (Step 5)

This is the Baseline Phase. For the first 10 seconds, the TARGAS-1 will record the baseline reading, which is the CO_2 concentration of the air before the sample is injected (typically 0 ppm). After 10 seconds the Injection Phase begins.

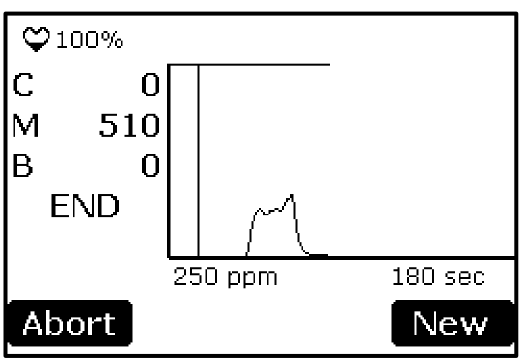


Injection Baseline Phase Menu	
♥ (Heartbeat)	Pulses to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining (%).
C	Current CO_2 concentration in tubing (ppm).
M	Calculated CO_2 concentration inside syringe (ppm).
B	Average baseline of CO_2 concentration (ppm).
BSLN	Indicates that the process is in the Baseline phase for the first 10 readings.
X-axis	Time (seconds). It is fixed at 180 seconds.
Y-axis	CO_2 concentration in tubing (ppm).
250 ppm	CO_2 concentration maximum. This is the same value as the Max CO_2 value for the Graph setting and can be modified under Main > Settings > Settings 2 > Graph.
Abort Button	Stops the Injection process and returns to Injection – Settings (Step 2). Process data is not saved to the USB flash drive.
New Button	Stops the Injection process and returns to Injection - Settings (Step 2). Injection Process results are saved to the USB flash drive.

If the baseline (B) does not drop to either 0 or a very small number (typically 1-3 ppm), then there is either a leak in the system, or the system has not adequately "zeroed". Try aborting the process, wait 2-3 minutes, and try again. If the problem persists, check the injection setup for leaks and ensure that the absorber column is properly seated and contains fresh soda lime.

Injection – Injection Phase (Step 6)

During the Injection Phase, the syringe should be slowly and steadily injected into the airstream through the septum. The injection rate should not exceed 3 ml/second to avoid over-pressurization of the system (in other words, it should take the user at least 3 seconds to inject a 10 ml syringe).

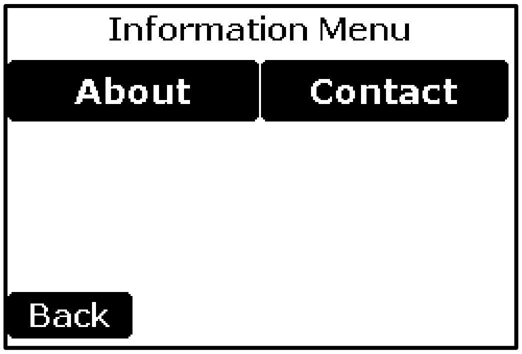


Injection Step 4 Menu	
♥ (Heartbeat)	Pulses to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining (%).
C	Current CO_2 concentration in tubing (ppm).
M	Calculated CO_2 concentration inside syringe (ppm).
B	Average baseline of CO_2 concentration (ppm).
INJT/END	INJT Indicates that the process is in the injection phase. END indicates CO_2 concentration calculations have been terminated.
X-axis	Time (seconds). It is fixed at 180 seconds.
Y-axis	CO_2 concentration in tubing (ppm).
250 ppm	CO_2 concentration maximum. This is the same value as the Max CO_2 value for the Graph setting and can be modified under Main > Settings > Settings 2 > Graph.
Abort Button	Stops the Injection process and returns to the Injection Baseline menu (Step 4). Process results are not saved to the USB flash drive.
New Button	Stops the Injection process and returns to Injection Baseline menu (Step 4). Injection Process results are saved to the USB flash drive.

Typically during an injection, the first value will rise quickly and drop back to zero; correspondingly, the value of M will increase quickly as the value of C peaks and then plateaus at a constant value. Once C has dropped to 0 ppm (or a very low background value), wait 3-5 seconds to make sure M has stabilized and take note of the value. This value is also recorded on the USB memory stick, if a memory stick has been inserted.

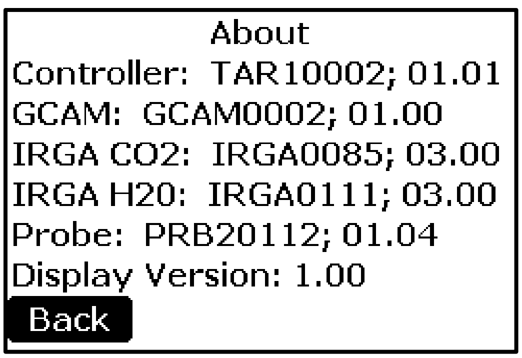
Errors from injection measurements are typically larger than flow-through methods (larger errors could come from both instrumental and handling sources), so it is recommended that you measure the same sample multiple times and calculate an average whenever possible.

Information Menu



Information Menu	
About Button	Provides information about serial numbers and the firmware versions
Contact Button	Information to contact PP Systems
Back Button	Returns to the Main Menu.

About



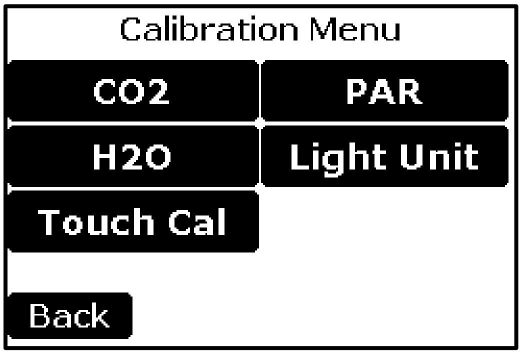
About	
About	Provides important information related to the instrument hardware including serial number of the TARGAS-1 console.
Back Button	Returns to the Information Menu.

Contact

Contact	
Contact	Contact information for PP Systems.
Back Button	Returns to the Information Menu.

Calibration

This TARGAS-1 allows calibration of the CO_2 IRGA, the H_2O IRGA, the Touch Screen, the PLC5 leaf cuvette PAR sensor and the PLC5 Light Unit.



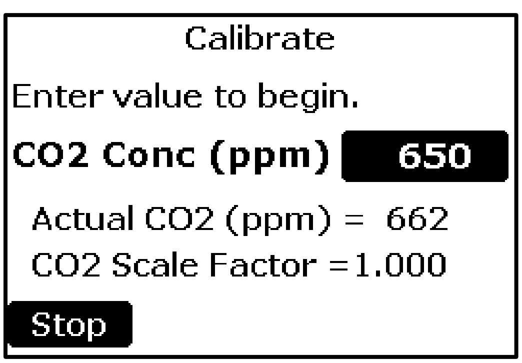
Calibration Menu	
CO2 Button	To perform CO_2 calibration.
H2O Button	To perform H_2O calibration.
Touch Cal Button	To perform Touch Screen calibration
PAR Button	To perform PAR calibration.
Light Unit Button	To perform Light Unit calibration.
Back Button	Returns to the Main Menu.

CO_2 Calibration

This menu allows the user to recalibrate the CO2 gas analyzer.

Before calibrating, confirm that:

- All absorber columns are properly seated in each manifold
- The molecular sieve is fresh in the Zero Column.
- The TARGAS-1 has been on for at least 30 minutes.
- The Gas Out port is unobstructed.



Calibration	
CO2 Conc Button	CO_2 concentration (ppm) of the calibration reference gas. Entering a value will begin the calibration process
Actual CO2	The current CO2 Reading based on the Scale Factor
CO2 Scale Factor	The current Scale Factor being used
Stop Button	Returns to the Calibration Menu.

Connecting Calibration Gas to the TARGAS-1

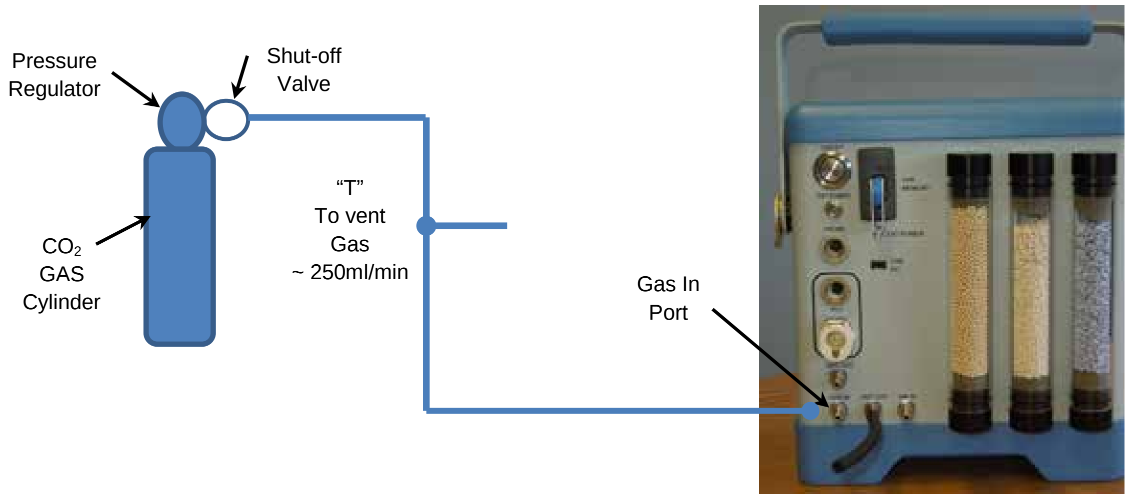
During calibration, the signal from the CO_2 detector is referenced against a gas of known CO_2 concentration. The TARGAS-1 calibration procedure uses two reference points:

1. Zero CO_2, generated from air that has been scrubbed of CO_2 through the soda lime in the absorber column.
2. Span (reference) gas, a user-provided gas with a known CO_2 concentration, typically from a very accurate (+/- 1%) certified source.

It is vital that both of these references are accurate. For greater accuracy, cylinder mixtures should be traceable to NIST (National Institute of Standards and Technology) standards. The zero gas will only be accurate if the soda lime in the absorber column is fresh.

Assuming that a calibration gas mixture is used to calibrate the TARGAS-1, follow these instructions:

1. To avoid excess pressure in the sample cell and possible damage to the analyzer, you must place a T-fitting between the reference gas source and the **GAS IN** port on the TARGAS-1. One end of the T-fitting should be left open in order to relieve excess pressure, as follows:

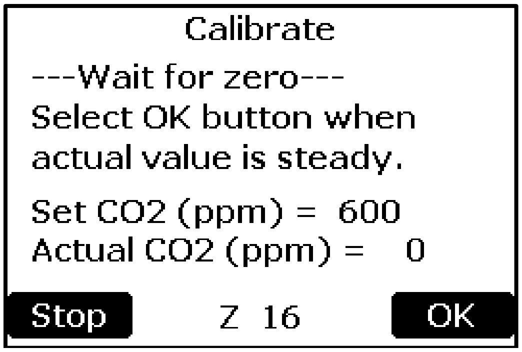


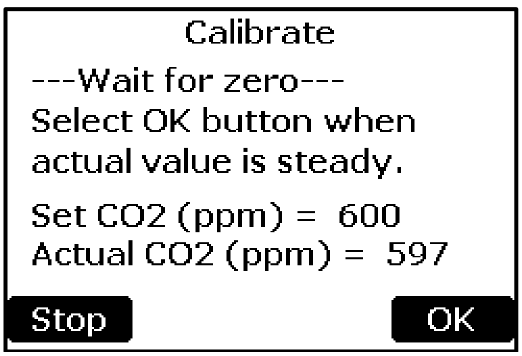
2. The pressure regulator on the reference source should be set to a very low pressure, such that the flow rate of excess gas from the open end of the T-fitting should be approximately 250 ml/min.

3. Select the button to the right of the "CO2 Conc (ppm):" text.

4. Enter the CO_2 concentration of the reference gas. This value must match the certified CO_2 concentration of the reference source and be greater than or equal to the anticipated measurement range of the instrument. For example, if the anticipated measurement range of your samples will be 0 - 350 ppm, the instrument should be calibrated using reference gas with a CO_2 concentration between 350 – 400 ppm.

5. The TARGAS-1 will then perform a zero. At completion of successful zero, a similar message to the following will be displayed:

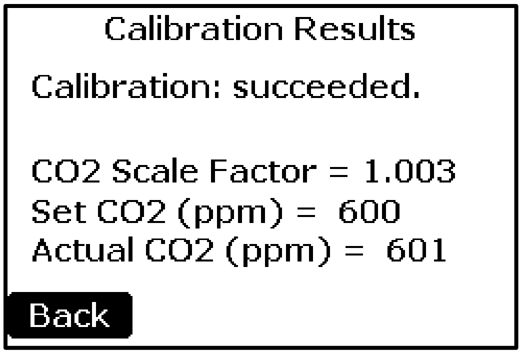




Calibration	
Set CO2	The CO_2 concentration value entered at the beginning of the Calibration Process.
Actual CO2	The current CO_2 reading
Stop Button	Returns to the Calibration Menu with no changes.
OK Button	Calculates new Scale Factor and goes to next screen

Note, the displayed value may not be the value you entered in step 4 above. When the Actual CO2 value has stabilized (i.e., not changing by more than 1 ppm after 30 seconds), press the OK button. To cancel without performing a Calibration, press Stop.

If the process is successful, the screen below will be displayed and the new calibration constant will be stored in non-volatile memory. If the process is unsuccessful, the message “Calibration: failed.” will be displayed and no changes made.

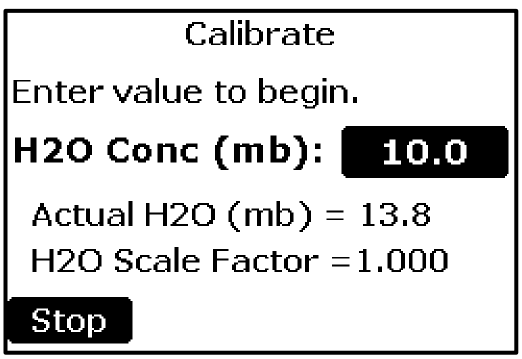


The Back button returns the user back to the Main Menu.

H_2O Calibration

This function allows the user to recalibrate the internal H_2O IRGA used with the TARGAS-1.
Before calibrating, confirm that:

- The absorber column is properly seated in its manifold
- The Molecular Sieve (H_2O scrubber) is fresh.
- The TARGAS-1 has been on for at least 30 minutes.
- The Gas Out port is unobstructed.



Calibration	
H2O Conc Button	H_2O concentration (mb) of the calibration reference gas. Entering a value will begin the Calibration Process
Actual H2O	The current H_2O reading based on the Scale Factor
H2O Scale Factor	The current Scale Factor being used
Stop Button	Returns to the Calibration Menu.

Connecting Dew Point Generator to the TARGAS-1

During calibration, the H_2O IRGA readings are referenced against air of known H_2O concentration. For H_2O recalibration we recommend using an accurate dew point generator or water vapor generator which are commercially available. For more information please contact PP Systems.

The TARGAS-1 calibration procedure uses two reference points:

1. Zero H_2O, generated from air that has been scrubbed of H_2O through the Molecular Sieve in the absorber column.
2. Span (reference) gas, a user-provided air with a known H_2O concentration, typically from a very accurate (+/- 1%) source.

Follow these instructions to calibrate the TARGAS-1 H_2O sensor:

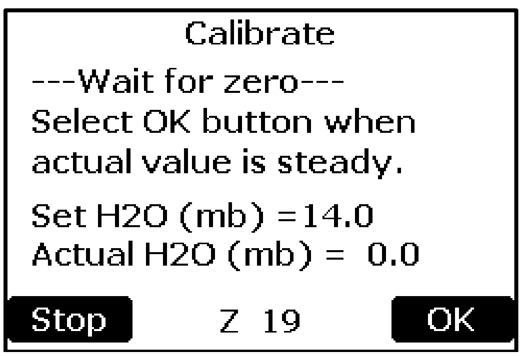
1. Connect the reference (sample) gas from your H_2O calibration device to the **GAS IN** port on the TARGAS-1. A T-fitting should be in place between your calibration device and the TARGAS-1 console and left open in order to relieve excess pressure.

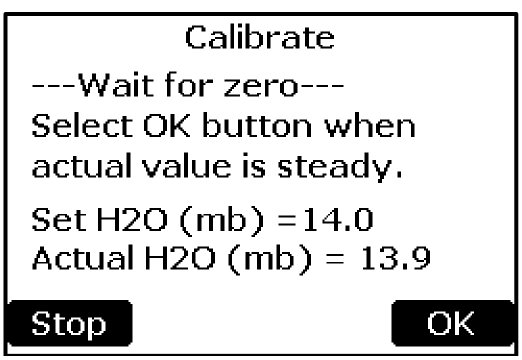
2. Set the flow on your device so that the flow rate exhausting out the T-fitting should be approximately 250 ml/min.

3. Select the button to the right of the “H_2O Conc (mb):” text.

4. Enter the H_2O concentration of the reference gas. This value must match the H_2O concentration of the reference source and be greater than or equal to the anticipated measurement range of the instrument. For example, if the anticipated measurement range of your samples will be 0 - 20 mb, the instrument should be calibrated using reference air with an H_2O concentration of 20 mb or higher.

5. The TARGAS-1 will then perform a zero. After completion of successful zero, a similar message to the following will be displayed.

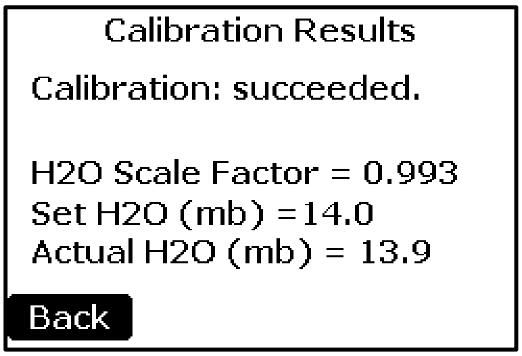




Note, the displayed value may not be the value you entered in step 4 above. When the Actual H_2O value has stabilized (i.e., not changing by more than 0.1 mb after seconds), press the OK button. To cancel without performing a Calibration, press Stop.

Calibration	
Set H2O	The H_2O concentration Value entered at the beginning of the Calibration Process.
Actual H2O	The current H_2O Reading
Stop Button	Returns to the Calibration Menu with no changes.
OK Button	Calculates new Scale Factor and goes to next screen

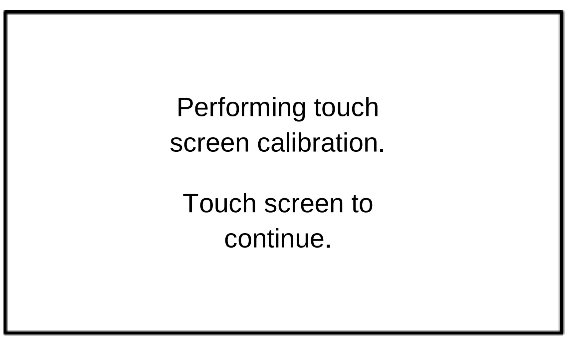
If the process is successful, the screen below will be displayed and the new calibration constant will be stored in non-volatile memory. If the process is unsuccessful, the message “Calibration: failed.” will be displayed and no changes made.



The Back button returns the user back to the Main Menu.

Touch Calibration

This function allows the user to calibrate the touch screen display. Follow the on-screen prompts to complete the process.



NOTE: This function can also be initiated by holding a finger on the screen while powering up the TARGAS-1. If your touch screen is not reacting to your touch:

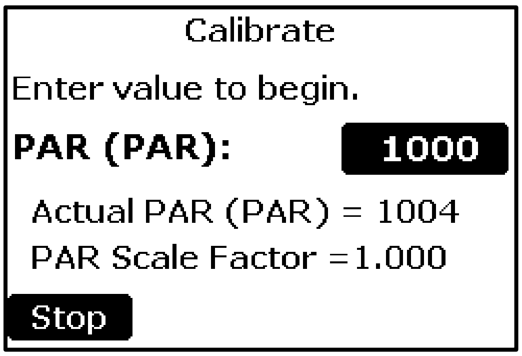
1. Turn the instrument off.
2. Place your finger anywhere on the touch display and turn system power on and wait for the next screen to appear.
3. Proceed as directed with the touch screen calibration.

PAR

This function allows the user to recalibrate the external PAR sensor on the PLC5 leaf cuvette. We recommend using a high precision PAR sensor as a reference standard when calibrating the external PAR sensor. All the PAR calibration values are saved in the PLC5 Leaf Cuvette.

Before calibrating, confirm that:

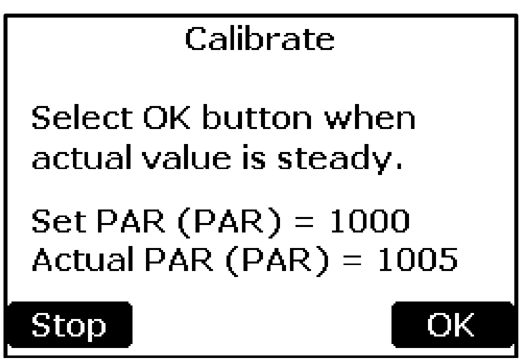
- The PLC3 is attached to the TARGAS-1
- The Device mode selection is PLC5
- The System has been on for at least 10 minutes.



Calibration	
PAR Button	PAR calibration value, entering a value will begin the Calibration Process
Actual PAR	The current PAR reading based on the Scale Factor
PAR Scale Factor	The current Scale Factor being used
Stop Button	Returns to the Calibration Menu.

Follow these instructions to calibrate the PLC5 PAR sensor:

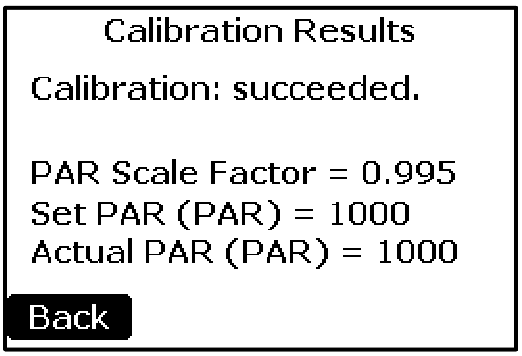
1. Apply a known PAR light to the PAR sensor.
2. Select the button to the right of the “PAR (PAR):” text and enter the PAR value.
3. After calibration, a similar message to the one below will be displayed.



Note, the displayed value may not be the value you entered in step 2 above. When the Actual PAR value has stabilized (i.e., not changing by more than 1 µmol m^{-2} s^{-1} after 5 seconds), press the OK button. To cancel without performing a Calibration, press Stop.

Calibration	
Set PAR	The PAR value entered at the beginning of the Calibration Process.
Actual PAR	The current PAR reading
Stop Button	Returns to the Calibration Menu with no changes.
OK Button	Calculates new Scale Factor and goes to next screen

If the process is successful, the screen below will be displayed and the new calibration constant will be stored in non-volatile memory of the PLC5 leaf cuvette. If the process is unsuccessful, the message "Calibration: failed." will be displayed and no changes made.



The Back button returns the user back to the Main Menu.

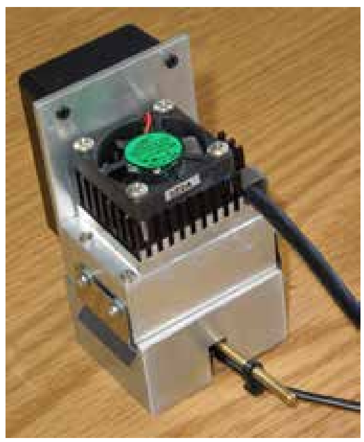
Please Note. Once the external PAR sensor is calibrated it can be used to calibrate the Light Unit used with the PLC5 Leaf Cuvette. See Light Unit Calibration on page 100.

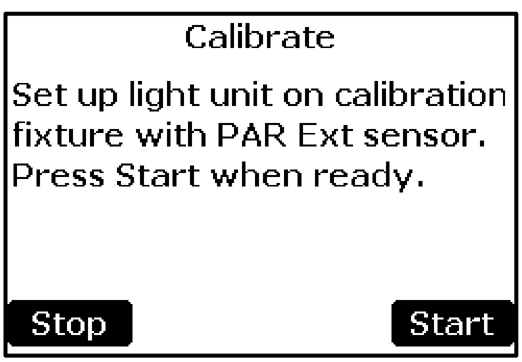
Light Unit Calibration

This function allows the user to calibrate the Light Unit (optional) using the removable, external PAR sensor on the PLC5 leaf cuvette. The Light Unit Calibration uses the PLC5 PAR sensor as a reference and steps the light unit through multiple light values from 0 to 3000 μmol m^{-2} s^{-1}. The calibration results are stored in the PLC5 cuvette (not the light unit), so if the light unit is used with a different PLC5, the Light Unit calibration should be redone. Note that PARi readings reported when the Light Unit is installed on a PLC5 are reduced from the readings that would be reported on the PARe external sensor for the same Light Unit setting by the attenuation of the PLC5 window glass which is 10%.

Before calibrating, confirm that:

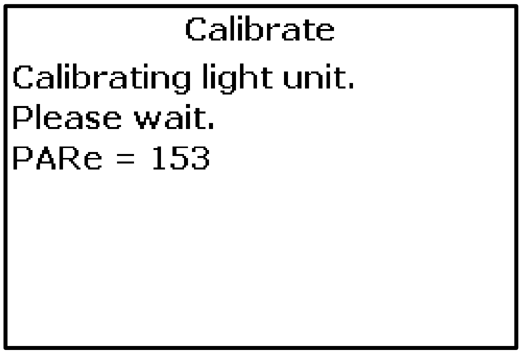
- The external PAR sensor on the PLC5 Leaf Cuvette is calibrated. For protective measures you can also compare the PAR sensor readings against a reliable quantum sensor.
- The PLC5 is attached to the TARGAS-1 and the light unit is connected electrically to the PLC5 Leaf Cuvette
- The Device Mode selection is PLC5
- The System has been on for at least 10 minutes.
- The Light Unit is mounted to the light sensor calibration fixture (Part No. 20665-1) and placed flat on the table and the external PAR Sensor is situated inside the calibration fixture as shown below (after removal from the PAR Sensor holder on the side of the cuvette as shown below):





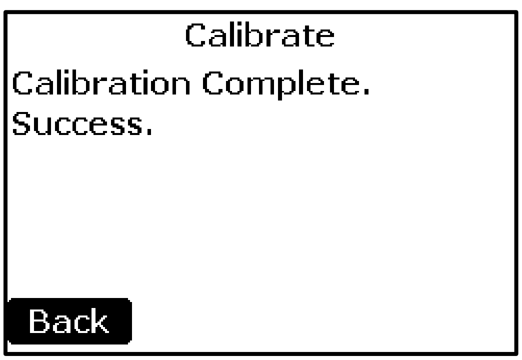
Important Note. The light unit calibration fixture (Part No. 20665-1) supplied with the system must be used to accurately carry out the light unit calibration. If you do not have this you must contact PP Systems to order a replacement.

Calibration	
Stop Button	Returns to the Calibration Menu.
Start Button	Start the Calibration process and proceeds to next screen

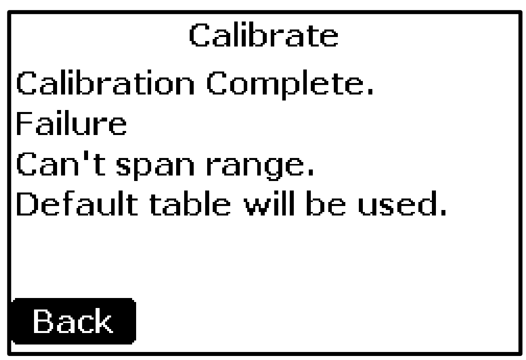


Calibration	
PARe	Current PAR reading as the calibration process steps through the range of 0 to 3000 µmol m^{-2} s^{-1}.

Note: The calibration process can take several minutes to complete. Do not remove the light unit or the PAR sensor until the calibration is complete.



or

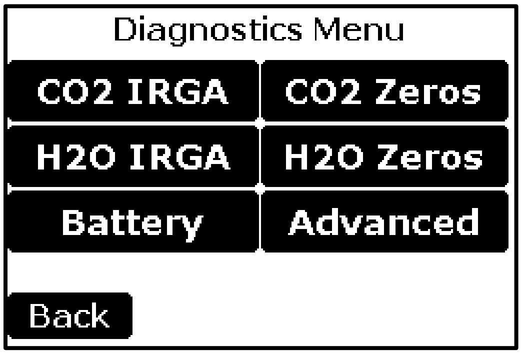


Calibration	
Back Button	Returns to the Calibration Menu.

If the process is successful the new calibration constant will be stored in non-volatile memory of the PLC5. If the process is unsuccessful, the message “Calibration: failed.” will be displayed and no changes made.

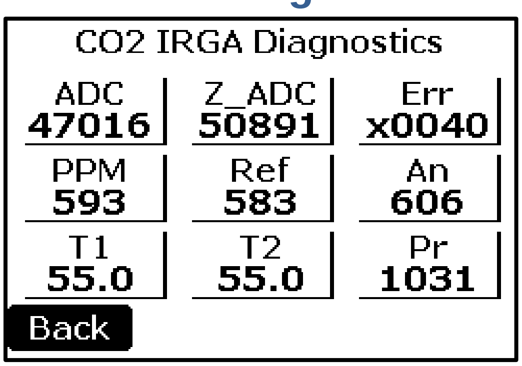
Diagnostics

This menu monitors and reports key system diagnostics associated with TARGAS-1 hardware. It is generally used for troubleshooting and diagnosing potential problems associated with the instrument.



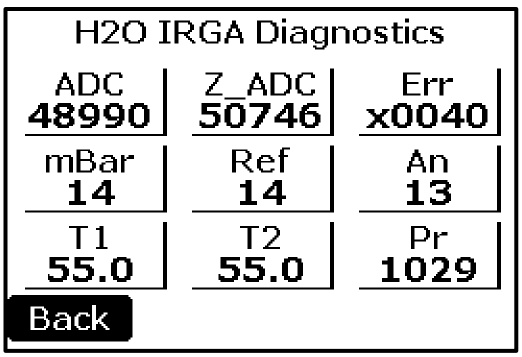
Diagnostic Menu	
CO2 IRGA	CO_2 IRGA Readings
H20 IRGA	H_2O IRGA Readings
Battery	Displays the percentage of battery remaining, the voltage and current of the battery and an estimate of time remaining before the battery is completely discharged.
CO2 Zeros	Displays the A/D counts for the last 7 CO_2 zero operations.
H2O Zeros	Displays the A/D counts for the last 7 H_2O zero operations.
Advance	Displays more advanced diagnostics functions. These functions are password protected and are for PP Systems use only.
Back Button	Returns to the Main Menu.

CO2 IRGA Diagnostics



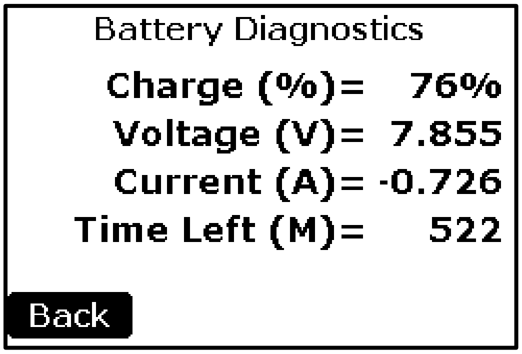
CO2 IRGA Diagnostics	
ADC	Current CO_2 ADC Readings
Z_ADC	Last CO_2 ADC Zero Readings
Err	IRGA Error and Status
PPM	Current CO_2 Reading
Ref	Reference reported Value
An	Analysis reported Value
T1	Temperature of zone 1 (detector)
T2	Temperature of zone 2 (detector)
Pr	Pressure Reported by IRGA
Back Button	Returns to the Diagnostics Menu.

H2O IRGA Diagnostics



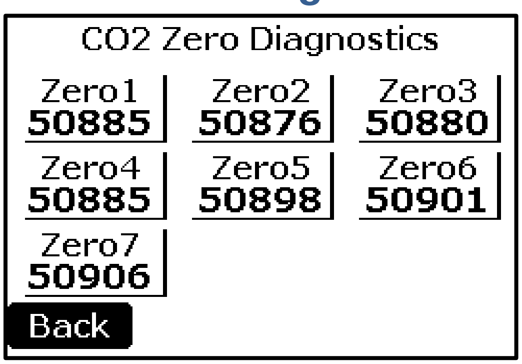
H20 IRGA Diagnostics	
ADC	Current H_2O ADC Readings
Z_ADC	Last H_2O ADC Zero Readings
Err	IRGA Error and Status
mb	Current H_2O Reading
Ref	Reference reported Value
An	Analysis reported Value
T1	Temperature of zone 1 (detector)
T2	Temperature of zone 2 (detector)
Pr	Pressure Reported by IRGA
Back Button	Returns to the Diagnostics Menu.

Battery Diagnostics



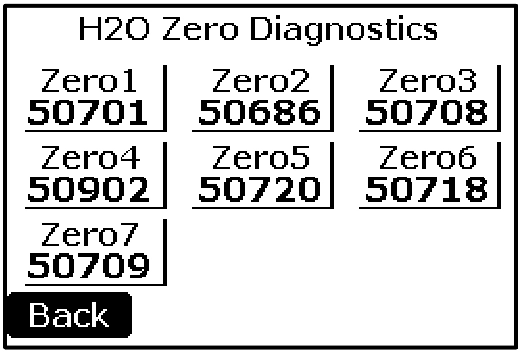
Battery Diagnostics	
Battery Diagnostics	Charge (%): Percent capacity left (%) Voltage (V): Battery Voltage (V) Current (A): Battery Current (Amp) (- means discharging) Time Left (M): Estimated time remaining before discharge (minutes)
Back Button	Returns to the Diagnostics Menu.

CO2 Zeros Diagnostics



CO2 Zero Diagnostics	
Zero 1 - 7	The last 7 CO_2 Zero Readings
Back Button	Returns to the Diagnostics Menu.

H2O Zeros Diagnostics



H2O Zero Diagnostics	
Zero 1 - 7	The last 7 H_2O Zero Readings
Back Button	Returns to the Diagnostics Menu.

Advance Diagnostics

Advance Diagnostics	
Enter PIN	Password (PP Systems only)
Back Button	Returns to the Diagnostics Menu.

Data Storage

Data is stored directly to a USB Flash Drive for convenience. Generally speaking the data format will default to the proper M type format required for the specific sensor/chamber being used. All data is stored as a .txt file in standard ASCII format making it very easy to open and view in Excel. See the following sections for more information on data storage and measurement formats.

NOTE: An Excel file is included on the flash drive that comes with each new instrument (Part No. 10182-1), under the “Documentation” directory. The file contains all the headers for each data record type.

USB Flash Drive (Memory Stick)

The USB Type A port on the back panel is designed specifically for a USB flash drive (commonly referred to as a memory stick or thumb drive). Most memory sticks can be used and one is provided with the TARGAS-1. If you are using your own memory stick, ensure it is formatted as FAT32 with a 512-byte sector size for best performance.

Data recording begins when a flash drive is inserted into the USB port on the TARGAS-1 unless the Interval is set to 0 seconds under “Memory Measure Settings”. Data recording ends when the flash drive is removed from the USB port. The recording interval is defined in the Memory Measure Settings screen, under “Memory Measure Interval”.

When the memory stick is inserted for the first time, a directory named “TAR1” is created. A filename is created within the directory using the following format:

YYMMDDWI.txt

Where:

- YY is the last 2 digits of the calendar year.
- MM is the 2 digit month.
- DD is the 2 digit day.
- W is the TARGAS-1 ID (0-9).
- I is the increment of the file if there is more than one file created in a day.

Each time the memory stick is removed and then reinserted, or when the instrument is power cycled, a new file is created and the increment ‘I’ is increased. Any files in this directory with extensions other than .txt do not contain valid data and may be deleted or ignored.

Even if the Measure Interval is set to 0, Manual recordings and Process Data are still sent to the USB Flash Drive. A manual record is initiated by hitting RECORD on the touchscreen or by pressing the remote recording switch on the PLC5.

Refer to Error Messages on page 125 for disk errors.

Data Storage Format

The table below is an example of the data format from a PLC measurement. The headers were manually created in Excel to show what each field represents.

Mtype	Date	Time	Rec Num	CO2r	CO2a	H2Or	H20a	atm	Flow supply
MM	2/8/2016	14:57:19	11385	379.6	359.0	19.2	23.4	1029.3	299
MM	2/8/2016	14:57:30	11396	377.6	357.6	19.6	23.9	1029.2	299

Flow sample	% abs	% Bat	Error	Ext type	PARe	PARi	Tamb	Tcuv	Tleaf
142	26.62	83	0	14	1858	1673	0	28.4	30.8
146	26.62	83	0	14	1826	1643	0	28.3	30.6

Trans	VPD	gs	A	Ci	Area
0.99	21.1	47	4.49	197	4.5
1.04	20.3	52	4.47	209	4.5

Data Storage/Measure Format Table

This table describes the data storage format in the TARGAS-1.

MH, MM, and RR Format (sent to the Host and USB memory)	
Type Format	MH (Measured Host), MM (Measured Memory), or RR (Manually Recorded Record)
Date	DD/MM/YY
Time	HH/MM/SS
Record Number	Number
CO_2 Ref	CO_2 reading in parts per million (ppm = µmol mol^{-1})
CO_2 An	CO_2 reading in parts per million (ppm = µmol mol^{-1})
H_20 Ref	H_2O reading in millibars (mb)
H_20 An	H_2O reading in millibars (mb)
AP	Atmospheric pressure in millibars (mb)
Flow Supply	Supply flow: cc/min
Flow Sample	Sample flow: cc/min
% abs	Zero absorber percentage (0-100%)
% Bat	Battery percentage of charge (0-100%)
Error Code	If applicable.
Extension Code	Determines following data format

Measure Extension Code Format Tables

The following tables describe the different Extension Formats.

Probe Extension Data	
Extension Type	1-19 except 7 ,14
PAR	µmol m^{-2} s^{-1}
Air Temperature	˚C
Soil Temperature	˚C

PLC Extension Data	
Extension Type	7,14
PAR External	µmol m^{-2} S^{-1}
PAR Chamber	µmol m^{-2} s^{-1}
Ambient Temperature	˚C
Chamber Temperature	˚C
Leaf Temperature	˚C
Transpiration	millimol(H_2O) m^{-2} s^{-1}
VPD	millibar (mb)
gs	millimol(H_2O) m^{-2} s^{-1}
Assimilation	µmol(CO_2) m^{-2} s^{-1}
Cinternal	ppm = µmol mol^{-1}
Leaf Area	cm^2

SRC, CUSTOM Extension Data	
Extension Type	20, 25, 60, 65
Plot Number	Number
Area	cm^2
Volume	CC
DC	Change in CO_2 concentration (ppm)
DT	Process time (Seconds)
SRL Rate	Respiration (g (CO_2) m^{-2} $Hour^{-1}$) using linear data fit
SRQ Rate	Respiration (g (CO_2) m^{-2} $Hour^{-1}$) using quadratic data fit
PAR	µmol m^{-2} s^{-1}
Air Temperature	˚C
Soil Temperature	˚C

Injection Extension Data	
Extension Type	30, 31
Plot Number	Number
C_F	Correction Factor
Volume	Syringe sample volume (CCs)
Base	CO_2 Baseline (ppm)
CO_2 int	CO_2 Integration value (ppm)
PAR	µmol m^{-2} s^{-1}
Air Temperature	˚C
Soil Temperature	˚C

CPY Extension Data	
Extension Type	50,51
Plot Number	Number
Area	cm^2
Volume	CC
DC	Change in CO_2 concentration (ppm)
DT	Process time in seconds
SRL Rate	Assimilation (µmol(CO_2) m^{-2} s^{-1})
SRQ Rate	Assimilation (µmol(CO_2) m^{-2} s^{-1})
PAR	µmol m-2 s-1
Air Temperature	˚C
Soil Temperature	˚C

Warming Up Extension Data	
Extension Type	70
CO2 IRGA Temperature	˚C
H2O IRGA Temperature	˚C

Zero Extension Data	
Extension Type	71
Zero Count Down	

CO2 IRGA Test Extension Data	
Extension Type	80
CO2 ppm	ppm
Sensor Temperature	˚C
Lamp Temperature	˚C
Pressure	millibar
Sensor adc	
Zero adc	
IRGA error Word	Bits = error

H2O IRGA Test Extension Data	
Extension Type	81
H2O	millibar
Sensor Temperature	˚C
Lamp Temperature	˚C
Pressure	millibar
Sensor adc	
Zero adc	
IRGA error Word	Bits = error

Refer to “TARGAS Data Format Descriptions.xlsx” file in the Documentation folder on the USB memory stick. The Excel file provides header examples that are useful when reviewing data.

Digital Connection Methods

There are two methods of connecting to the TARGAS-1 to view digital data:

1. PC USB port
2. Wireless (if WiFi Option is installed).

USB

A USB cable (Mini-B to Type A) can be used to connect the TARGAS-1 to a host device such as a PC, laptop or tablet. This cable is supplied by PP Systems with every TARGAS-1. When using a terminal emulator, the COM port settings to communicate with the EGM-5 are: 19200 baud, 8 bit, 1 stop, no parity, no flow control.

Wireless

Not available at this time.

Digital Communication Protocols and Software

Once a connection is made to the TARGAS-1, communication software is needed to read, display, and record data. This section describes three methods for reading TARGAS-1 data and changing settings: the TARGAS-1 Command Set, for direct communication using TARGAS-1 ASCII character strings; GAS Software, for a Windows based graphical user interface with graphing and logging; and Web Pages, which are available only with the WiFi Option.

TARGAS-1 Command Set

When a computer is connected to the TARGAS-1 using a USB cable, a communication protocol and command set comprised of ASCII characters and strings allows receipt of TARGAS-1 data and setting of TARGAS-1 parameters. A terminal emulation program (e.g., HyperTerminal or PuTTY) is generally used for this, but other custom software may also be used to observe and interact with the TARGAS-1 using these commands.

Measured data is continuously output by the TARGAS-1. The time interval can be modified using the Host Measure Interval setting (default is every 1 second).

Sending a command

To initiate a command, the Host (e.g., a PC running HyperTerminal) sends an ASCII string in comma-delimited format to the TARGAS-1. The command can be sent with or without a CRC-8 (9-bit Cyclic Redundancy Check). If a CRC-8 is sent, a ‘C’ follows the CRC-8 value.

For example,
Host sends command without CRC-8: S,1,25<CR>
Host sends command with CRC-8: S,1,25,080C<CR>

The CRC calculation includes everything but the CRC itself and the ‘C’ character. In the example above, the CRC was calculated from the string “S,1,25,”.

The command is processed by the TARGAS-1 after the command string terminator <CR> is received.

Only commands that are less than 90 characters in length will be successful. If a CRC-8 is present, the CRC-8 also needs to be correct in order for the command to be successful.

On successfully receiving the command string, TARGAS-1 sends an acknowledgement by sending to the Host a ‘+’ followed by a <CR>.

On a failure, a ‘–‘ is sent back to the Host with a <CR>.

A failure can be caused by a string longer than 90 characters or an incorrect CRC.

Receiving a response

Depending on the value of the CRC parameter, a CRC will/will not be appended to the command received from the TARGAS-1. If the CRC parameter value is ‘0’ (CRC Off), no CRCs will be appended to any of the commands received from the TARGAS-1. If the CRC parameter value is ‘1’ (CRC On), CRCs will be appended (including the ‘C’) to all commands received from the TARGAS-1. See Get/Set Parameter Values Table on page 119 for more details on turning off/on the CRC.

For example,
With CRC=0 (CRC Off):
Received from TARGAS-1: G,1,25<CR>

With CRC=1 (CRC On):
Received from TARGAS-1: G,1,25,043C<CR>

The following table describes the TARGAS-1 Command Set that can be used by the Host to communicate with the TARGAS-1. Note, the examples shown below have CRC disabled (CRC=0). There are two types of commands; Auto and Standard. Auto commands are commands that the TARGAS-1 will send without being prompted by the user. For example, the ‘W’ (Warm Up) command is automatically sent by the TARGAS-1 when it is warming up. Standard commands are commands that are sent by the user. Standard commands can be only a single character, or a single character followed by one or more parameters. All commands are terminated with <CR> which represents a carriage return (ASCII 13).

TARGAS-1 Auto Strings

Auto Strings are text strings that are sent by the TARGAS-1 automatically under certain states and conditions

<table>
<tr><th colspan="3">TARGAS-1 Auto Command Set</th></tr>
<tr><td>String</td><td>Type</td><td>Description</td></tr>
<tr><td>*</td><td>Auto</td><td>“*” String (Power Reset)

Sent immediately after the TARGAS-1 is turned on or reset.

Example:
*<CR></td></tr>
<tr><td>E</td><td>Auto</td><td>“E” String (Error Status)

Transmitted whenever an error is detected. The E string contains an Error Code that indicates the problem. See Error Messages on page 125 for more details.

Example:
E,11<CR>

In this example, 11 is the code for the Low CO_2 Alarm.</td></tr>
<tr><td>M</td><td>Auto</td><td>“M” String (Measurements)

The M string is sent on a fixed interval. The interval and the string format may be modified. When the interval is set to 0 the M string stops sending automatically, but can be manually polled by sending the “M” command.

Example:
MH, 03/06/15, 9:32:15, 1, 0003, 481, 475, 15.4, 17.3, 1004.2, 327, 100, 91.4, 75, 0, 7,956,899,0,25.4,26.2,1,1,1,1,1,4.5<CR>

See Measurement Format Table below for more details.</td></tr>
<tr><td>V</td><td>Auto</td><td>“V” String (Versions)

This is sent once right after the TARGAS is powered or if the system is reset. The V string returns the serial numbers and software versions of the TARGAS controller, the IRGAs and the Probes.

Example:
V, TAR10010,01.01, GCAM0010,01.03 ,IRGA0097,03.00, IRGA0110,03.00, PRB10000,00.00, PRB20000,00.00<CR>

Where, in this example,
TARGAS-1 serial number = TAR10010
TARGAS-1 firmware version number = 1.01
IRGA serial number = IRGA00097
IRGA firmware version number = 3.00</td></tr>
</table>

TARGAS-1 Command Set Table

TARGAS-1 Standard Command Set		
Command	Type	Description
‘	Character	**“ ’ ” Command (Comment)** This command ignores any characters between the quote and <CR>. This is useful for documentation; for example, it allows comments in a configuration file to be ignored when the file is uploaded. Example: Sent from Host: ‘ This file sets all the default values<CR> Received from TARGAS-1: +<CR>
G,x	Character with Parameters	**“G” Command (Get Setting)** This command gets a parameter stored in EEPROM (non-volatile memory). x corresponds to a parameter value (See Get/Set Parameter Values Table on page 119.). When G,x is sent from the Host, the value associated with that particular parameter is returned. Example: Sent from Host: G,1<CR> (Get Zero Type) Received from TARGAS-1: +<CR> G,1,1.000<CR> In this example the value of Zero Type is 1 (Automatic).
H,x	Character with Parameters	**“H” Command (Get Run Hours)** This command gets the total hours of unit operation. The x parameter is the number that determines the module the hours is retrieved from. Module number: 1 = Main Controller Example: Sent from Host: H,1<CR> Received from TARGAS-1: +<CR> H,1, 463.1 In this example, the main controller has reported 463.1 hours of operation.
Mx	Character with Parameters	**“M” Command (Measure String)** This command performs a “one shot” measurement output. Each time ‘Mx’ is sent to the instrument, one set of data is displayed in the currently specified format The value of x determines where the data will be sent: H=Host M=Memory Stick W=Wireless A=All three

		Example: Sent from Host: MH<CR> Received from TARGAS-1: +<CR> MH, 03/06/15, 9:32:15, 1, 0003, 481, 475, 15.4, 17.3, 1004.2, 327, 100, 91.4, 75, 0, 7,956,899,0,25.4,26.2,1,1,1,1,1,4.5<CR> See Measurement Format Table below for more details.
N	Character	**“N” Command (Read Voltages)** This command returns 3 voltage measurements. External Voltage, Battery Voltage, and Probe 1 Analog are sent in order in CSV format. Example: Sent from Host: N<CR> Received from TARGAS: +<CR> N,12.123, 7.123, 0.6143<CR> In this example, External Voltage=12.123V, Battery Voltage=7.123V, Probe 1 Analog =0.6143V
P,x	Character with Parameters	**“P” Command (Process Modes)** This command is used to Select and Control a process. The x parameter determines which Process action will be performed. **Description of x:** 1 = Stop process (returns to standard Measure mode) 2 = Stop process and Save Last Measurement 3 = Save Last Measurement 4 = Fan on High Speed 5 = Fan on High Speed and stop Zeros 6 = Fan on low speed 7 = Fan on low speed and start Zeros 20 = Start the SRC process or Restart if already running 30 = Start the Injection process or Restart if already running 40 = Start the Static process or Restart if already running 50 = Start the CPY process or Restart if already running 60 = Start the Custom process or Restart if already running 80 = Start The CO_2 Diagnostics

		81 = Start The H_2O Diagnostics Example: Sent from Host: P,20<CR> (Start SRC process) Received from TARGAS-1: +<CR> In this example the SRC process is started.
R	Character	"R" Command (Record) This command saves the last measured M record, An ' R' replaces the M. The record is send to; the USB memory, the Host port, and the Wifi port. An E,27<CR> is sent back to the Display, host, and WiFi. Example: Sent from Host: R<CR> Received from TARGAS: +<CR> E,27<CR> Note, the E,27 is the message for recording a record
S,x,v	Character with Parameters	**"S" Command (Save Setting)** This command sets a parameter in EEPROM (non-volatile memory). The x parameter specifies a particular setting, and the v parameter is the desired value of the particular setting, which will be saved in the EEPROM. A 'G' command is returned to confirm that the request was accepted. See Get/Set Parameter Values Table on page 119. Example: Sent from Host: S,1,1<CR> Received from TARGAS-1: +<CR> G,1,1.00<CR> In this example, Zero Type is set to 1 (Automatic).
T	Character & Character with Parameters	**"T" Command (Time)** This command gets and sets the time in 24-hour format. The command can be implemented in three different ways: 1. Get values: The 'T' command is used to get the complete set of day/time values. Example: Sent from Host: T<CR> Received from TARGAS-1: +<CR> T,04,42,15,05,01,15<CR> In this example, seconds=04, minutes=42, hour=15, day=05, month=01 and year=(20)15.

		2. Set All Parameters: The ‘T’ command can be used to set all of the day/time values at once. Example: Current time: 05/01/2015 15:42:04 Sent from Host: T,04,42,10,05,02,15<CR> Received from TARGAS-1: +<CR> T,04,42,10,05,02,15<CR> In this example, hour is changed from 15 to 10 and month is changed from 1 to 2. If any one of the attributes is different from the current the value, it will be updated. 3. Partial Parameter Set: The ‘T’ command can be used to set particular attributes of the day/time values using 1-6, where 1=seconds, 2=minutes, 3=hour, 4=day, 5=month and 6=last 2 digits of year. Example: Sent from Host: T<CR> (Get current time) Received from TARGAS-1: +<CR> T,04,42,15,05,01,15<CR> Sent from Host: T,3,11<CR> Received from TARGAS-1: +<CR> T,4,42,11,05,02,15<CR> In this example, the hour was changed from 10 to 11. All other values stayed the same.
V	Character	**“V” Command (Get Versions)** The V string returns the serial numbers and software versions of the TARGAS controller, the IRGAs and the Probes. Example: V, TAR10010,01.01, GCAM0010,01.03 ,IRGA0097,03.00, IRGA0110,03.00, PRB10000,00.00, PRB20000,00.00<CR> Where, in this example, TARGAS-1 serial number = TAR10010 TARGAS-1 firmware version number = 1.01 IRGA serial number = IRGA00097 IRGA firmware version number = 3.00
X	Character	**“X” Command (Get Zeros)** This command retrieves last seven zeros performed from both IRGAS Example: Sent from Host: X<CR> Received from TARGAS: +<CR> XC, 44200, 44223, 49971, 49972, 49976, 49981, 49973<CR> XH, 48900, 48919, 48921, 48922, 48916, 48921, 48923<CR>

		Where 'XC' are the Co2 Irga zeros 'XH' are the H2o Irga zeros
Z	Character	**"Z" Command (Do a Zero)** This command initiates a zero. During a zero operation, the TARGAS-1 transmits a Z string every second until the end of the zero operation. No "M" strings are sent during this time. This command can be initiated by the user or by the TARGAS-1 itself. Example: Sent from Host: Z<CR> Received from TARGAS-1: +<CR> Z, 025<CR> Z, 024<CR> … A zero has been initiated by the user. In this example, 025 and 024 indicate the number of seconds remaining in the zero operation.

Get/Set Parameter Values Table

Get/Set Parameter Values				
Number (X)	Parameter Name	Description	Valid Values	Default Value
1	Zero Type	See Zero Settings section. The values are: 1=Automatic, 2=User Set, 3=Manual	1 - 3	1 (Automatic)
2	Zero Time (min)	See Zero Settings section.	1 - 40	20
3	Average Limit (ppm)	See Averaging Settings section.	0 - 100	30
4	Alarm Low (ppm)	See Alarm Settings section.	0 - 100000	0
5	Alarm High (ppm)	See Alarm Settings section.	0 - 100000	2000
6	Alarm Sound	See Alarm Sound section.	0=Off; 1=On	0 (Off)
7	CO_2 Concentration (ppm)	Not used in TARGAS	n/a	n/a
8	TARGAS ID	See TARGAS ID section.	0-9	1
9	Pump Power (%)	Not used in TARGAS	n/a	n/a

10	Host Measure Format	See **MH Format**	0 = Cal 1 = MH 2 = MD 3 = MM 4 = MW	1
11	Host Measure Interval (seconds)	Time between records. Use '0' for manual mode to stop broadcast.	0 - 3600	1
12	Memory Measure Format	See **MM Format**	n/a	n/a
13	Memory Measure Interval (seconds)	Time between records	0 - 3600	0
14	WIFI Measure Format	See **MW Format**	n/a	n/a
15	WIFI Measure Interval (seconds)	Time between records	0 - 3600	0 (Manual)
16	Display Measure Format	See **MD Format** Note: Interval time is always 1 second.	n/a	n/a
17	CRC	Determines whether a CRC-8 will be appended to each command sent from the TARGAS. This works for the Host only. Note: the Display always gets a CRC-8	0=Off; 1=On	0 (Off)
18	Web Monitor	Adds terminator to strings sent to the WiFi Port to use for web pages	0=Off; 1=On	1 (On)
19	Host Serial	Selects which Serial Host input to use: the USB or Wi-Fi (port2)	0 =USB 1 = Wi-Fi	0 (USB)
20	Chamber Volume (cc)	The Volume of the measuring chamber in CCs	10-100000	1171
21	Chamber Area (Cm^2)	The measuring Area of the Chamber	1- 10000	78
22	CO2 limit (ppm)	The co2 sampling limit	1-1000	50
23	Time Limit (Sec)	The sampling time limit	10-300	60
24	Plot Number	Plot number (not saved in EEprom) Defaults to 1 on power up	1-1000	1
25	Used Absorber (mm^3)	The amount of absorber material used in doing zeros (mm^3)	0-100000	*
26	Absorber Volume (mm^3)	The number of ml the Zero column holds	100-100000	20000
27	Syringe Volume	The sample volume of gas (CCs)	1 - 1000	10

28	Correction Factor	Correction factor for injection mode	0.5 – 2.0	1
29	SRC Volume (cc)	The Volume of the SRC chamber in CCs	1000 - 2000	1171
30	SRC Area (cm^2)	The measuring Area of the SRC Chamber	50 - 100	78
31	CPY Volume (cc)	The Volume of the CPY chamber in ccs	1000 - 5000	2427
32	CPY Area (cm^2)	The measuring Area of the CPY Chamber	150 - 200	167
33	Chamber Air Temperature (^oC)	Chamber Air Temperature in degrees Celcius	0 - 50	20
34	Ship Mode	Used to prevent power turning on, Must have external power to exit mode	0 = Normal 1=shipmode	0
35	Probe 1 Function	Select the functionality of probe 1 port. I2C, Analog, or SDI-12	0= I2C 1= PAR2 2=SoilTemp 3=SoilMoist 4=NewProbe	0
36	Wi-Fi Power	Turns the Wi-Fi Power on / off	0 = OFF 1 = ON	0
37	Probe 2 Function	Select the functionality of probe 2 port. I2C, Analog, or SDI-12	n/a	n/a
38	Flow Rate	Not used in TARGAS	n/a	n/a
39	SUPPLY_FLOW	PLC flow	200 - 400	250
40	SAMPLE_FLOW	Analysis flow	50 - 200	150
41	CO2_DUTY_CYCLE	Percent time at ambient	0 -100	100
42	H2O_DUTY_CYCLE	Percent time at ambient	0 -100	100
43	MEASURE_MODE_GCAM	What type of IRGA reading	0 = Last 1 = Average 2 = Project	2
44	DIFF_MEASURE	How the TARGAS is configured to do measurements.	0 = Diff 1 = Ref 2 = An 3 = Zero	0
45	CO2_REF_DELAY	Time when measurement is read after valve switch	0.1 - 6.0	1.1
46	H2O_REF_DELAY	Time when measurement is read after valve switch	0.1 - 6.0	2.7
47	CO2_AN_DELAY	Time when measurement is read after valve switch	0.1 - 6.0	1.1
48	H2O_AN_DELAY	Time when measurement is read after valve switch	0.1 - 6.0	2.7

49	REF_ON_TIME	Time in Ref state	3 - 15	5.0
50	AN_ON_TIME	Time in An state	3 - 15	5.0
51	DEVICE_MODE	The type of device that is expected to connected	0 = Diff 1 = PLC5 2 = Closed 3 = Absolute 4 = PLC3 5 = SRC?? 6 = CPY??	1
52	LEAF_AREA	Area of the leaf exposed in the cuvette	0.5 – 4.5	4.5
53	RB	PLC Value	0.20 – 0.90	0.30
54	RS_FACT		0.10 -1.00	0.5
55	TEMPERATURE_CONTROL	Temperature setting when the temperature mode is 1	0 - 45	25
56	TEMPERATURE_MODE	How the temperature in the chamber is controlled	0= none 1= Chamber 2= track Amb 3= leaf 4= leaf Amb	1
57	PAR_CONTROL	Par setting for Light unit	0-2500	500
58	RED_PERCENT		0-100	25
59	GREEN_PERCENT		0-100	25
60	BLUE_PERCENT		0-100	25
61	WHITE_PERCENT		0-100	25
62	LIGHT_MODE	How the light unit is controlled	0= no LU 1= Normal 2= not used 3= not used 4= Calibrate	0
63	PAR_SCALE_FACTOR	User Correction Factor of the Extern PAR (PLC3)	0.8 – 1.2	1
64	LU_SCALE_FACTOR	User Correction Factor of the light unit (PLC3)	0.8 – 1.2	1
65	LEAF_TYPE_MEASUREMENT	What method is used to determine the temperature of the leaf	0 = Chamber 1 = IR PLC3 2 = Chamber 3 =Energy	3
66	CO2_SCALE_FACTOR	User Correction Factor of the CO2 IRGA	0.8 – 1.2	1
67	H2O_SCALE_FACTOR	User Correction Factor of the H2O IRGA	0.8 – 1.2	1

GAS (Gas Analysis Software)

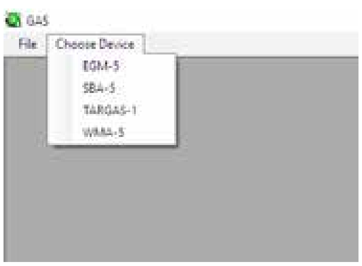
PP Systems Windows® based GAS (Gas Analysis Software) software is available for displaying and logging data from the TARGAS-1, and any additional environmental probes connected to it. No programming or command-line knowledge is required to utilize the GAS software. Connection between the TARGAS-1 and computer is via the USB interface. GAS will run on Windows XP and above.

The GAS software is included on the flash drive that comes with each new instrument (Part No. 10182-2), under the “PC Utilities\GAS_v[x]” directory, where [x] is the version number. GAS is also available for download directly from our website (for registered users only). To install GAS, double click on “setup.exe”. A number of standard installation windows will be shown to guide you through the installation process. Once GAS is installed, the following icon will appear on the desktop:

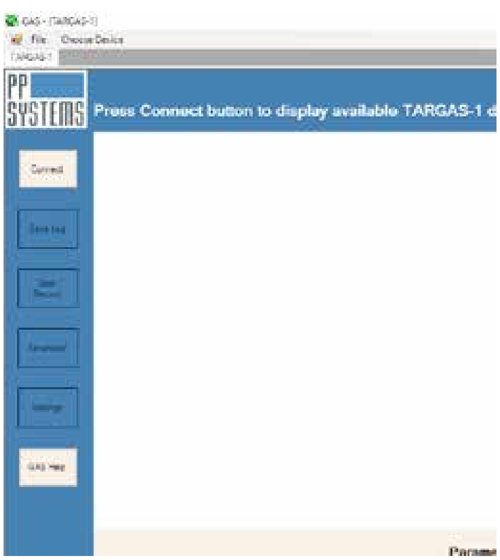
GAS

Double click this icon to start GAS.

Click Choose Device and choose TARGAS-1.

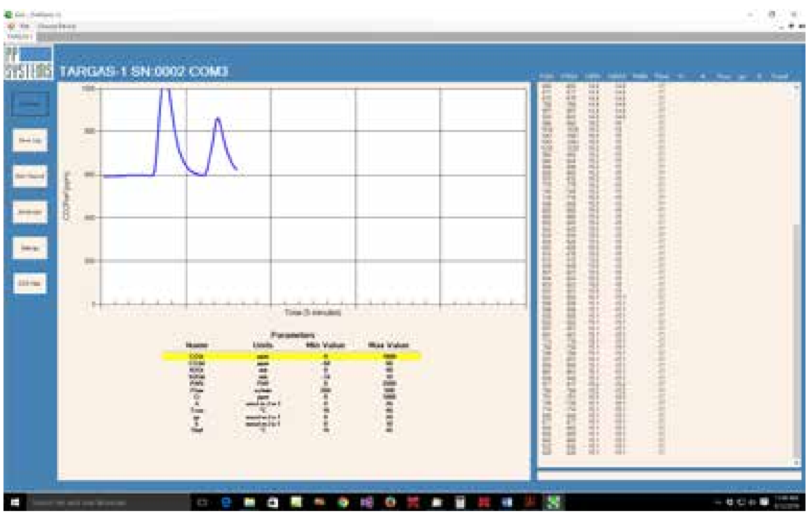


A new TARGAS-1 tab window will appear. Next, click the Connect button.



In the top left corner, a box will appear listing all available TARGAS-1 devices. Select one and click OK.

After clicking OK, the main measurement screen will be displayed.



Note: In the top left area, the device name (e.g., TARGAS-1, EGM-5, SBA-5 or WMA-5), serial number, and COM port are all displayed. Data is displayed both graphically and numerically. GAS gives the ability to log past data activity in a current session (Save Log) or record data (Start Record) for a time segment. Clicking the Advanced button will show a command-line window for sending commands directly to and from the TARGAS-1. The Settings button allows the user to modify the parameters' minimum and maximum values. Data is saved in comma-delimited .txt files. A graphical representation of each parameter can be seen by clicking the parameter name in the table below the graph. The highlighted parameter will be displayed on the graph.

For more detailed information on the functionality of GAS, refer to "Gas Help" under the Help menu in the software.

Error Messages

Error and status messages are displayed in the Status Area during system operation. The following table highlights the most common messages that you may see. An error message may appear after making a change to system setting and if this happens do not be concerned as the message will likely disappear after a few seconds. However, if an error message is displayed and does not disappear after a few seconds then the instrument is telling you something and the message should be addressed.

Error Messages		
Error Code	**Status Box Message**	**Description**
10	Low Zero	A/D values from the last Zero are too low (<2500).
11	Low Alarm	Measured CO_2 is less than the low CO_2 setting (250 ppm by default).
12	High Alarm	Measured CO_2 is greater than the high CO_2 setting (2000 ppm by default).
13	Under Temp	Analyzer temperature < 50 ^oC.
14	Over Temp	Analyzer temperature > 60 ^oC.
15	Low Flow	Sample flow rate is less than 50 cc/min.
16	IRGA Write	IRGA unable to perform a write operation. If error persists, call PP Systems technical support.
17	IRGA CRC	IRGA read/write EEPROM CRC incorrect. If error persists, call PP Systems technical support.
18	IRGA Range	IRGA setting error. Value is out of range. If error persists, call PP Systems technical support.
19	CO_2 limit	Reached Process CO_2 limit
20	Time limit	Reached Process time limit
21	Non Linear	The SR measurement is Non Linear
22	End Process	The process has been terminated
23	Absorber used	The Absorber column material has been exhausted and needs replacing
24	Zero 2 min	Zero will occur in 2 minutes
25	Zero 1 min	Zero will occur in 1 minutes
26	IRGA DigiPot	Could not successfully write the IRGA DigiPot
27	Record Saved	Recording a record to the memory stick
30	Unknown CMD	Host only. First character is not recognized as a command.
31	Invalid Format	Host only. First character is a recognized command but the next character is invalid. Example: S1,1<CR> (as opposed to S,1,1<CR>.
32	Invalid Param	Host only. Command is correct but parameter is not valid. Example: S,20,5. The value of 20 is an invalid parameter.
33	Low Limit	Host Only. Value entered is below the valid range of values for that parameter.
34	High Limit	Host Only. Value entered is above the valid range of values for that parameter.
35	PLC3 PAR LT	Plc-3 internal par 1 error
36	PLC3 PAR RT	Plc-3 internal par 2 error
37	No PLC3	Expecting a PLC3 to be connected to port 2
38	No PLC5	Expecting a TARGAS PLC5 to be connected to port 2
39	No PAR2	Expecting a PAR2 device to be connected to port 1
40	No STP-2	Expecting a STP-2 device to be connected to port 1
41	No SRC	Expecting a SRC device to be connected to Port 1 or Port 2

42	No CPY	Expecting a CPY device to be connected to Port 1 or Port 2
50	No Memory	No flash drive detected.
51	Memory CF	Flash drive error. Command failed – Filename or directory name not found.
52	Bad Record	Flash drive error. Bad command – Command not recognized.
53	Memory Full	Flash drive full – No free space on disk.
54	Memory FI	Flash drive error. Invalid – Attempt to open a directory for reading or writing. Attempt to change currently selected directory to a file.
55	Memory RO	Flash drive error. Read only – Attempt to open a read only file for writing.
56	File Open	Flash drive error. File open – A file is currently open for writing and must be closed before this command can be executed.
57	Memory NE	Flash drive error. Directory not empty – Attempt to delete a directory which is not empty.
58	Memory FN	Flash drive error. Filename invalid – Firmware invalid or contains disallowed characters.
60	Memory NU	Flash drive message. No upgrade – Firmware upgrade file not found on disk. This message is displayed each time a disk is inserted into the drive.
61	Mem Detected	Flash drive message. Disk detected - This message should be displayed each time a disk is inserted into the drive.
62	Mem Removed	Flash drive message. Disk removed - This message should be displayed each time a disk is removed from the drive.
63	Vdrive Buffer	The UART Buffer for the flash drive is Full. Flash drive file too large. (slow to update) Use new flash drive or delete files.

Display Generated Error Messages

Status Box Message	**Description**
Low Abs	Absorber column is < 10%.
Replace Abs	Absorber column is 0%
Low Battery	Battery is < 10%.

Maintenance

The TARGAS-1 requires minimal maintenance. There should be no need to open the enclosure to access internal components (e.g., battery, pump, IRGA, etc.). The two most common items requiring periodic inspection and maintenance include:

- External air filter
- Absorber columns and desiccants

Both of the above items are external to the TARGAS-1 and easy to service and maintain.

External Air Filter

An external air filter should be used at all times and fitted in-line with the **AIR IN** port on the TARGAS-1 to protect internal components from dirt and dust (see below). PP Systems includes one air filter (STD558) with every system as standard and it should not require replacement unless it is broken or missing. You can purchase replacement filters (STD556) for use with the main assembly if required.

When changing out filters you should put a slight smear of silicone grease on the "O" ring which provides a good seal on the filter.

Re-Order Information	
Part Number	**Description**
STD558	External Inlet Air Filter Assembly (Complete)
STD556	Replacement Filter Element, 48 um (Blue)

Absorber Columns and Desiccants

There are 3 absorber columns located on the rear of the TARGAS-1 enclosure. Each one can easily be removed from the instrument by gripping it around the middle of the column and gently pulling it out of its manifold.

Periodically inspect the following:

Gray Foam Filters

The gray foam filters used inside the absorber column (top and bottom) will wear over time and should be inspected regularly and replaced when torn or reduced in size. The foam must be of an open celled type, such as packing foam. The foam filters at the bottom of each column will likely require more frequent changes versus the upper foam filters.

Absorber Filters

Each absorber end cap contains a white plastic filter disk. Generally these do not need to be replaced but should be checked periodically. However, they must be present to prevent any of the column contents being drawn with the gas stream causing damage to the instrument.

End Cap "O" Rings

Each end cap has two "O" rings, one that seals inside the plastic column and another that seals at the manifold. All "O" Rings on the absorber column should periodically (every couple of weeks) receive a slight smear of silicone grease to aid ease of fitting, improve the seal and extend the life of the "O" rings and to keep them from cracking or breaking. Once sealed, end fittings should be checked to ensure that the O-rings are seated correctly in their groove and that they are not trapped or pinched resulting in system leaks.

Soda Lime

Soda lime (calcium hydroxide, sodium hydroxide, water) is used to remove CO_2 from air entering the TARGAS-1. Both self-indicating (white to violet) and non-indicating Soda Lime can be can be used with the TARGAS-1. Soda Lime cannot be regenerated and should be discarded after exhaustion.

- Type: Sofnolime, 1.0-2.5 mm, self-indicating (white to violet), 1 kg
- Manufacturer: Molecular Products. (www.molecularproducts.com)
- For the latest Material Safety Data Sheet, please visit www.molecularproducts.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of soda lime, please contact the manufacturer directly or contact PP Systems.

Take caution to wash your hands completely after handling soda lime.

Re-Order Information	
Part Number	**Description**
STD007W	Sofnolime, 1 kg

Drierite

Drierite (anhydrous 97% calcium sulfate ($CaSO_4$) and 3% cobalt chloride) is an excellent H_2O absorber making it an ideal choice for controlling H_2O. Both self-indicting (blue to pink) and non-indicating Drierite can be can be used with the TARGAS-1. It can be regenerated easily by simply spreading out the granules one layer deep and placed in a preheated oven for 90 minutes at 230 °C or 425 °F. The regenerated material should be returned to the original glass container and sealed while hot. The color of the self-indicating Drierite may become less distinct on successive regenerations due to the migration of the indicator into the interior of the granule and sublimation of the indicator.

- Type: 8 mesh, self-indicating (blue to pink) or non-indicating, 1 lb. Jar
- Manufacturer: W.A. Hammond Drierite Company Ltd. (www.DRIERITE.com)
- For the latest Material Safety Data Sheet, please visit www.DRIERITE.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of Drierite, please contact the manufacturer directly or contact PP Systems.

Take caution to wash your hands completely after handling Drierite.

Re-Order Information	
Part Number	**Description**
STD008	Drierite, 1 Lb.

Molecular Sieve

Molecular Sieve is used to scrub both CO_2 and H_2O from the air in order to perform Auto-Zero and to ensure system stability and accuracy for CO_2 and H_2O. Unfortunately, Molecular Sieve is not self-indicating and there is no obvious way to see that it is exhausted. **It is therefore best to always change the Molecular Sieve if there is any doubts as to the status of this desiccant.**

Molecular Sieve can easily become contaminated through absorption of CO_2 and H_2O from atmospheric air. It is therefore **strongly recommended and advised** that Molecular Sieve is decanted into small air-tight, glass containers sealed by electrical tape to minimize any exposure to air. The Zero absorber columns should be placed in a sealed polythene bag if the TARGAS-1 is not going to be used for an extended period (i.e. days) to preserve the desiccants.

- Type: Molecular Sieve, 13X 1/16, 1.25 lb. container
- Manufacturer: AGM Container. (www.agmcontainer.com)

For the latest Material Safety Data Sheet, please visit www.agmcontainer.com and request the latest MSDS or contact PP Systems.

Take caution to wash your hands completely after handling Drierite.

Re-Order Information	
Part Number	**Description**
STD006	Molecular Sieve, 1.25 lb.

When changing out desiccants, the user must take care to ensure that the columns are properly seated in the correct manifolds, the proper desiccant is used in appropriate columns which are clearly marked and that all “O” rings are in place and slightly lubricated with silicone grease. Any leakage of ambient air into the gas circuit generally results in error messages during Zero or fluctuating CO2r values during measurement.

Tip

Always change the molecular sieve at least once per week when the TARGAS-1 is in use regardless of operation time.

Molecular Sieve Repackaging

The Molecular Sieve is originally supplied by PP Systems in tin packaging. After initial opening, we strongly urge all users to repackage the Molecular Sieve in small glass containers with a screw top to seal the desiccant from room air. This desiccant saturates very quickly in room air and if not properly stored it will cause it to go bad and subsequently affect CO_2 readings and calibration.

To ensure a good seal, we also recommend putting some electrical tape around the screw top as shown here. If you have any questions, get in contact with PP Systems.

Each absorber column includes the following items which should be checked periodically and replaced when necessary:

Foam Filters

The gray foam filters used inside the absorber columns become worn over time and should be inspected regularly and replaced when torn or reduced in size. The foam must be of an open celled type, such as packing foam. The foam filters at the bottom of each column will likely require more frequent changes versus the upper foam filters.

Re-Order Information	
Part Number	**Description**
30118-1	Filter Foam

Absorber Filters

Each absorber end cap contains a white plastic filter disk. Generally these do not need to be replaced but should be checked periodically. However, they must be present to prevent any of the column contents being drawn with the gas stream causing damage to the instrument.

"O" Rings

All "O" Rings on the absorber columns should periodically (every couple of weeks) receive a slight smear of silicone grease to aid ease of fitting, improve the seal and extend the life of the "O" rings and to keep them from cracking or breaking. Once sealed, end fittings should be checked to ensure that the O-rings are seated correctly in their groove and that they are not trapped or pinched resulting in system leaks.

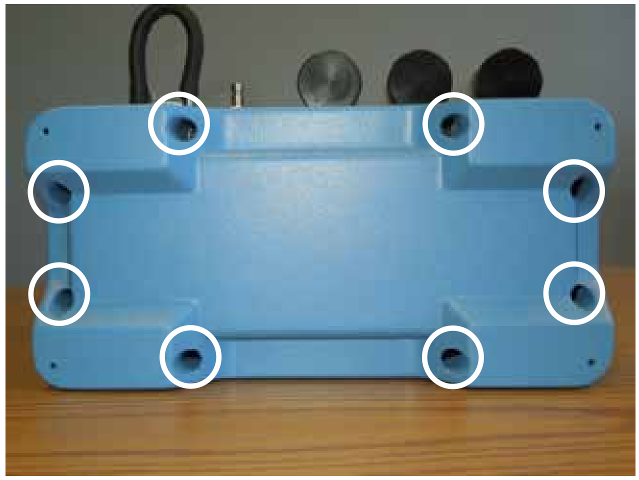
Re-Order Information	
Part Number	**Description**
30013-1	O-ring 4.76 x 1.78
30013-19	O-ring 20.8 x 2.4

Access to Internal Components

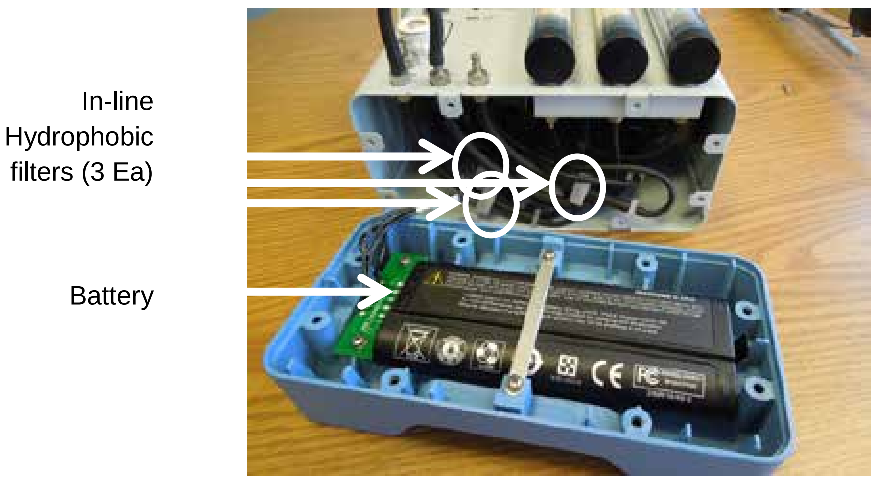
Under most circumstances there should be no need to service internal components (pump, IRGA, IR source, etc.). There are only two internal items that may require replacement at some point:

- Internal, rechargeable Li-ion battery pack
- In-line hydrophobic filters (3)

In the event that you do need to troubleshoot and examine these items you can gain access into the TARGAS-1 enclosure by removing the 8 screws securing the base to the main enclosure as shown below.



Gently remove the base from the upper enclosure as shown below:



Hydrophobic Filters

There are three internal hydrophobic filter located inside the TARGAS-1 enclosure to protect the analyzers from water ingestion. They are all secured in place by black Viton tubing. These filters should not require replacement unless you are working in extremely high humidity conditions or if you incur any regular flow related messages. If you are regularly seeing “low flow” messages, or if you are unable to achieve flow rates greater than 50 cc/min, then the “In-line” hydrophobic filters should be replaced. Simply remove the filter from the tubing and replace it with a new one.

Re-Order Information	
Part Number	**Description**
10045-1	Hydrophobic Filter

Battery

The internal, rechargeable Li-Ion battery pack should last for many years. When fully charged it should allow continuous operation of the instrument up to 10 hours. We recommend that you always fully recharge the battery after use. If the instrument is stored for longer periods, ensure that the battery is fully charged prior to storage.

Re-Order Information	
Part Number	**Description**
41535-1	7.2V Li-Ion Battery

Pumps

There are 2 pumps used in the TARGAS-1 and both are rotary vane style pumps. One is used as a sampling pump and one as a forwarding pump. They are secured in place by a simple mounting clip and electrically connected to the internal PCB. Both operate from 1.0 – 5.0 VDC, which is generated by the TARGAS-1 controller board. They are capable of delivering flow rates up to 500 cc/min flow. History has shown that these types of pump are rugged and durable and should last for many years. If replacement is necessary, please contact PP Systems.

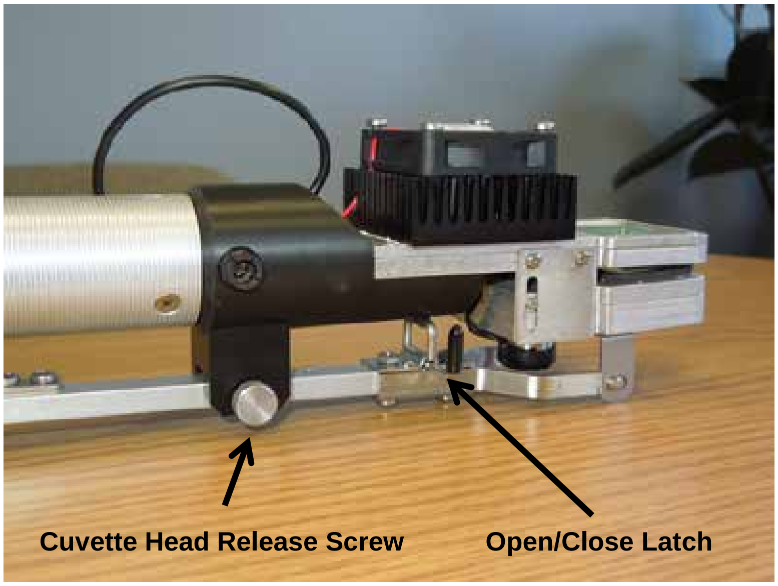
Re-Order Information	
Part Number	**Description**
10181-1	Miniature Rotary Pump

Infrared Source

The infrared source should last for many years without replacement. Please contact PP Systems for more information if you suspect a faulty Infrared source.

PLC5 Leaf Cuvette

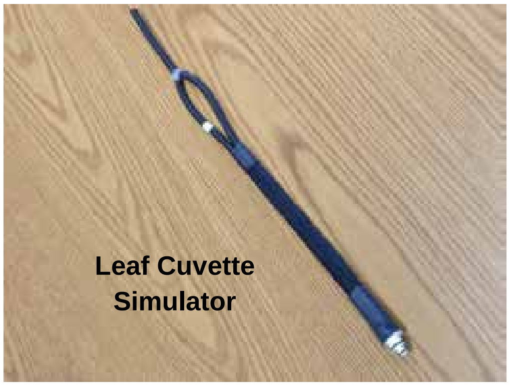
The cuvette leaf gaskets will require periodic replacement. Over time the gaskets can become worn, damaged, cracked and/or creased. The leaf gaskets are seated in individual channels with adhesive backing. We strongly recommend that the cuvette head is in the open position when not in use to keep the gaskets from compressing.



Replacement of leaf gaskets

1. Loosen the "Cuvette Head Release Screw" by rotating it counter-clockwise and slide it out from the handle.
2. The cuvette head can now drop down making it very easy to replace the leaf gaskets.
3. Using a fine screwdriver gently pry the old leaf gaskets out of each respective channel. There are two rectangular gaskets below the chamber window (25 x 18mm) and two round gaskets (18mm diameter) at the rear of the chamber. Make sure each channel is clean of any debris and adhesive material that may have accumulated in that area.
4. Carefully replace the gaskets and make sure that they are seated properly in each respective channel.
5. Close the cuvette head and reassemble by securing everything in place using the "Cuvette Head Release Screw". Slide the screw into the small hole and turn clockwise until snug. **Do not overtighten.**

Checking for Leaks Associated with the PLC5



How do I know if there is a leak in the system? Good question. If you have the leaf cuvette closed with no leaf present, you should observe a CO_2 differential (CO2d) close to 0 (± 1.0 ppm and stable). If your CO2d is > ppm and fluctuating this usually is the result of a leak. To help isolate the leak and to determine if the leak is associated with the TARGAS-1 console or the PLC5, we include a simple "Leaf Cuvette Simulator" (Part No. STD553) with each new system that can be very helpful.

To checks for leaks, connect the cuvette simulator to the PLC Gas port on the TARGAS-1 console just like you would connect the PLC5 gas connector. This will allow you to sample the same air in both the reference and analysis cells of the infrared gas analyzer. When the simulator is connected to the TARGAS-1 you should observe stable CO2r, CO2a, H2Or and H2Oa readings and the CO_2 differential (CO2d) should be close to 0 (± 1.0 ppm and stable).

If you observe a CO2d value close to 0 and stable with the Leaf Cuvette Simulator and you do not when the PLC5 leaf cuvette is connected to the TARGAS-1, the leak is likely associated with the PLC5 leaf cuvette. As described earlier, PLC5 leaks are normally associated with the leaf cuvette gaskets. To isolate the leak, take a small piece of tubing and gently breathe around the gaskets and monitor the CO2d on the TARGAS-1 console. If you see a spike or increase in CO2d you have found the leak. Replace or re-seat the gaskets as described above. Also, you should check to make sure that the head is closing and sealing properly.

If you observe a fluctuating CO2d value that is also > 1.0 ppm with the leaf cuvette simulator connected, the leak is likely associated with the TARGAS-1 console. Normally leaks associated with the console can be found around absorber columns especially after a recent change in chemicals. Gently blow around the absorber columns to isolate leaks.

Re-Order Information	
Part Number	**Description**
STD525	PLC5 Leaf Gaskets, 25 x 18mm (Qty. 10)
STD553	Leaf Cuvette Simulator

PLC5 Gas Connector

The PLC5 gas connector (white) has two small “O” rings (see below) to make a leak-tight seal with the TARGAS-1 console. Periodically apply a slight smear of silicone grease on each “O” ring to keep it from cracking or breaking.

PAR Sensor

The PAR Sensor should be recalibrated every two years. Please consult with PP Systems for PAR sensor recalibration services. Calibration can also be performed by the end user if required. Refer to PAR on page 98 for more information on recalibration of the external PAR sensor.

Light Unit

The light unit should not require recalibration. If you suspect any problems with your light unit please contact PP Systems.

Appendix 1. Photosynthesis Equations Used in TARGAS-1

Calculations

Step 1.0

Calculate the mass flow of air (W) per unit leaf area entering the cuvette

The mass flowmeter is calibrated to read the volume flow at 20 °C and 1013.25 mb (V_{20}). Molar volume is 22.414 at 0 °C and 1 standard atmosphere (STP). Therefore:

$$W(mol\ m^{-2}s^{-1}) = \left(\frac{V_{20}}{60 \times 10^3}\right) \times \left(\frac{1}{22.414}\right) \times \left(\frac{273.15}{293.15}\right) \times \left(\frac{1000}{1013.25}\right) \times \left(\frac{10^4}{a}\right)$$

Where: *a* is projected leaf area (cm^2). The V_{20} term is calculated above using cc sec^{-1}, but is converted from cc min^{-1} (TARGAS-1 default flow rate set to 300 cc min^{-1}).

Step 2.0

Calculate transpiration rate (E) from the partial pressures of water vapor of the air entering (e_{in}) and leaving (e_{out}) the cuvette

(2.1) The molar flow of *water vapor* (mol m^2 s^{-1}) into the cuvette is:

$$W \times \left(\frac{e_{in}}{P}\right)$$

(2.2) The molar flow of *air* out of the cuvette (due to the addition of transpired water) is (W+E). Therefore, the molar flow of *water vapor* out of the cuvette is:

$$(W + E) \times \left(\frac{e_{out}}{P}\right)$$

(2.3) However, the difference between the molar flows into and out of the cuvette must equal the transpiration, so:

$$E = \left[(W + E) \times \left(\frac{e_{out}}{P}\right)\right] - \left[W \times \left(\frac{e_{in}}{P}\right)\right]$$

(2.4) Therefore:

$$E(mmol\,m^{-2}\,s^{-1}) = \left[\frac{W \times (e_{out} - e_{in})}{(P - e_{out})}\right] \times 10^3$$

Clarification of nomenclature:

e_{in} is defined as the partial pressure of water vapor of dry reference air supplied to the cuvette, but not yet inside the cuvette, and therefore un-influenced by the cuvette stirring fans or the leaf itself. In TARGAS-1 e_{in} is equivalent to H2Or.

e_{out} is defined as the partial pressure of water vapor of air inside the cuvette, surrounding the leaf. This air is both highly mixed by the stirring fans and influenced by transpirational water vapor. In TARGAS-1 e_{out} is equivalent to H2Oa.

As relates to the measured values in TARGAS-1 output:

$$e_{out} = (Mb\, Ref + Mb\, Diff) = Mb_{analysis}$$

Step 3.0

Calculate leaf temperature (T_{leaf}) from the energy balance

(3.1) From *Reference 1* the difference between air and leaf temperature is:

$$\Delta t = \left[\frac{H - \lambda \times E}{\left(\frac{0.93 \times M_a \times C_p}{r_b}\right) + [4\sigma \times ((T_c + 273)^3)]}\right]$$

Where:

H = incident radiation absorbed by the leaf

l = latent heat of vaporization of water

E = transpiration rate

M_a = molecular weight of air

C_p = specific heat at constant pressure

r_b = boundary layer resistance to water vapor transfer, empirically determined for each cuvette by the pseudo-leaf (filter paper) method. 0.93 converts it to that for heat transfer.

σ = Stefan Boltzmann constant

T_c = cuvette air temperature

H is calculated from the photon flux incident on the cuvette (Q), taking into account the ratio of infrared to PAR in the light source, transmission through the cuvette window (*Trans*), and reflection/absorption by the leaf: (H = Q x *Trans*).

The following approximation is made in the program:

$$4\sigma \times \left((T_c + 273)^3 \right) \cong \left(4.639 + (0.5834 \times T_c) \right)$$

(3.2) From this we derive:

$$T_{leaf} = (T_c + \Delta t)$$

Step 4.0

Derive i) saturated vapor pressure at leaf temperature (e_{leaf}) from T_{leaf} and ii) stomatal resistance (r_s)

(4.1) From *Reference 2*:

$$e_{leaf} = 6.1121 * exp\left[\frac{T_{leaf} \times \left(18.564 - \left(\frac{T_{leaf}}{254.4} \right) \right)}{T_{leaf} + 255.57} \right]$$

(4.2) Stomatal resistance (to water vapor) is derived by:

$$r_s = \left[\left[\frac{(e_{leaf} - e_{out})}{\frac{(e_{out} - e_{in}) \times (P - e_{out})}{P}} \right] \div W \right] - r_b$$

(4.3) An alternative expression of Step 2.4 is:

$$E = \left[\frac{(e_{leaf} - e_{out})}{P \times (r_s + r_b)} \right]$$

(4.4) Because,

$$\left[\frac{(P - e_{out})}{W \times (e_{out} - e_{in})} \right] = \frac{1}{E}$$

(inverse of equation 2.4)

(4.5) Then,

$$r_s (m^2\, s\, mol^{-1}) = \left[\frac{(e_{leaf} - e_{out})}{(E \times P)} \right] - r_b$$

(4.6) It follows that stomatal conductance is the inverse of stomatal resistance:

$$g_s (mmol\, m^{-2}\, s^{-1}) = \frac{1}{r_s} \times 10^3$$

Step 5.0

Determine the rate of net photosynthesis (A) from the difference between CO_2 concentrations entering (C_{in}) and leaving (C_{out}) the cuvette

(5.1) IRGA CO_2 readings are corrected for water vapor, temperature, and atmospheric pressure. The addition of transpirational water vapor dilutes the air leaving the cuvette (C_{out}), and this is compensated for in the calculation:

$$A = (C_{in} \times W) - [C_{out} \times (W + E)]$$

(5.2) Therefore,

$$A = -\left[\left((C_{out} - C_{in}) \times W\right) + (C_{out} \times E)\right]$$

The TARGAS-1 calculates and displays the CO_2 difference (C_{out} - C_{in}). As relates to the calculated values in the TARGAS-1 output:

$$C_{out} = (CO2\ Ref + CO2\ Diff) = C_{analysis}$$

Step 6.0

Calculate CO_2 concentration in the sub-stomatal cavity (C_i) using the equation derived by von Caemmerer & Farquhar (Reference 3)

(6.1)

$$C_i(\mu mol\, mol^{-1}) = \frac{\left[\left(g_c - \frac{E}{2}\right) \times C_{out}\right] - A}{\left(g_c + \frac{E}{2}\right)}$$

(6.2) Where:

$$g_c\ (mmol\, m^{-2}\, s^{-1}) = \left[\frac{1}{(1.585 \times r_s) + (1.37 \times r_b)}\right] \times 10^3$$

Please note: These calculations are based on the following assumptions:

- the leaf is exposed on both upper and lower leaf surfaces
- the upper and lower boundary layer resistances are similar
- stomata are evenly distributed on both upper and lower leaf surfaces.

Symbol Definitions

Measured Parameters

Symbol	Measured Parameter	Units
V_{20}	Mass flow of dry air into cuvette at STP	$cm^3\ sec^{-1}$
a	Projected leaf area	cm^2
r_b	Boundary layer resistance to water vapor	$m^2\ s\ mol^{-1}$
P	Atmospheric pressure	mb
Q	Photon flux density incident on cuvette	$\mu mol\ m^{-2}\ s^{-1}$
T_c	Cuvette air temperature	°C

Calculated Parameters

Symbol	Calculated Parameter	Units
W	Mass flow of dry air per unit leaf area	$mol\ m^{-2}\ s^{-1}$
e_{in}	Partial pressure of water vapor of air *entering* cuvette	mb
e_{out}	Partial pressure of water vapor of stirred cuvette air	mb
E	Transpiration Rate	$mmol\ m^{-2}\ s^{-1}$

Symbol	Calculated Parameter	Units
e_s	Saturated vapor pressure at cuvette air temperature	mb
$\mathbf{e_{leaf}}$	Saturated vapor pressure (inside the leaf) at leaf temperature	mb
$\mathbf{T_{leaf}}$	Leaf Temperature	°C
Δt	Temperature difference between the air and the leaf	°C
H	Radiation absorbed by the leaf	$W\ m^{-2}$
$\mathbf{r_s}$	Stomatal resistance to water vapor	$m^2\ s\ mol^{-1}$
$\mathbf{g_s}$	Stomatal conductance to water vapor	$mmol\ m^{-2}\ s^{-1}$
$\mathbf{C_{in}}$	CO_2 concentration of air *entering* cuvette	$\mu mol\ mol^{-1}$ *
$\mathbf{C_{out}}$	CO_2 concentration of air *inside* and *exiting* the cuvette	$\mu mol\ mol^{-1}$ *
A	Rate of CO_2 assimilation (Net Photosynthetic Rate)	$\mu mol\ m^{-2}\ s^{-1}$
$\mathbf{g_c}$	Total conductance to CO_2 transfer	$mmol\ m^{-2}\ s^{-1}$
$\mathbf{C_i}$	CO_2 concentration of sub-stomatal cavity	$\mu mol\ mol^{-1}$

*Determined by IRGA. Temperature and pressure corrected for water vapor effects on measurement and analyzer temperature.

Physical Constants Used in Equations

Volume of one kg mole of gas =0.0224 m^3, at 1013.25 millibars of pressure and 273.15 °K

Latent heat of vaporization of water (λ) = 45064.3 - (T_c x 42.9)

Molecular weight of air (M_a) = 28.97

Specific heat at constant pressure (C_p) = 1.012 kJ kg^{-1} K^{-1}

Stefan Boltzmann constant (σ) = 5.6704 x 10^{-8} W m^{-2} K^{-4}

Saturated Vapor Pressure of Water from Air Temperature

Modified from *Reference 1* to optimize the fit in the temperature range of 0-50 °C, above 0 °C:

$$e_s = 6.1078 * exp\left[\frac{T_a \times \left(18.564 - \left(\frac{T_a}{254.4}\right)\right)}{T_a + 255.57}\right]$$

References

1. *Parkinson, K.J. 1983. Porometry in S.E.B. Symposium of Instrumentation for Environmental Physiology. Cambridge University Press.*

2. *Buck, A.L. 1981. New equations for computing vapour pressure and enhancement factor. Appl. Meteorol., Vol. 20:1527-1532.*

3. *von Caemmerer, S. and G.D. Farquhar 1981. Some relationships between the biochemistry of photosynthesis and the gas exchange of leaves. Planta, Vol. 153:376-387.*

4. *Parkinson, K.J., W. Day and J.E. Leach 1980. A Portable System for Measuring the Photosynthesis and Transpiration of Graminaceous Leaves. J. Expt. Bot., Vol. 31:1441-1453.*

Appendix 2. Soil CO_2 Efflux and Net Canopy CO_2 Flux

The **SRC-2 Soil Respiration Chamber** can be used with the TARGAS-1 Portable CO_2 Gas Analyzer for closed system measurement of soil CO_2 efflux. The **CPY-5 Canopy Assimilation Chamber** can also be used with the TARGAS-1 for closed system measurement of net canopy CO_2 flux**.**

Theory

The respiration/assimilation is measured by placing a closed chamber on the soil and measuring the rate of increase of the CO_2 concentration inside the chamber. Then, assuming a well-mixed and sealed system:

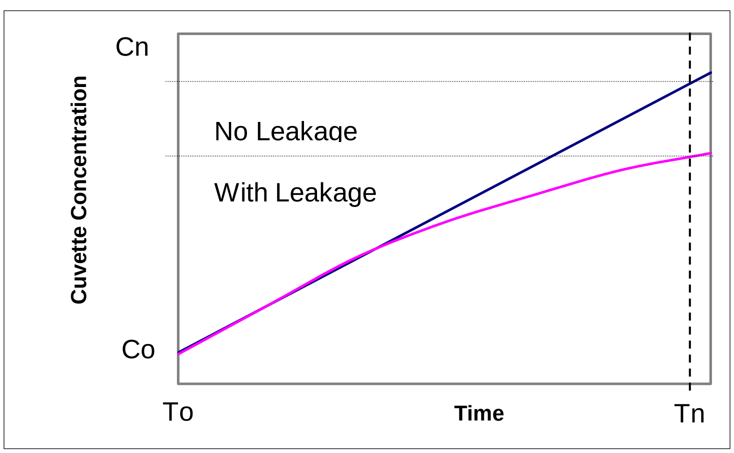
$$R = \frac{(Cn - Co)}{Tn} * \frac{V}{A} \qquad (1)$$

Where R is the respiration/assimilation rate (CO_2 flux, or moles of CO_2 unit area^{-1} unit time^{-1}), C_O is the CO_2 concentration at T=0 and C_n is the concentration at a time T_n later. A is the area of soil exposed and V the total system volume.

It has been suggested that to make accurate measurements of the assimilation it is essential to start with a CO_2 concentration in the cuvette below (respiration)/above(photosynthesis) ambient and measure until the concentration is above/below ambient, presumably with the intention of getting some compensation for leakage. However, this leakage can only take place at ground level, where the CO_2 concentration is unknown and most certainly will not be what we would consider as ambient.

Over the short period of measurement and with the relatively small CO_2 concentrations in the chamber compared with the soil concentrations, we would expect the assimilation to be a constant flux, giving a constant rate of change in the cuvette CO_2 concentration.

Any leakage should be a function of the concentration difference between the cuvette and the exchange air. Due to leakage, the apparent assimilation rate decreases with time.



Simulated Soil Respiration Measurements

The TARGAS-1 software continuously performs a least square fit of the chamber concentration (C=y) and time (T=x) data from the start of measurement with both a linear equation (y = a + bx) and a quadratic equation (y = a + bx + cx2). In both cases, the b estimates the rate of change of CO2 for a given set of data, and therefore is directly related to CO2 flux. With no leakage, the computed value for b will be identical whether using the linear and quadratic calculation. As leakage increases at the end of the data set, the value of the quadratic fit cx2 term will increase, and the value of b will diverge between the linear fit and quadratic fit. A comparison of b and cT gives an indication of the leakage. To help identify when the linear fit is probably not accurate, the software gives a "Non-linear" message when the value of cT is more than 20% of the value of b. This is believed to be a better approach than lowering the CO_2 value at the start of the measurement.

In general, there are three field conditions that can lead to the non-linear message:

1. The chamber to soil seal is poor or intermittent at some point, so the data is compromised. The non-linear message comes on and stays on. Data is suspect and should be redone.
2. The chamber did not purge or return to ambient prior to test start, or the chamber was moved slightly during the initial seconds of the data run. The non-linear message appears at the start of the run, but may go away as more data is taken. Data is generally good even though message appears at the start. A longer delay or longer measurement period will reduce these type of starting transient effects.
3. The chamber concentration raises high compared to its initial value so that a linear increase can not be maintained as described above. The non-linear message come on toward the end of the data run. Linear and Quadratic results are generally similar until the message appears, and the quadratic fit will still produce accurate predictions of the CO2 flux. A lower maxDC or maxDT to end the data set before the leakage becomes large will reduce this effect.

Measurement Units

From 1 and 2:-

R = b x V/A

To give the flux in mass/unit area/unit time then b must be measured in mass/unit volume.

The CO_2 analyzer measures the volume/volume ratio (= ppm by volume = micro-liter/liter = micro-bar/bar = micro-mol/mol).

Now one kg mol of gas (44.01kg of CO_2) at STP (0 ºC, 1013.25 mb) occupies 22.41 m^3.

Thus:

$$R = b * \frac{P}{1013.25} * \frac{273}{273+Ta} * \frac{44.01}{22.41} * \frac{V}{A} \qquad (3)$$

Where:

R is the CO_2 flux in $kg.m^{-2}.s^{-1}$

V is the system volume (largely the chamber volume) in m^3

A is the soil area exposed in the chamber in m^2, P is the atmospheric pressure in mb

Tc is the temperature of the system volume (chamber) in ºC.

We measure: -

DC/DT = b as ppm/second

V, in cm^3

A, in cm^2

R is expressed as $g.m^{-2}.hr^{-1}$.

To convert ($g.m^{-2}.hr^{-1}$) to (micro-mol.$m^{-2}.s^{-1}$) multiply by 6.312

References

Parkinson K.J. (1981). An improved method for measuring soil respiration in the field. Journal of Applied Ecology, 18, 221-228.