METER

SC-1

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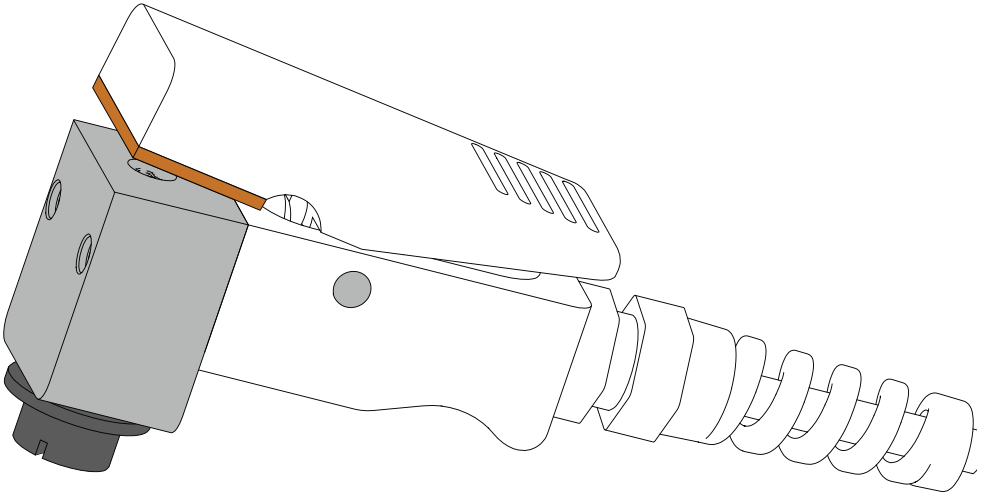

1. INTRODUCTION

Thank you for choosing the SC-1 Leaf Porometer from METER Group.

The SC-1 measures stomatal conductance, which is a function of the density, size, and degree of opening of plant pores. The SC-1 measures stomatal conductance by putting the conductance of a leaf in series with two known conductance elements and comparing the relative humidity (RH) measurements between them. This manual describes the functions of the SC-1 and how to make high-quality stomatal conductance measurements.

Verify all SC-1 Leaf Porometer components are included and appear in good condition:

- SC-1 sensor head (Section 3.2)
- SC-1 controller (Section 3.3)
- USB-to-serial cable
- USB drive with Leaf Porometer Utility (attached to manual cover)
- Calibration plate
- Bottle of deionized (DI) water
- Bottle of desiccant
  (Molecular sieve desiccant, 8–12 mesh)
- Dispensing cap
- Tweezers
- Leaf pads
- Bead retention screens
- Teflon™ filters
- Calibration filter papers
  (Whatman® filter paper, grade #3)
- Spare hinge pin
- Short hinge pin
- White fluoropolymer agitation beads
  (McMaster-Carr® PTFE balls, 1/8 in, part #9660K13)

The SC-1 was shipped without batteries to preserve battery life and prevent damage to the instrument. Install four AA batteries in the SC-1 controller prior to use.

2. OPERATION

Please read all instructions before operating the SC-1 Leaf Porometer to ensure it performs to its full potential.

⚠ PRECAUTIONS

METER instruments are built to the highest standards, but misuse or neglect may damage the device and possibly void the manufacturer's warranty. Before using the SC-1, follow the recommended user instructions and arrange proper protections to safeguard the instrument from damage.

2.1 CONFIGURING

Before taking measurements, configure the SC-1 system date, time, and units to ensure accurate timestamps and measurements readings. The date and time can also be changed using the Leaf Porometer Utility (Section 3.4). The units can be changed at any time on the Measurement tabs (Section 3.3.1).

Use the following steps to configure the SC-1 controller prior to readings.

1. Turn on the SC-1 controller.
2. Press **MENU** to navigate to the Configuration tab (Figure 1).

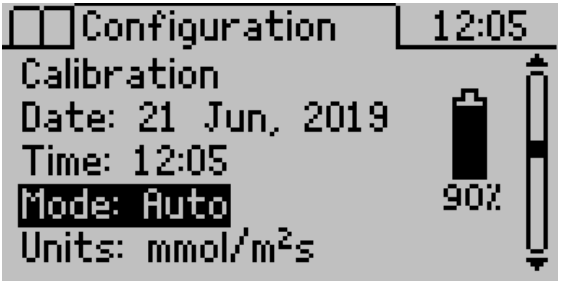

Figure 1 Configuration tab

3. Use **UP** and **DOWN** to highlight `Date`.
4. Press **ENTER**.

   The system date appears in the center of the screen in a day/month/year format (Figure 2). Arrows appear above and below the first value, indicating the value can be edited.

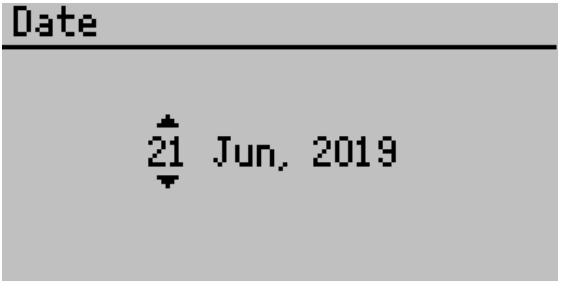

Figure 2 Select current date on the Date screen

5. Use **UP** and **DOWN** to change the first number. Holding down the arrow buttons will scroll quickly between values.
6. Press **ENTER** to move to the next value or **ESC** to return to the previous value. Repeat step 5 until the correct date is selected.
7. After the last value is changed, press **ENTER** to return to the Configuration tab.
8. Use **DOWN** to highlight `Time`.
9. Press **ENTER**.

   The system time appears in the center of the screen, in 24-h format (Figure 3). Arrows appear above and below the first value.

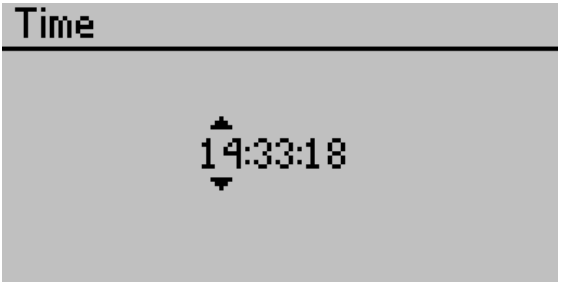

Figure 3 Select current time on the Time screen

10. Use **UP** and **DOWN** to change the value.
11. Press **ENTER** to move to the next value or **ESC** to return to the previous value. Repeat step 10 to select the accurate time.
12. After the last number is changed, press **ENTER** to return to the Configuration tab.
13. Use **DOWN** to highlight `Units`.
14. Press **ENTER** to scroll through the options.

    NOTE: The SC-1 default is millimoles per meters squared seconds (mmol/[m²s]).

    The units can also be changed at any time on the Measurement tab.
15. Press **MENU** to return to the Measurement tab.

2.2 TAKING A MEASUREMENT

Before using the SC-1, install the batteries (Section 4.2.1) and set the date and time (Section 2.1). Review factors that may affect measurements (Section 2.2.1) and follow the measurement process closely (Section 2.2.2).

2.2.1 MEASUREMENT CONSIDERATIONS

Leaf stomatal conductance depends on the amount of shade and sunlight the leaf receives, its age, and its position on the plant. To obtain a plant stomatal conductance average, take a variety of readings from different positions on the plant. The average will be proportional to the type of readings taken. For example, if the plant receives 70% sunlight, take seven readings from the sunny part and three from the shady part. Do not make repeated measurements on the same spot on a single leaf.

NOTE: Prolonged exposure (>2 min) to low RH conditions induces stomatal closure in most plant species. The SC-1 Auto mode measures stomatal conductance in 30 s, so the presence of the desiccated leaf clip should not cause stomatal closure unless multiple measurements are made in quick succession on the same location of the same leaf.

Average readings can also be taken for a field of plants. For example, readings from a leaf on the same place of each stalk of corn in a field would give an average for that field.

While taking measurements or storing the sensor, avoid chemical fumes (e.g., alcohol, gasoline, or volatile organics). Fumes can be extremely harmful to the sensor (Section 4.3).

The following factors will affect measurements taken by the SC-1:

- Light: Stomatal conductance readings vary in different lights. Readings taken on overcast days, in shadow, or in shade generally have lower conductances than those taken in greater light.
- Temperature: Temperature also affects stomatal conductance readings. For most plants, extreme temperatures (very hot or very cold) will cause photosynthesis to slow down or stop and the stomata will narrow or close.
- Relative Humidity: RH at the leaf surface will affect readings. Stomata open more widely as RH increases.
- Carbon Dioxide: An increase in carbon dioxide (CO_2) causes the stomata to close, while a decrease causes them to open. Exhaling CO_2 directly onto the plant will adversely affect readings, particularly in growth chambers or greenhouses.

Additionally, METER recommends always using desiccant to take readings. If operators wish to make readings without desiccant, METER recommends doing so at an ambient RH of <30%. Follow these exceptions when measuring without desiccant:

- Remove the desiccant chamber from the sensor head and do not cover the hole in the sensor head. Keep fingers away from the diffusion path when taking measurements.
- Recalibrate the sensor without desiccant (Section 4.1).
- Allow equilibration between measurements at ambient RH by opening the clip and shaking the sensor head to mix the air in the diffusion path.

- Discard the first reading in Auto mode. This first reading always reads low. Begin recording data with the second measurement.

NOTE: This is not an issue while using the desiccant chamber.

2.2.2 MEASUREMENT PROCESS

Prior to taking a measurement, perform the following tasks for best results.

1. Confirm the weather will be clear of precipitation and wait for dew or other water to evaporate.
2. Ensure sensor head is clean and free of dirt and pollen (Section 4.2.2). Use a dry swab to clear out debris from the sensor head instead of blowing on it, which can affect the stomatal conductance reading.
3. Firmly connect the sensor head cable to the SC-1 controller.
4. Equilibrate the sensor head to ambient temperature.

   This may take 10 min or longer if the temperature of the SC-1 is very different from the sampling environment (e.g., from a cool air-conditioned room to a hot outdoor environment). Thermal disequilibrium will cause inaccurate measurements.

   Holding the sensor head in the correct manner during the measurement is very important for maintaining thermal equilibrium. Figure 4 illustrates the correct way to hold the sensor head.

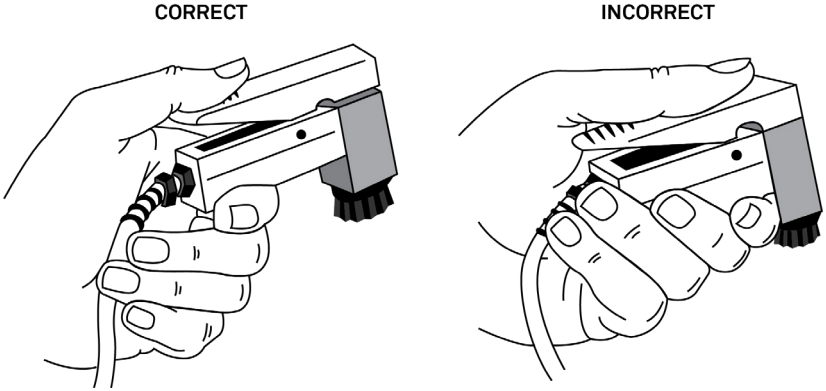

Figure 4 Correct way to hold the sensor head

Also prior to taking measurements, add desiccant to the desiccant chamber using the following steps. METER recommends fresh desiccant be used for each day of measurement.

NOTE: Early versions of the SC-1 sensor block do not have the desiccant chamber because the discontinued sensors in those models did not require it. However, current sensors require the use of the desiccant chamber for best results.

1. Unscrew the black detachable dessicant chamber from the bottom of the aluminum sensor block (Figure 5).

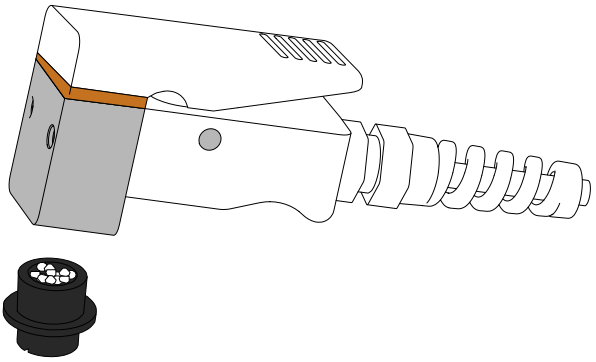

Figure 5 Filling desiccant chamber

2. Fill the chamber with molecular sieve desiccant approximately three-quarters full.
3. Screw the desiccant chamber back to the sensor head. Ensure the chamber is screwed in far enough to compress the o-ring on the desiccant chamber and create a good vapor seal.

Use the following steps to take a measurement:

1. Turn the SC-1 controller on.
2. Press **MENU** to navigate to the Configuration tab (Figure 6).

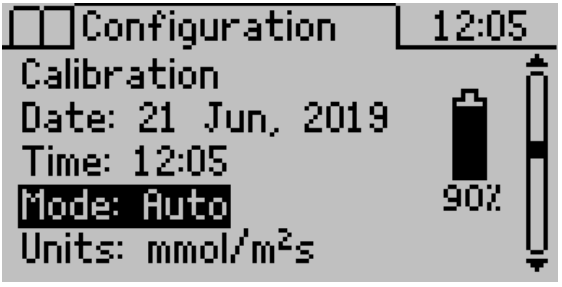

Figure 6 Toggle between Auto and Manual modes

3. Use the **UP** and **DOWN** arrows to navigate to `Mode` (Figure 6).
4. Press **ENTER** to select `Auto`.

   NOTE: See Section 3.3.2 for explanations of Auto and Manual modes.
5. Press **MENU** to return to the Measurement tab (Figure 7).

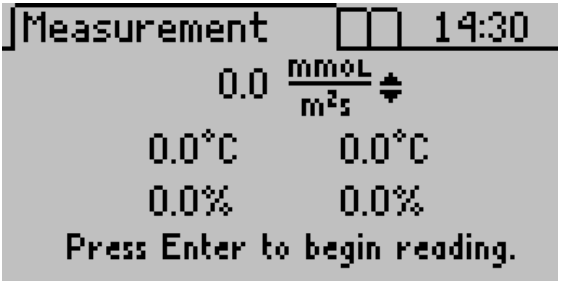

Figure 7 Measurement tab before beginning a reading

6. Press **ENTER** to begin a reading.

   The SC-1 will check the initial conductance and the absolute values of the RH sensors prior to beginning a reading. It is common to need to equilibrate the sensor due to one of these issues. The status bar on the right shows progress toward equilibration as a black bar dropping toward the `EQU` pointer.

   If a warning appears that `Initial conductance is too high` (Figure 8), equilibrate the humidity in the sensor head by closing the leaf clip and allowing the desiccant to dry the air in the measurement path. Hold the sensor in a vertical orientation and shake the sensor head briskly side to side to accelerate the process. Generally speaking, the faster the shake, the faster the sensor head equilibrates. The bead will bounce between the screen and the Teflon filter, effectively mixing the air in the measurement path.

   NOTE: The presence of the bead does not affect the stomatal conductance measurement as long as the bead does not move during the measurement. Keep the leaf clip oriented with the black desiccant chamber down during measurements. Do not invert the leaf clip during a measurement or the bead will rest on the screen and distort the diffusion of water vapor from the leaf through the diffusion path.

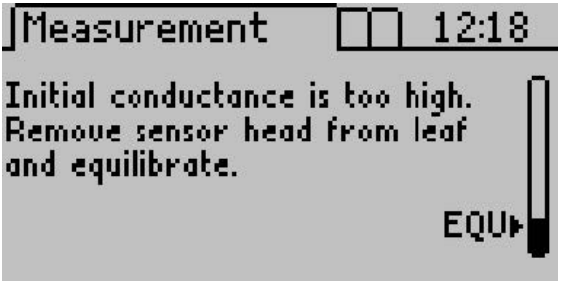

Figure 8 Warning screen for high initial conductance

Once the humidity in the measurement chamber has equilibrated, the porometer checks the absolute value of the RH sensors. If either sensor is above 10% RH, a second warning screen will appear indicating `High RH Reading` (Figure 9). Shake the sensor head to help the desiccant scrub the remaining water vapor from the measurement chamber.

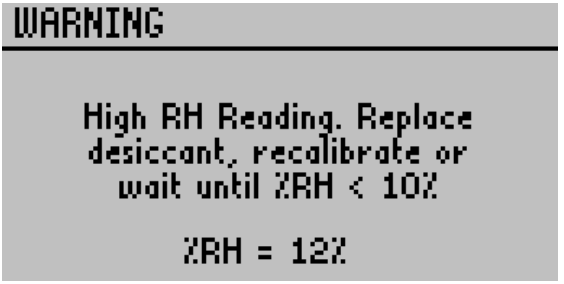

Figure 9 Warning screen for high RH reading

The total shake down period should be approximately 50 s. If it takes longer than 75 s to equilibrate, the SC-1 may have a problem. Refer to Section 4.3.

7. Once the measurement chamber has dried and equilibrated, the Measurement tab will display a prompt to insert the leaf (Figure 10).

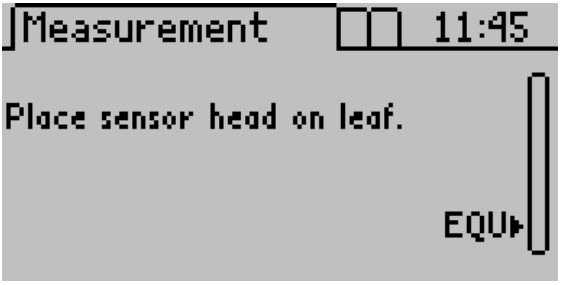

Figure 10 Prompt to place sensor head on the leaf

8. Choose to measure adaxial (the top of the leaf) or abaxial (the bottom of the leaf) conductance, depending on plant type and desired data.
9. Orient the leaf appropriately for the measurement. The dessicant chamber must always be oriented down (Figure 11).

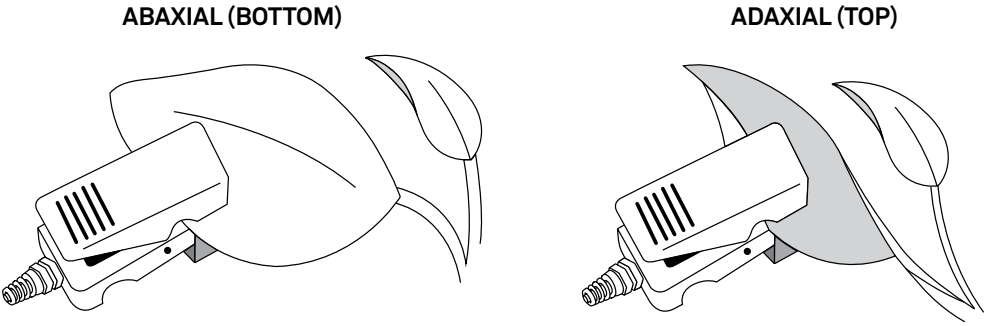

Figure 11 Leaf orientation during adaxial or abaxial conductance measurements

10. Squeeze the leaf clip, quickly slide the leaf inside, and allow it to close gently.

    NOTE: It is critical to slip the leaf clip onto a leaf within 5 s of opening the clip or unacceptable errors may be introduced into the conductance measurement.

    The sensor head must remain still during measurement.

    When measuring small needles or leaves, insert them into the sensor as shown in Figure 12. Multiple needles or small leaves (including blades of grass) may be needed to adequately cover the sensor aperture for an accurate measurement. It may be necessary to remove the leaves or needles from the plant to arrange them over the opening in the diffusion path. Complete readings of removed leaves within 2 min of removal (prior to stomatal closure) for an accurate measurement.

    NOTE: The SC-1 may not be appropriate for all needle types. Highly sclerified, angular needles will prevent a good seal over the diffusion path and the reading will be compromised.

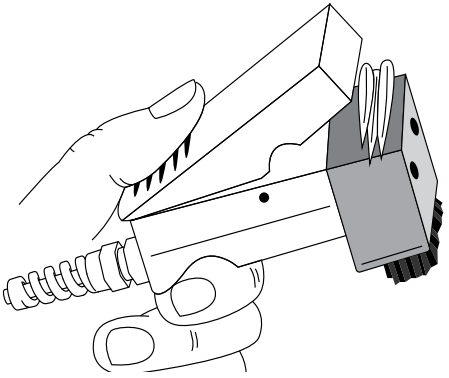

Figure 12 Measuring small leaves

The reading will begin once the leaf clip has been opened and closed. A progress bar will indicate the reading is underway, and a countdown timer in the top right will appear (Figure 13).

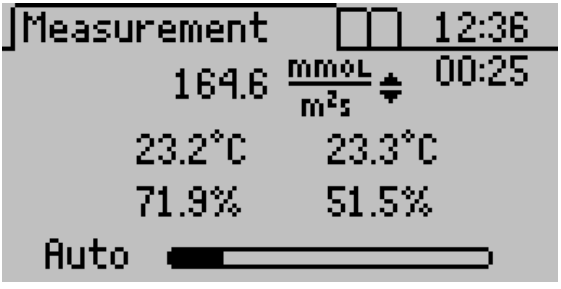

Figure 13 Measurement tab during reading

11. Once the measurement is complete, remove the leaf clip from the leaf and close it to start equilibration for the next measurement.
12. Choose to save, annotate, or discard the data (Section 2.3).

The SC-1 can measure the stomatal conductance beyond its recommended range of 0 to 500 mmol/(m^2s). Between 500 mmol/(m^2s) and 6,000 mmol/(m^2s), a ≈ symbol appears to the left of the reading. If the stomatal conductance reaches a value greater than or equal to 6,000 mmol/(m2s), an ∞ symbol appears in place of the measurement.

2.3 SAVING DATA

In Auto mode, the option to save data appears as soon as the timer has expired. In Manual mode, data can be saved at any time during the reading. These steps explain how to save data in either mode.

1. In Auto mode, the Select Method screen appears at the completion of the measurement (Figure 14).

   In Manual mode, press **ENTER** at any time to access the Select Method screen.

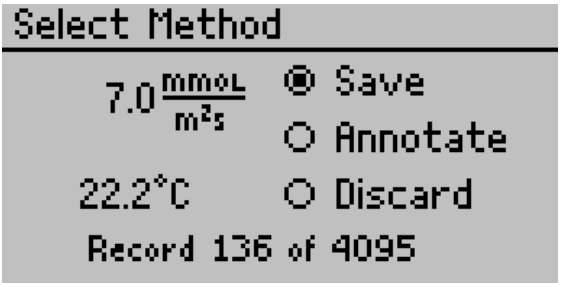

Figure 14 Choose to save, annotate, or discard data

2. Use **UP** and **DOWN** to move the radio button selection to `Save`, `Annotate`, or `Discard`.
   a. `Save` will save the reading as-is.
   b. `Discard` will not save the reading and will return to the Measurement tab.
   c. `Annotate` will bring up the Annotate screen to give the data a file name (Figure 15).

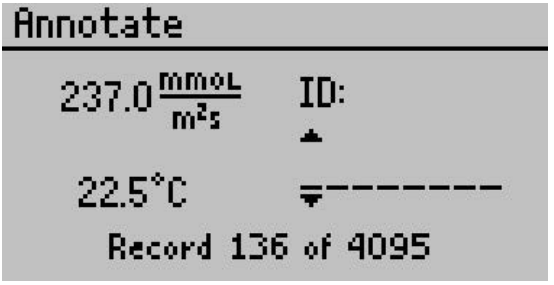

Figure 15 Annotate screen

3. Use **UP** and **DOWN** to change the character of each space (A-Z, 0-9, or special characters ., -,‘, #, or space). Holding down the arrow buttons will scroll quickly between values.
4. Press **ENTER** to move to the next character. Repeat until the last character, pressing **ENTER** to reach the end of the row.

2.4 VIEWING DATA

To view prior test results, use the following steps:

1. Press **MENU** to navigate to the Data tab (Figure 16).

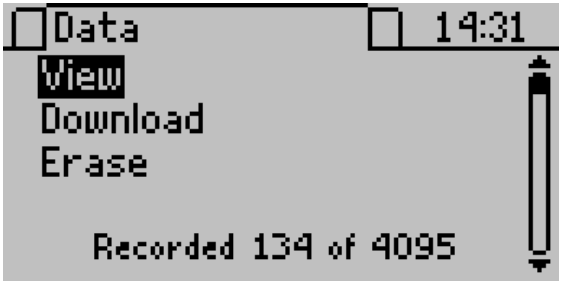

Figure 16 Data tab

2. Press **ENTER** to select `View`.
3. Scroll through the list of saved tests using **UP** and **DOWN** (Figure 17).

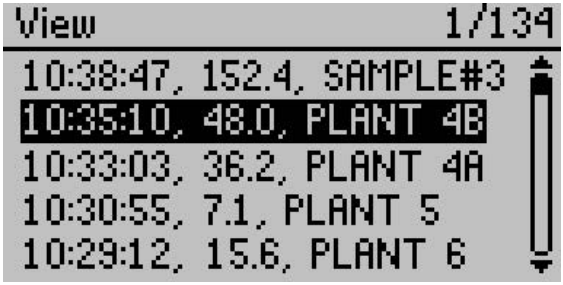

Figure 17 View data screen

Each entry shows the time acquired, stomatal conductance or resistance value (in the unit set as the default), and its annotation (if saved with one). Data must be downloaded to see more detailed information (Section 2.5)

4. Press **ESC** to return to the Data tab.

2.5 DOWNLOADING DATA

METER recommends using the Leaf Porometer Utility (Section 3.4) to download data. This function transfers all saved measurement data on the SC-1 to a computer. Follow step 1 through step 9 to download data.

NOTE: Leaf Porometer Utility is compatible with Microsoft® Windows® 98 and newer. See Section 3.4 for more details.

1. Connect the serial end of the USB-to-serial cable to the SC-1 controller.
2. Connect the USB end of the cable to an available USB port on the computer.

3. Open Leaf Porometer Utility (Figure 18).

Figure 18 Leaf Porometer Utility application

4. Choose the appropriate communication port from the from the Use computer communication port dropdown on the main window (Figure 19).

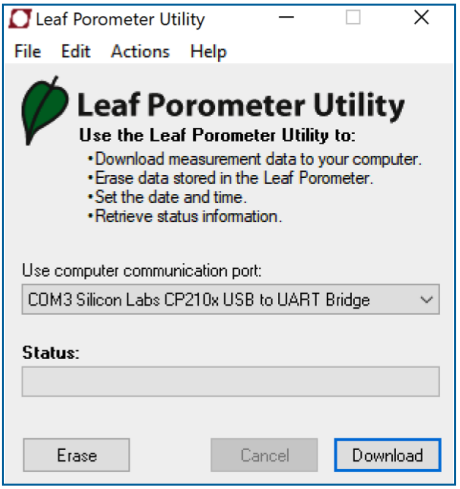

Figure 19 Leaf Porometer Utility main window

5. Click `Download`.

   The Save Leaf Porometer Data window appears (Figure 20).

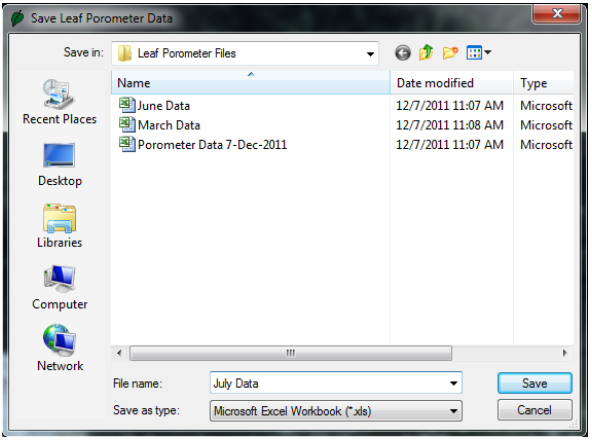

Figure 20 Choose file name and location on the Save Leaf Porometer Data window

6. Name the data file.

7. Select the location and the format of the file.

   The file can be saved as one of the following:

   - Microsoft Excel® Workbook (*.xls)
   - Text (tab delimited) (*.txt)
   - CSV (comma delimited) (*.csv)
   - Raw data (comma delimited) (*.txt)

8. Click `Save` to download.

   A progress bar shows the status of the download process (Figure 21).

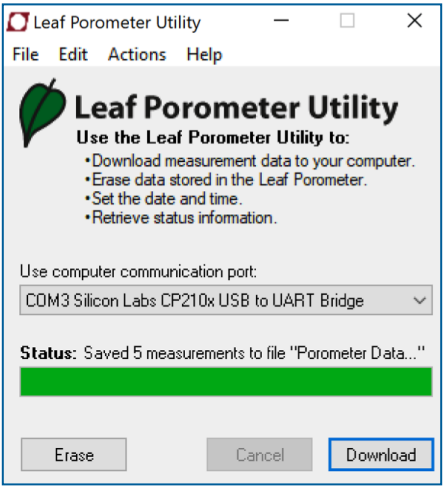

Figure 21 Download status

   Press **Cancel** to cancel the download at any time. The software will not save any downloaded data.

9. Navigate to the saved file location and open the file to view the data.

Data are organized in the same way regardless of format. The measurement record will be divided into eight columns:

- Measurement time
- Stomatal conductance or resistance
- Temperature (in degrees Celsius or Fahrenheit)
- Sample ID (if saved with measurement)
- Sensor head serial number
- Calibration number
- Leaf Sensor %RH
- Filter Sensor %RH

In all file types, scan records (saved from the Diagnostics screen) are interleaved with the normal data records and can be identified by the annotation `Scan`. Scan records have four additional columns:

- Leaf Sensor RH (in percent RH)
- Leaf Sensor Temperature (in degrees Celsius or Fahrenheit)
- Filter Sensor RH (in percent RH)
- Filter Sensor Temperature (in degrees Celsius or Fahrenheit)

Data can also be downloaded through the SC-1 controller or a terminal program, if the Leaf Porometer Utility is not functioning properly. Contact Customer Support for more information.

2.6 ERASING DATA

Data can be erased using the SC-1 controller or the Leaf Porometer Utility.

Data cannot be erased one measurement at a time. This feature erases all data from the SC-1 permanently and it cannot be recovered!

To erase all stored data from SC-1 using the SC-1 controller:

1. Press **MENU** to navigate to the Data tab.
2. Use **UP** or **DOWN** to highlight `Erase`.
3. Press **ENTER**.

   The following warning will appear (Figure 22).

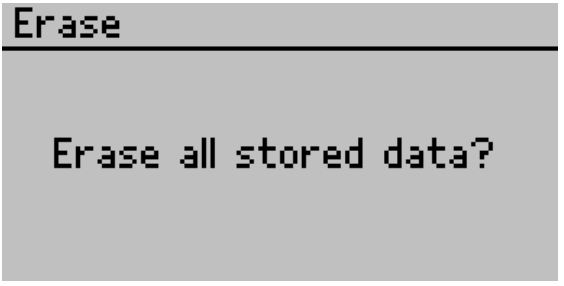

Figure 22 Warning confirming to erase all stored data

4. To return to the Data tab and leave stored data intact, press **ESC**.

   To erase data from memory, press **ENTER**. `Erasing...` will be displayed as data is being removed, which usually takes about 6 s.

   WARNING: This will delete all data permanently.

   When the process is complete, the Data menu will reappear.

To erase all stored data using the Leaf Porometer Utility (Section 3.4) :

1. Connect the serial end of the USB-to-serial cable to the SC-1 controller.
2. Connect the USB end of the cable to an available USB port on the computer.
3. Open Leaf Porometer Utility (Figure 23).

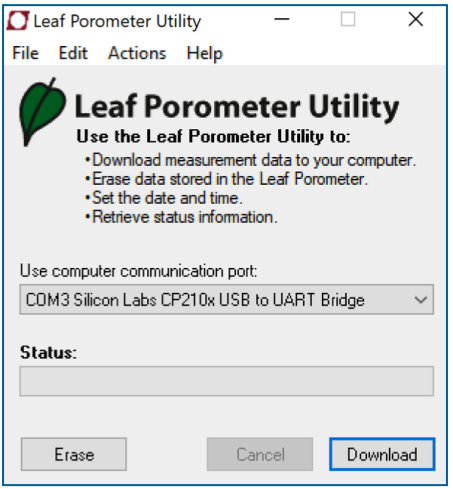

Figure 23 Leaf Porometer Utility main window

4. Choose the appropriate communication port from the Use computer communication port dropdown on the main screen.
5. Click `Erase` (Figure 23).
6. Click `OK` (Figure 24).

   WARNING: This will delete all data on the SC-1 permanently.

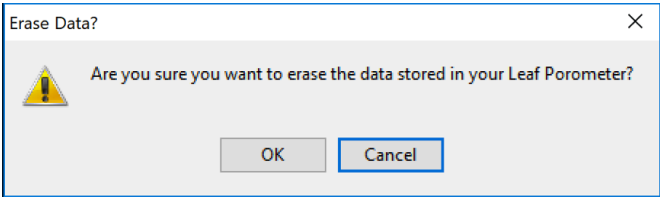

Figure 24 Erase data confirmation dialog

7. A progress bar shows the status of the erase process.

3. SYSTEM

This section describes the SC-1 Leaf Porometer components and theory.

3.1 SPECIFICATIONS

MEASUREMENT SPECIFICATIONS

Stomatal Conductance	
Range	0 to 1,000 mmol/(m^2s)
Resolution	0.1 mmol/(m^2s)
Accuracy	±10% of measurement from 0 to 500 mmol/(m^2s)

NOTE: The SC-1 can measure higher than 500 mmol/(m^2s) and detect relative stomatal conductance change in the high range, but absolute accuracy becomes unverifiable past 500 mmol/(m^2s).

Measurement Time	
30 s	

PHYSICAL SPECIFICATIONS

Controller Dimensions	
Length	15.8 cm (6.2 in)
Width	9.5 cm (3.8 in)
Height	3.3 cm (1.3 in)
Sensor Head Dimensions	
Length	12.0 cm (4.7 in)
Width	2.5 cm (1.0 in)
Height	5.5 cm (2.2 in)
Sensor Aperture Diameter	
6.35 mm (0.25 in)	
Sensor Cable Length	
1.2 m (4 ft)	

Operating Temperature Range	
Minimum	5 °C
Maximum	40 °C
Operating Relative Humidity Range	
Minimum	1%
Maximum	100%, with desiccant chamber
Power	
4 AA batteries	
Battery Life	
2 years (battery drain in sleep mode is <50 µA)	
Data Storage	
4,095 measurements in flash memory	
Connector Type	
Serial-to-USB	

COMPLIANCE
Manufactured under ISO 9001:2015
EM ISO/IEC 17050:2010 (CE Mark)

3.2 SC-1 SENSOR HEAD

This SC-1 sensor head gathers the measurements (vapor pressure, RH, etc.) that the SC-1 uses to calculate stomatal conductance in a leaf. Figure 25 shows the external components of the sensor head and Figure 26 shows the internal components.

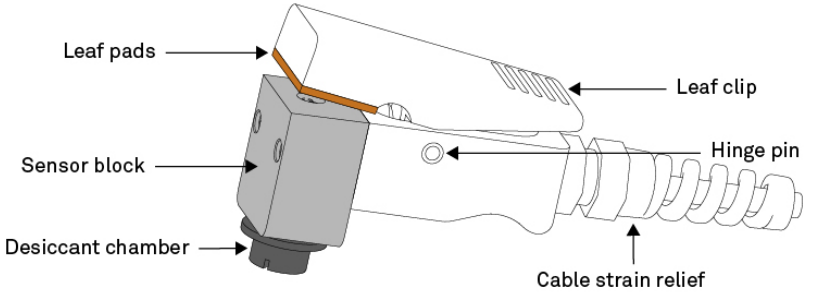

Figure 25 Sensor head external components

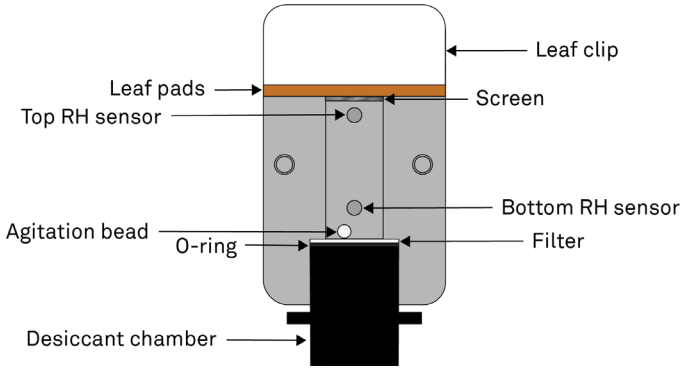

Figure 26 Sensor head internal components

The cable and the sensor head electronics are connected and the cable and cable strain relief are not designed to be disconnected from the sensor head. Keep the strain relief screwed into the sensor head firmly.

The SC-1 relies on a measurement of the RH gradient between the leaf evaporating surface and the desiccant chamber. The use of the desiccant chamber lowers the ambient RH to near 0%, thus ensuring a steep RH gradient between the leaf and desiccant chamber. Although several different desiccants may work in the SC-1 (e.g., silica gel and Drierite®), METER recommends molecular sieve 8-12 mesh because it has the best combination of sorption rate and total water sorption properties for this application.

NOTE: For the molecular sieve safety data sheet (SDS), a printable version is available at metergroup.com/environment/meter-safety-data-sheets.

3.3 SC-1 CONTROLLER

The SC-1 controller is the menu-driven handheld interface with the sensor head (Figure 27). The controller requires four AA batteries to operate and has a serial connection to connect to the sensor head or computer.

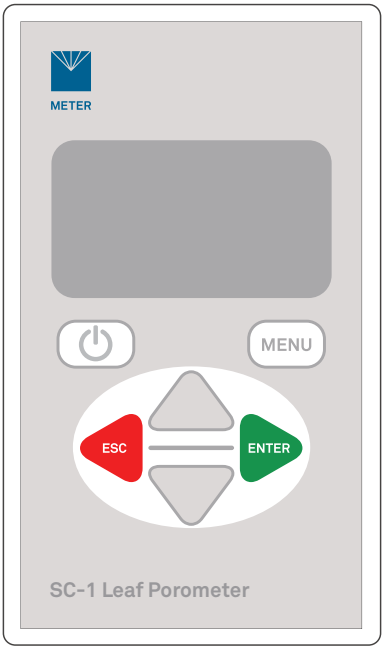

Figure 27 SC-1 controller

The SC-1 controller has six buttons. The **POWER** button turns the controller on and off. Pressing **MENU** switches between the Measurement, Data, and Configuration tabs. Pressing **ENTER** selects an option or begins a measurement. The two arrow keys (**UP** and **DOWN**) navigate within menus, and **ESC** backs out of menus or cancels actions.

3.3.1 TABS

The SC-1 controller features three main menus: Measurement, Data, and Configuration.

MEASUREMENT TAB

The Measurement tab is the default screen (Figure 28). The top number is the stomatal conductance number and the currently selected unit of measurement. Below are two columns, the left for the top RH sensor (closest to the leaf) and the right for the bottom RH sensor (closest to the desiccant chamber). Each column has the temperature and percent RH of that sensor. The SC-1 uses these to calculate the stomatal conductance value (Section 3.5).

Using **UP** or **DOWN** will change the units of the stomatal conductance measurement. Pressing **ENTER** will initiate a reading (Section 2.2).

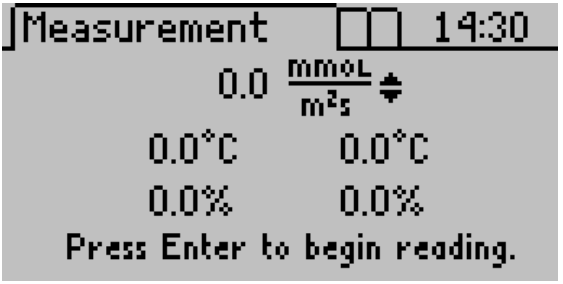

Figure 28 Measurement tab

DATA TAB

This menu is to view, download, or erase data (Figure 29).

- `View`: Select to see reading time, measurement, and annotation (Section 2.4).
- `Download`: Select to send data to computer (Section 2.5)
- `Erase`: Select to delete data from controller memory (Section 2.6).

Figure 29 Data tab

CONFIGURATION TAB

This menu is used to alter system settings (such as the current time, date, and operating mode), select the appropriate units for readings, and view information about the SC-1 (Figure 30). There is also a battery icon on the right, indicating remaining battery power.

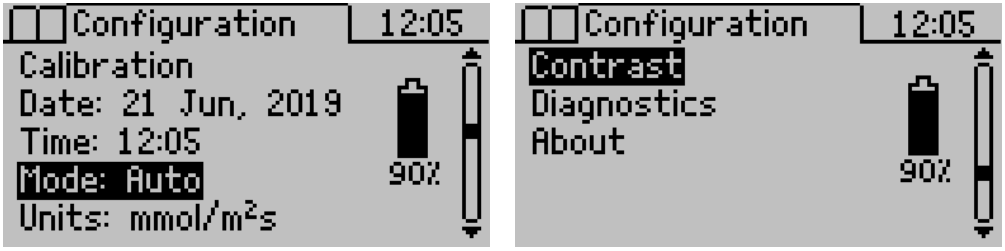

Figure 30 Configuration tab options

This menu features seven options:

- Calibration

  The Calibration screen gives a menu of four items related to calibration (Figure 31). The first option, `Calibrate`, initiates the calibration process (Section 4.1).

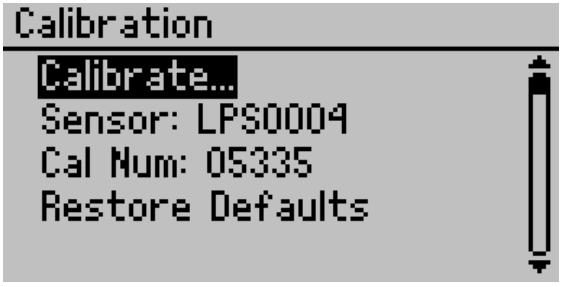

Figure 31 Calibration screen

  This menu can also be used to change the sensor serial number, manually input a calibration number, or restore factory defaults.

- Date

  The date must be changed prior to use to record accurate information (Section 2.1). The format can also be changed in the Leaf Porometer Utility.

- Time

  The time must be changed prior to use to record accurate information (Section 2.1).

- Mode

  Mode can be in either Auto or Manual mode (Section 3.3.2). The mode must be set prior to beginning a measurement.

- Units

  Data in the SC-1 can be displayed in three units: millimoles per meter squared seconds (mmol/[m^2s], the system default), meters squared seconds per mole (m^2s/mol), or seconds per meter (s/m).

- Contrast

  The Contrast screen controls the screen contrast. Press the **DOWN** arrow to scroll to it and press **ENTER** (Figure 32).

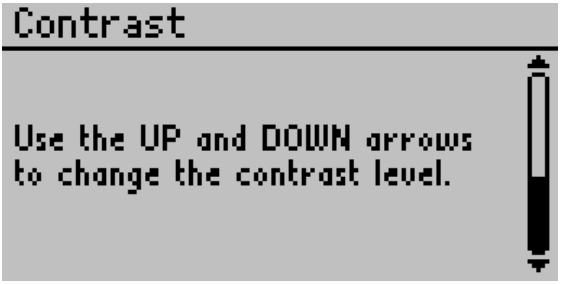

Figure 32 Contrast screen

Use the arrow keys to alter the contrast level. Press **ENTER** to save or **ESC** to cancel adjustments.

- Diagnostics

  The Diagnostics screen displays real-time sensor values from the sensor head. An error message will pop up next to a reading if the value is out of range (Figure 33). Pressing **ENTER** during this screen will save a scan record that can be viewed or downloaded at a later time.

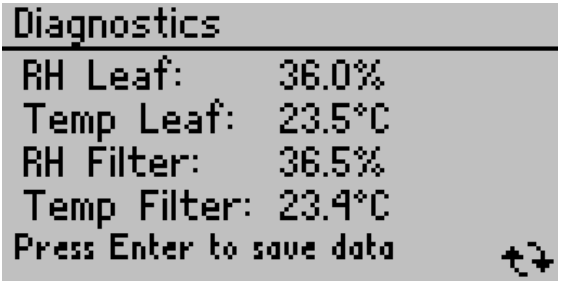

Figure 33 Diagnostics screen

- About

  The About screen displays SC-1 serial number and firmware version (Figure 34).

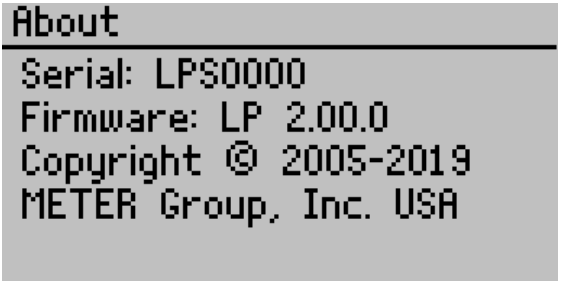

Figure 34 About screen

3.3.2 MODES

The measurement can be taken in two modes: Auto or Manual. For typical measurements on plant leaves, Auto mode is strongly recommended.

Auto mode makes an accurate stomatal conductance measurement in 30 s. To do this, the SC-1 takes the first 30 s of stomatal conductance data and applies a look-ahead algorithm to predict the final stomatal conductance reading if unlimited time were allowed for true steady state conditions to occur. The 30-s measurement duration ensures that stomatal conductance does not change due to the presence of the sensor head. Auto mode also sets a definite endpoint for the measurement and data can only be saved after that point.

Manual mode measures stomatal conductance continuously and directly from the RH gradient between the two RH sensors (Section 3.5). The real-time conductance measurement can be saved at any time during a Manual mode measurement. Manual mode assumes that a steady state is reached, and the user must determine at what point the readings have stabilised enough to consider the measurement complete. Some common uses for Manual mode are measuring dark conductance in plants and measuring conductance of static conductance materials (e.g., fruit peels, waterproof fabric).

NOTE: Manual mode should only be used at low conductances (i.e., <100 mmol/[m²s]).

In Manual mode, there is no time limit for taking readings, and the elapsed time is displayed directly below the system time (Figure 35).

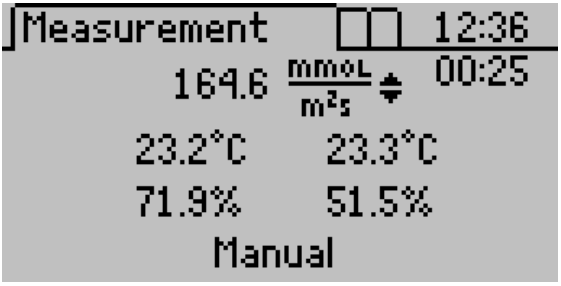

Figure 35 Measurement tab in Manual mode

3.4 LEAF POROMETER UTILITY

The Leaf Porometer Utility is a program designed specifically for interfacing with the SC-1. Use this program to download measurement data to a computer, erase the SC-1 data, set the date and time, and see information about the SC-1.

The following minimum system requirements must be met to use the Leaf Porometer Utility:

- Microsoft Windows 98 or NT 4 (SP 5) or better
- Intel® Pentium® Pro or newer processor
- One available serial or USB port
- Microsoft Excel 97 or better (for viewing data as .xls files)

Install the Leaf Porometer Utility using the included USB flash drive (inside the cover of the SC-1 Manual). The latest version of the Leaf Porometer Utility can also be installed from metergroup.com/sc1-support.

1. Insert the USB into the USB port.
2. Open the USB drive named `METER Group Inc. USA`.
3. Move the Leaf Porometer Utility application onto the computer's hard drive.

The four menus across the top of the screen change program and SC-1 settings. Below is a brief overview of the options each menu contains.

FILE MENU

- `Download Data`: Saves measurement data stored in the SC-1 as a data file on the computer (Section 2.5).
- `Erase Data`: Erases all data in SC-1 (Section 2.6).
- `Exit`: Quits the program.

EDIT MENU

- `Cut, Copy, Paste, and Select All`: Nonfunctional menu options
- `Preferences`: Opens the Preferences window.

The Preferences window has three tabs: Data File, Communications, and Application tabs (Figure 36).

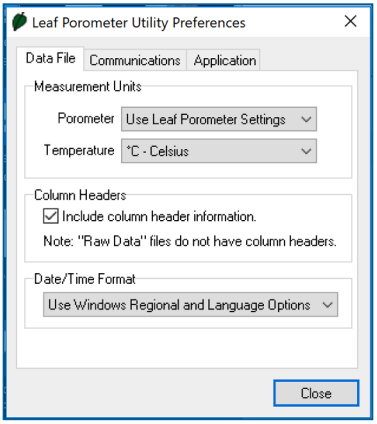

Figure 36 Data tab in the Leaf Porometer Utility Preferences window

The Data File tab is used to change measurement units, column headers, and the date/time format (Figure 36).

- Porometer measurement units selections are Use Leaf Porometer Settings (save downloaded measurement data in the units used on the SC-1), mmol/m^{2}s, m^{2}s/mol, or s/m.

  Temperature units can be saved in Celsius (°C) or Fahrenheit (°F).

- Column headers checkbox includes column headers for saved data files (Section 2.5). This feature is on by default.

- Date/Time Format sets how the date and time are displayed in saved data files. By default, the program will use Windows Regional and Language Options (the system settings accessible in the Windows Control Panel).

The Communications tab is to change settings in communicating with the SC-1 (Figure 37). These should only need to be changed if troubleshooting a connection issue.

- `Command Retries`: Set the number of times the computer should automatically try sending communications commands (up to 10).
- `Maximum Baud Rate`: Set the maximum baud rate for talking to the SC-1.
- `Force Find All Communication Ports`: Select checkbox to detect all communication ports on the computer.

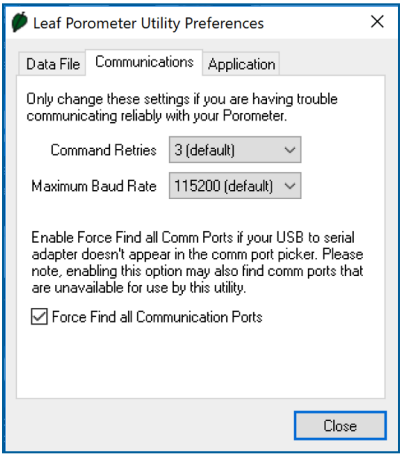

Figure 37 Communications tab in the Leaf Porometer Utility Preferences window

The Application tab sets application preferences (Figure 38).

- `Automatic Internet Version Check`: Select to automatically check for updates for the Leaf Porometer Utility when connected to the internet. Updates can be manually searched for in the Help menu.
- `Automatic Clock Synchronization`: Sets the SC-1 controller time to the computer time automatically, when connected.

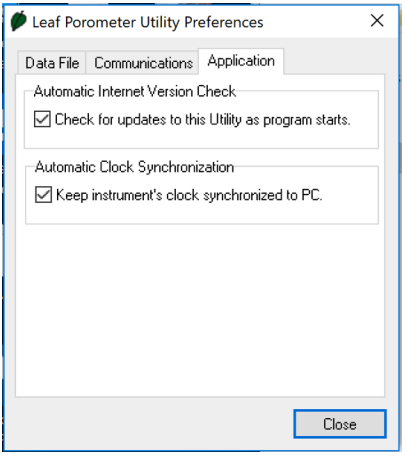

Figure 38 Applications tab in the Leaf Porometer Utility Preferences window

ACTIONS MENU

- Set `Porometer Date/Time`: Synchronizes the SC-1 controller date and time to the computer date and time.
- View Porometer Information: Shows the serial number, firmware version, number of stored readings in the SC-1, firmware status, battery status, current date and time, and sensor calibration number (Figure 39).

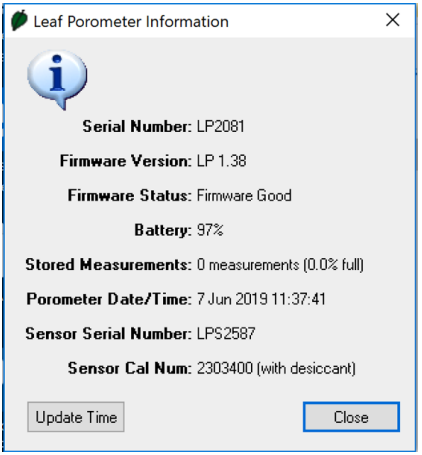

Figure 39 Leaf Porometer Information screen

HELP MENU

- Help...: Accesses the Leaf Porometer Utility help file that provides detailed information on how to use the program.
- Send Feedback to Decagon: Provides the user with a way to submit feedback to METER.
- Check for Utility Updates: Checks for application updates.
- Check for Firmware Updates: Checks for firmware updates for the SC-1 controller.
- About Leaf Porometer Utility: Displays the current program version and METER contact information.

Occasionally, METER releases firmware updates for the SC-1 to improve the performance of the instrument. These updates can be found through the Leaf Porometer Utility Help Menu. Do not turn off or disconnect the instrument from the communication port while the firmware is updating.

WARNING: Any data records on the instrument will be erased during a firmware update. Download data before loading new firmware.

If upgrading to the latest firmware, verify the SC-1 is equipped with a desiccant chamber. Porometers that predate the desiccant chamber should not be updated beyond firmware version 1.33. Contact Customer Support for more specific information on upgrading the sensor head.

To update the firmware, use the following steps:

1. Connect the SC-1 to an available communications port.
2. Download the SC-1 Firmware Updater executable file from the SC-1 product website (metergroup.com/sc1-support).
3. Click `Run`.

   If the application does not automatically ask, open the firmware updater application from the Downloads menu.

   A warning will appear to download all saved data (Figure 40).

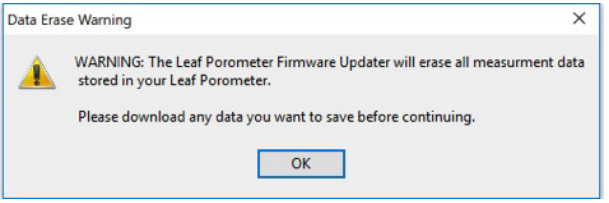

Figure 40 Data Erase Warning dialog

4. Click `OK`.

   The Leaf Porometer Firmware Updater window should appear (Figure 41).

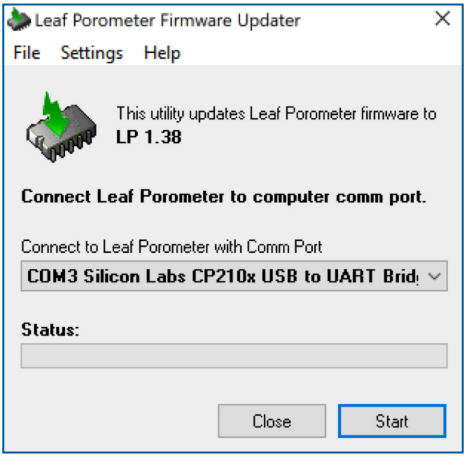

Figure 41 Leaf Porometer Firmware Updater

5. Select the correct communications port in the dropdown list.
6. Click `Start`.
7. When the firmware updater is finished, close the application.

3.5 THEORY

The SC-1 Leaf Porometer measures stomatal conductance of leaves. Stomata are small pores on the top and bottom of a leaf that are responsible for taking in and expelling CO_2 and moisture. Stomatal conductance is the rate of passage of CO_2 or water vapor through the stomata and is a function of the density, size, and degree of opening of stomata.

The SC-1 measures this rate by putting a leaf in series with two known conductance elements and comparing the RH measurements between them. The RH difference across the known conductance elements gives the water vapor flux. The conductance of the leaf can be calculated from the known conductances and the RH gradient. The SC-1 diagram represents these measurement processes (Figure 42).

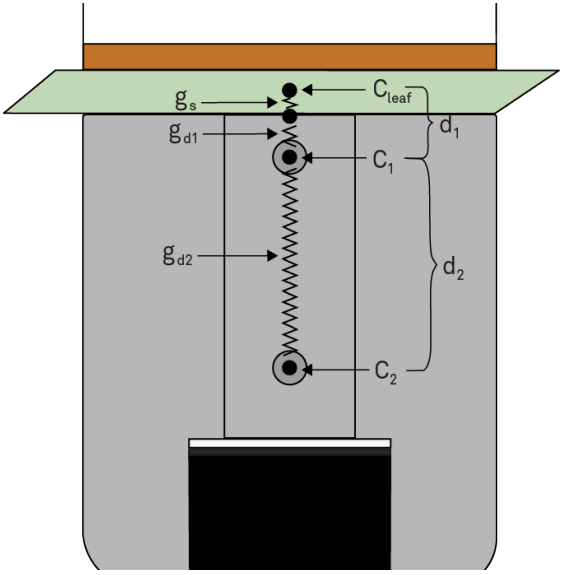

Figure 42 Diagram of SC-1 measurements

The parameters listed in Figure 42 represent the following:

C_{leaf} = mole fraction of vapor inside the leaf
C_1 = mole fraction of vapor at node 1
C_2 = mole fraction of vapor at node 2
g_s = stomatal conductance of the leaf surface
g_{d1} = vapor conductance of the diffusion path between leaf surface and node 1
g_{d2} = vapor conductance of the diffusion path between node 1 and node 2
d_1 = distance between the leaf surface and the first RH sensor
d_2 = distance between the two RH sensors

For the SC-1, the two distances are $d_1 = 3.35$ mm and $d_2 = 11.43$ mm.

The stomatal conductance (g_s) is the variable the SC-1 ultimately measures. The derivation below shows how the variables above yield stomatal conductance.

First, the vapor flux (F_{vapor}) along the diffusion path will be determined using the RH difference between nodes 1 and 2 as given in Equation 1.

$$F_{\text{vapor}} = g_{d2}\,(C_1 - C_2) \qquad \textbf{Equation 1}$$

C values are related to RH by Equation 2

$$C_i = \frac{h_r e_s(T_a)}{P_{atm}} \qquad \textbf{Equation 2}$$

where h_r is RH, $e_s(T_a)$ is the saturated vapor pressure at air temperature, and P_{atm} is atmospheric pressure. $e_s(T_a)$ is calculated by the Tetens formula with appropriate coefficients for water vapor:

$$e_s(T_a) = 0.611\exp\left(\frac{17.502T}{T + 240.97}\right) \qquad \textbf{Equation 3}$$

NOTE: T must be in degrees Celsius.

Next, the value of g_{d2} (Equation 1) must be determined by Equation 4

$$g_{d2} = \frac{\hat{\rho} D_{\text{vapor}}}{d_2} \qquad \textbf{Equation 4}$$

where $\hat{\rho}$ is the molar density of air (Equation 5) and D_{vapor} is the diffusivity of water vapor (Equation 6).

$$\hat{\rho} = 44.6\,\frac{P_a}{101.3}\left(\frac{273.15}{T}\right) \qquad \textbf{Equation 5}$$

$$D_{\text{vapor}}(T, P_a) = D_{\text{ref}}(273.15, 101.3)\left(\frac{101.3}{P_a}\right)\left(\frac{T}{273.15}\right)^{1.75} \qquad \textbf{Equation 6}$$

Both of these quantities are temperature and pressure dependent; however, when multiplied together as in Equation 4, some of this dependency drops out.

Next, solve for the numerator in Equation 4. If

$$D_{\text{ref}}(273.15, 101.3) = 2.12 \text{ x } 10^{-5}(\text{m}^2/\text{s}) \qquad \textbf{Equation 7}$$

then

$$\hat{\rho}D_{\text{vapor}} = (44.6)(2.12 \text{ x } 10^{-5})\left(\frac{T}{273.15}\right)^{0.75} \quad \textbf{Equation 8}$$

Using C (from Equation 2) and g_{d2} (from Equation 4) values, Equation 1 can be solved for the flux:

$$F_{\text{vapor}} = \left(\frac{\hat{\rho}D_{\text{vapor}}}{d_2}\right)\frac{1}{P_{\text{atm}}}\left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right] \quad \textbf{Equation 9}$$

Now that F_{vapor} has been solved, the stomatal conductance (g_s) can be determined. This requires some assumptions. First, the RH within the leaf tissue is assumed to be 1.0, so Equation 2 becomes

$$C_{leaf} = \frac{e_s(T_c)}{P_{atm}} \quad \textbf{Equation 10}$$

Second, all conductance values are assumed to be in series, so the flux is constant between any two nodes. Third, the temperature of the leaf is equal to the temperature of the first RH sensor (the sensor block head is aluminum to eliminate the temperature difference).

These assumptions mean Equation 1 can be written for node 1 and the leaf node (Equation 11, Equation 12) and then set equal to Equation 9 (Equation 13).

$$F_{vapor} = g_{s+d1}\left(C_{leaf} - C_1\right) \quad \textbf{Equation 11}$$

$$F_{vapor} = g_{s+d1}\left(\frac{1}{P_{atm}}\right)\left[e_s(T_{a1})\left(1 - h_r\right)\right] \quad \textbf{Equation 12}$$

$$\frac{g_{s+d1}}{P_{atm}}\left[e_s(T_{a1})\left(1 - h_r\right)\right] = \frac{1}{P_{atm}}\left(\frac{\hat{\rho}D}{d_2}\right)\left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right] \quad \textbf{Equation 13}$$

solving for g_{s+d1},

$$g_{s+d1} = \frac{\left(\frac{\hat{\rho}D}{d_2}\right)\left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right]}{\left[e_s(T_{a1})\left(1 - h_r\right)\right]} \quad \textbf{Equation 14}$$

Then solve for g_s using the rule for series combination of conductance (Equation 15)

$$\frac{1}{g_s} = \frac{1}{g_s + d1} - \frac{1}{g_{d1}} \qquad \textbf{Equation 15}$$

Hence,

$$\frac{1}{g_s} = \frac{e_s(T_{a1})(1-h_{r1})d_2}{\hat{\rho}D\left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right]} - \frac{d_1}{\hat{\rho}D} \qquad \textbf{Equation 16}$$

so:

$$g_s = \frac{\hat{\rho}D_{\text{vapor}}}{\frac{\left[e_s(T_{a1})(1-h_{r1})\right]d_2}{h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})} - d_1} \qquad \textbf{Equation 17}$$

Therefore, g_s is a function of the distances between RH sensors, temperature, and the two RH readings.

When the conductance is small, the humidities are nearly the same, and the denominator of the denominator of Equation 18 goes to 0, causing problems. Multiplying top and bottom by the denominator gives

$$g_s = \frac{\hat{\rho}D_{\text{vapor}}\left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right]}{\left[e_s(T_{a1})(1-h_{r1})\right]d_2 - \left[h_{r1}e_s(T_{a1}) - h_{r2}e_s(T_{a2})\right]d_1} \qquad \textbf{Equation 18}$$

NOTE: The resulting g_s is in units of mol/m²s.

For this theory to accurately predict the stomatal conductance using the steady-state diffusion technique, true steady-state conditions must exist in the diffusion path. The amount of time necessary to reach steady-state conditions is proportional to the conductance. At conductances <20 mmol/(m²s), steady-state conditions are generally reached in <5 min. At higher conductances, steady-state conditions can take up to 30 min and can become inaccurate.

4. SERVICE

This section contains calibration and recalibration information, calibration frequencies, cleaning and maintenance guidelines, troubleshooting guidelines, customer support contact information, and terms and conditions.

4.1 CALIBRATION

For the SC-1 to make accurate readings of stomatal conductance, the two RH sensors in the sensor head must behave in a very repeatable manner. The sensors occasionally change characteristics over time. While the endpoint RH measurement may still be accurate, the response time of the sensors can change subtly which creates inaccurate conductance measurements. The best way to ensure accurate conductance measurements is to verify the accuracy of the SC-1 before taking measurements (Section 4.1.1) and calibrate if necessary (Section 4.1.2). The SC-1 may also need recalibration if there are drastic changes to environmental conditions or if the sensor head is used on an alternate handheld.

4.1.1 VERIFICATION PROCESS

METER recommends verification before every day of use or for every different set of environmental conditions (e.g., >15 °C temperature change). Also verify the accuracy of the SC-1 after the desiccant chamber is installed or removed.

Use the following steps to verify porometer performance.

1. Allow the sensor head, DI water, and calibration plate to come to thermal equilibrium with the measuring environment.

   For example, moving the SC-1 from an air-conditioned environment into field conditions can take 10 min or more to reach equilibrium. A calibration block or bottle of DI water that has been kept in a pants pocket or hand for extended periods of time will also need time to reach equilibrium.

   Holding the sensor head in the correct manner during verification is very important for maintaining thermal equilibrium. Figure 43 illustrates the correct way to hold the external sensor.

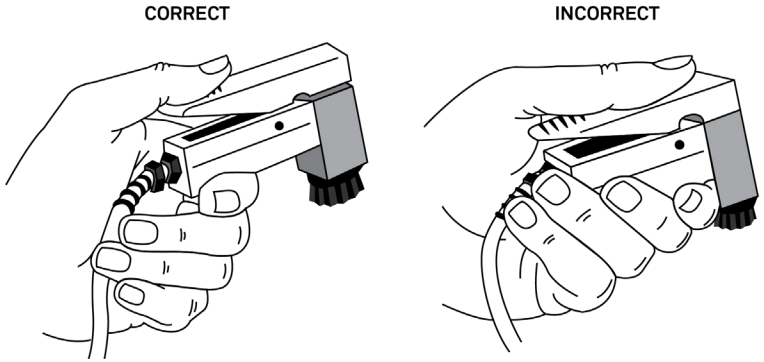

Figure 43 Holding the sensor head

To check for thermal equilibrium, initiate a measurement in Manual mode (Section 3.3.2) or navigate to the Diagnostic screen (Section 3.3.1) to monitor temperature readings until the temperature is changing <0.25 °C/min.

2. Turn on the SC-1 controller.
3. Navigate to the Configuration tab.
4. Select `Diagnostics`.
5. Check the `RH Leaf` or `RH Filter` values.

   If the values are above 5% RH, the desiccant is exhausted and must be replaced.

   a. Remove the desiccant chamber from the bottom of the leaf clip by unscrewing it counterclockwise.
   b. Discard the exhausted desiccant.
   c. Refill the desiccant chamber three-quarters full with fresh desiccant.
   d. Replace the desiccant chamber on the sensor head.
6. Use tweezers to remove a piece of filter paper from the plastic bag.

   NOTE: Do not touch the filter paper. Skin oils will contaminate the disk, resulting in improper readings.
7. Add one drop of DI to the filter paper to saturate it.
8. Allow the water a couple moments to fully absorb into the filter.
9. Still holding the disk with the tweezers, quickly flick the wrist to remove any excess water.

   The paper should glisten, but no water drops should be clinging to the disk.
10. Lay the filter paper flat over the hole in the calibration plate on the side marked Filter Paper. Make sure the paper completely covers the hole but does not cave into or bubble out from it.
11. Turn the calibration plate over and carefully examine the hole to make sure that no meniscus of water is present in the hole.

    If excess water is observed, remove the filter paper, dry the calibration plate, and repeat step 7 through step 11.

    NOTE: If the filter paper becomes too dry to adhere to the calibration plate, it will need to be wet again, and the calibration procedure will need to be restarted.
12. Make two or three consecutive measurements on the calibration plate.

    The resulting values should be within ±10% of the conductance value of the calibration plate, between 216 to 264 mmol/(m^2s). If the SC-1 does not return readings within this range, perfom a user-initiated calibration (step 6).

4.1.2 CALIBRATION PROCESS

SC-1 with firmware revision 1.30 or greater have the calibration feature. A video tutorial of the calibration process is available on metergroup.com/environment/articles/quick-guide-calibrating-sc-1-porometer. METER has a calibration service to perform maintenance and calibration on the SC-1. The calibration routine is the same as outlined in this section.

NOTE: For instructions on how to upgrade the SC-1 firmware to the latest version, see Section 3.4.

Each sensor head has a default 7-digit calibration number on the sensor head cable tag and on the calibration certificate. This default calibration number will be applied to each measurement until a user-initiated calibration is performed. The new calibration number will be stored and applied to all subsequent measurements until another calibration is done or the calibration is reset to the default.

If verification (Section 4.1.1) indicates that the measurements are inaccurate, use the following steps to calibrate the SC-1.

1. Allow the SC-1 sensor head, DI water, and calibration plate to come to thermal equilibrium with the measuring environment.

   For example, moving the SC-1 from an air-conditioned environment into field conditions can take 10 min or more to reach equilibrium. A calibration block or bottle of DI water that has been kept in a pants pocket or hand for extended periods of time will also need time to reach equilibrium.

   To check for thermal equilibrium, initiate a measurement in Manual mode (Section 3.3.2) or navigate to the Diagnostic screen (Section 3.3.1) to monitor temperature readings until they are steady.

   Holding the sensor head in the correct manner during calibration is very important for maintaining thermal equilibrium. Figure 43 illustrates the correct way to hold the external sensor.
2. Turn on the SC-1 controller.
3. Navigate to the Configuration tab.
4. Select `Diagnostics`.
5. Check the `RH Leaf` or `RH Filter` values.

   If the values are above 5% RH, the desiccant is exhausted and must be replaced.

   a. Remove the desiccant chamber from the bottom of the leaf clip by unscrewing it counterclockwise.
   b. Discard the exhausted desiccant.
   c. Refill the desiccant chamber three-quarters full with fresh desiccant.
   d. Replace the desiccant chamber on the sensor head.
6. Press **MENU** to navigate back to the Configuration tab (Figure 44).

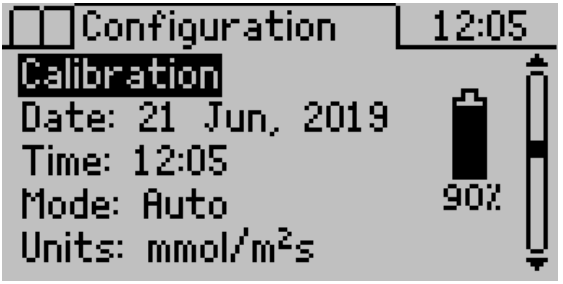

Figure 44 Configuration tab

7. Press **ENTER** to select `Calibration`.
   The Calibration screen will appear (Figure 45).

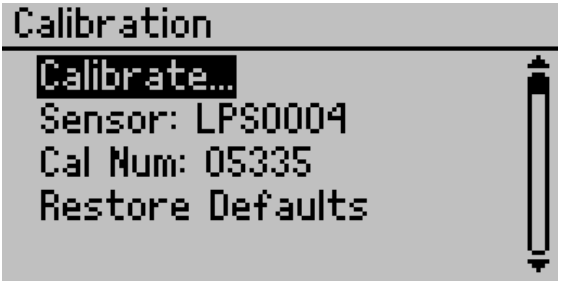

Figure 45 Calibration screen options

8. Press **ENTER** to select `Calibrate...`
   A warning screen will appear (Figure 46).

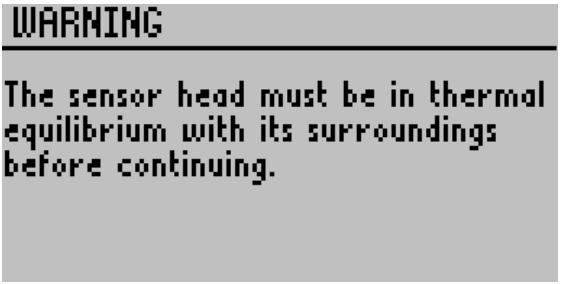

Figure 46 Warning screen to wait for thermal equilibrium

9. Press **ENTER**.
10. Enter the sensor head serial number (found on the sensor head cable tag) by pressing the **UP** or **DOWN** keys and pressing **ENTER** after each digit (Figure 47).

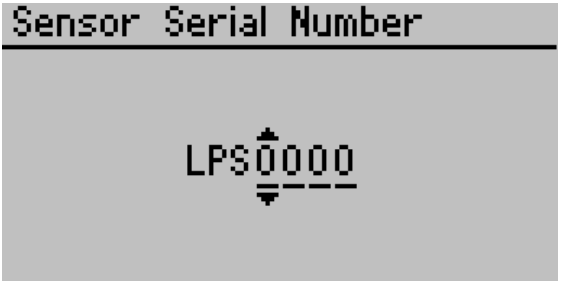

Figure 47 Enter sensor head serial number

The Stability Test screen will appear (Figure 48).

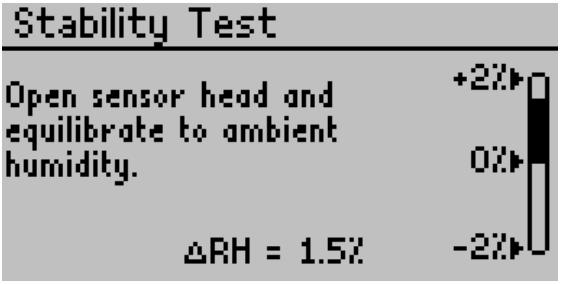

Figure 48 Stability Test screen

The RH sensors must give similar RH readings to reach accurate stomatal conductance measurements. Before beginning a calibration, the SC-1 checks agreement between the two sensors in the sensor head.

11. Shake the leaf clip briskly in a vertical orientation to mix the air in the diffusion path and wait for the sensors to come to equilibrium (the indicator bar will move closer to the 0 line).

    NOTE: Do not open the clip. The water vapor in the ambient atmosphere will slow the equilibration process.

    Once the sensor readings stabilize and are confirmed to be within 2% RH of each other, the calibration routine automatically advances to the Prepare Calibration Plate screen (Figure 49). If the sensors do not equilibrate to similar RH values, refer to Section 4.3.

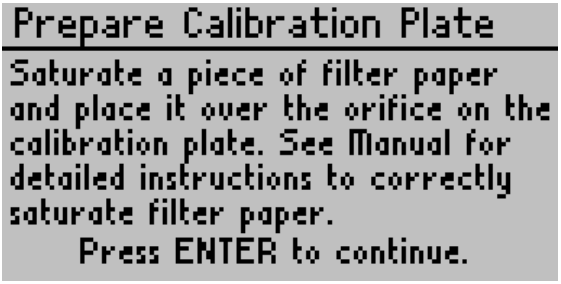

Figure 49 Prepare Calibration Plate screen

12. Use tweezers to remove a piece of filter paper from the plastic bag.

    NOTE: Do not touch the filter paper. Skin oils will contaminate the disk, resulting in improper readings.

13. Add one drop of DI to the filter paper to saturate it.
14. Allow the water a couple moments to fully absorb into the filter.
15. Still holding the disk with the tweezers, quickly flick the wrist to remove any excess water.

    The paper should glisten, but no water drops should be clinging to the disk.

    The wetness state of the filter paper is critical for an accurate calibration. The paper must be wet enough to provide a 100% RH surface. However, if the paper is too wet, free water will be pulled into the calibration plate hole by surface tension and will change the effective dimensions of the hole and its conductance.

16. Lay the filter paper flat over the hole in the calibration plate on the side marked Filter Paper. Make sure the paper completely covers the hole but does not cave into or bubble out from it.

    The plastic calibration plate has a known conductance of 240 mmol/(m^2s). It is critical that the filter paper be properly placed for this conductance value to be correct.

17. Turn the calibration plate over and carefully examine the hole to make sure that no meniscus of water is present in the hole.

    If excess water is observed, remove the filter paper, dry the calibration plate, and repeat step 13 through step 17.

    NOTE: If the filter paper becomes too dry to adhere to the calibration plate, it will need to be wet again and the calibration procedure will need to be restarted.

18. Press **ENTER** on the SC-1 controller.

    The Attach Sensor Head screen will appear (Figure 50).

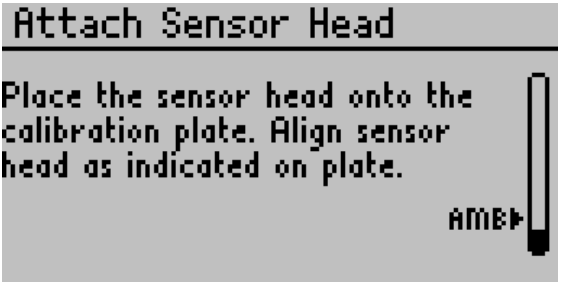

Figure 50 Attach Sensor Head screen

19. Slide the calibration plate into the sensor head, orienting the side of the plate marked Metal Block toward the aluminum block side of the sensor head (Figure 51). A seating click will occur when the plate is placed correctly. The lip on the calibration plate should be fully fitted into the top of measurement hole.

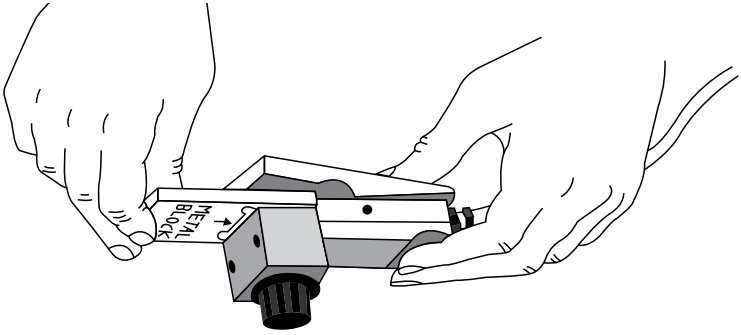

Figure 51 Sensor head on calibration plate

20. Orient the sensor head with the desiccant cap facing downward. The sensor can be held in this orientation by hand, or the entire sensor head and calibration plate assembly can be set on top of the SC-1 controller with the desiccant cap hanging off the edge.

    Proper orientation ensures the agitation bead sits on the Teflon filter and does not interfere with the water vapor diffusion from the leaf to the two sensors.

    NOTE: The sensor head must remain still during the calibration. The stomatal conductance measurement relies on water vapor transfer from purely molecular diffusion and any air mixing from movement will cause a substantial loss of accuracy.

    The SC-1 will automatically begin the first reading (Figure 52).

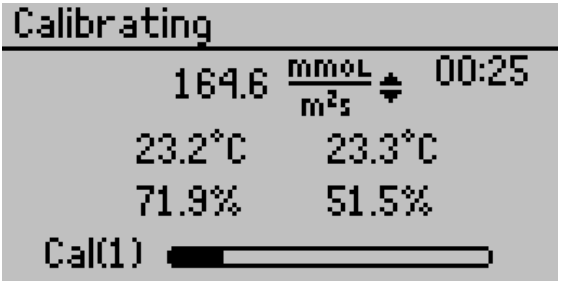

Figure 52 Calibrating screen during calibration

Each calibration measurement will take 30 s. The progress bar at the bottom of the screen and the timer at the top right of the screen indicate the status of the calibration measurement.

Once a reading is complete, a prompt to equilibrate sensors will appear (Figure 53).

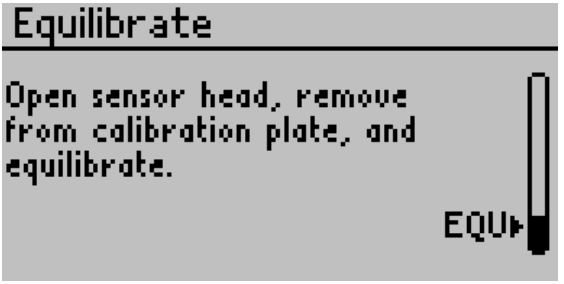

Figure 53 Equilibrate sensors

21. Remove the sensor head from the calibration plate and close the clip.
22. Shake the sensor head to speed up the equilibration process.

    As the sensors come to equilibrium, the indicator bar should move closer to the `EQU` line.

    Once the sensors have equilibrated, the Attach Sensor Head screen will automatically reappear.
23. Repeat step 20 through step 22.

    The SC-1 will continue to take calibration measurements until three consecutive measurements are within 7.5% of each other. This ensures that the SC-1 measurements have stabilized. The calibration should end after performing three to five calibration measurements and will continue for a maximum of 10 measurements. If this does not happen, consult Section 4.3.

    If the calibration is successful, the Calibration Complete screen will appear (Figure 54).

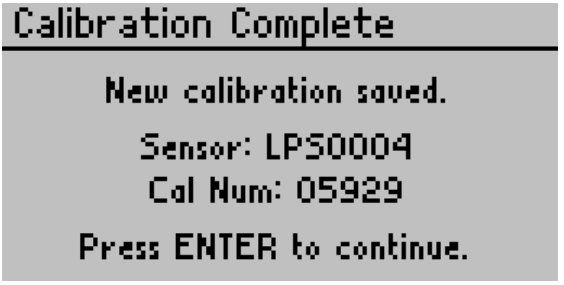

Figure 54 Calibration Complete screen

The new calibration number is automatically saved into the controller. The most recently saved calibration number will be applied to all subsequent measurements until a new calibration is completed or the factory default calibration is restored.

The SC-1 is ready to take measurements.

After a calibration, METER recommends verifying that a calibration was effective.

1. Navigate to the Measurement tab.
2. Press **ENTER** to take a measurement on the calibration plate.

   NOTE: If possible, do not wet the filter paper again for the verification readings. If wetting is necessary, disregard the first measurement taken.
3. Repeat two to three times.

   The measured conductance should be close to 240 mmol/(m^2s).

4.2 MAINTENANCE

The SC-1 may be returned to METER for maintenance in the following areas: system inspection, parts replacement, and instrument cleaning. Replacement parts can also be ordered from METER. Contact Customer Support for more information.

The SC-1 should be kept clean with full batteries to ensure proper working condition. To further extend the life of the SC-1, allow the sensor head to equilibrate to the ambient temperature before using and do not use it in rain or on leaves covered with dew or water droplets.

4.2.1 INSTALL BATTERIES

Although the SC-1 has been designed to provide an excellent battery lifespan, the batteries will eventually require changing. A low-battery indicator will appear in the upper left corner of the screen.

1. Carefully turn over the SC-1 controller and locate the battery cover.
2. Place the thumb on the grooves and slide the cover off the controller.
3. Remove the old batteries.
4. Insert new ones, orienting them properly.
5. Replace the battery cover.
6. Update the time and date (Section 2.1).

4.2.2 CLEAN SENSOR HEAD

Clean the sensor head periodically to remove contamination that can build up during routine use. It may be helpful to disconnect the sensor head from the controller prior to cleaning.

Items in this section are included with the SC-1; please contact Customer Support to order missing or replacement parts. The sensor block may become contaminated with dust, sap, and leaf exudates that can lead to inaccurate readings and drastically increased shake-down time between readings.

CLEANING MINOR CONTAMINATION

Follow step 1 through step 22 to remove minor contamination of the diffusion path and other components (Figure 55). A short video of this procedure is at metergroup.com/environment/articles/sc1-leaf-porometer-repair. Figure 55 can be used as a reference when performing the following steps.

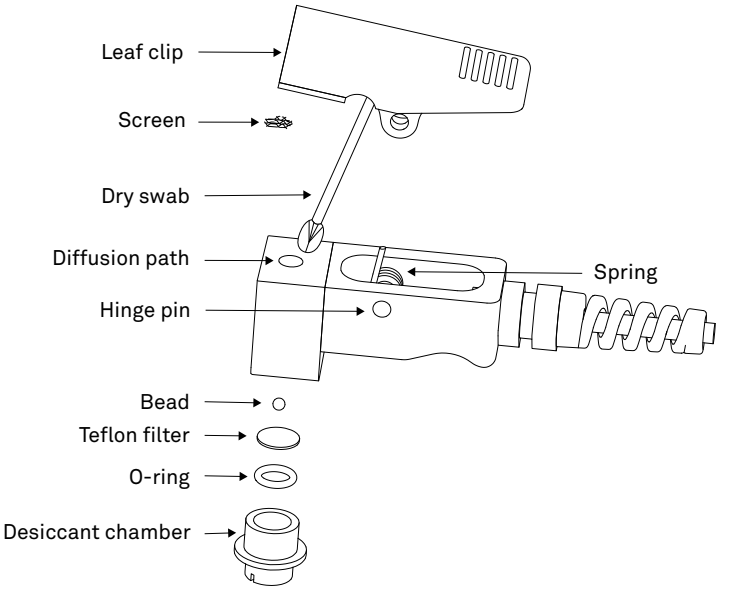

Figure 55 Thorough cleaning of the diffusion path

1. Unscrew the desiccant chamber.
2. Use tweezers to remove the o-ring.
3. Use tweezers to remove the Teflon filter and discard.
4. Remove the agitation bead.
5. Use a spare hinge pin to push the leaf clip hinge pin out of its seating, and remove both pins.
6. Remove the top of the leaf clip.
7. Remove the screen, if necessary.

   Use a thin implement to press the bead retention screen out of the aluminum sensor block.
8. Clean the screen with water or alcohol.

   If using alcohol, clean the screen far from the sensor head to prevent exposure of the RH sensor to the alcohol.
9. Clean the diffusion path with DI water and a cotton swab or paper towel.

   NOTE: Avoid scrubbing the aluminum block with abrasive materials as they can remove the hydrophobic finish on the block and affect conductance measurements.

10. Use water and a soft cloth to clean contamination from the exterior surfaces of the aluminum block and rubber pads.
11. Allow the sensor head and screen to dry completely.
12. Place the bead retention screen over the diffusion path opening, with the concave side up.
13. Gently push the edges down into the diffusion path.

    Ensure the bead rentention screen is fully recessed in the diffusion path but completely above the first RH sensor port, so it does not interfere with the leaf or the diffusion of vapor into the upper RH sensor port.
14. Place the spring inside the leaf clip top and use the short hinge pin to hold it in place temporarily.
15. Align the leaf clip top and spring with the leaf clip bottom.
16. Insert the hinge pin into the hinge hole, pushing the short hinge pin out the opposite side. Ensure the hinge pin is flush with the sides of the leaf clip.
17. Replace the agitation bead.
18. Replace a new Teflon filter.

    NOTE: The Teflon filter looks very similar to the calibration paper disk. Ensure to select a filter.
19. Replace the o-ring.
20. Fill the desiccant chamber with fresh desiccant.
21. Replace the desiccant chamber.
22. Recalibrate the sensor prior to taking new readings (Section 4.1).

CLEANING MAJOR CONTAMINATION

If water is not effective at dissolving the contamination in the diffusion path, the leaf clip assembly can be further disassembled and cleaned with alcohol. The most important consideration is to make sure that the porometer sensors are not exposed to alcohol vapors during the process.

1. Follow step 1 through step 7 from the previous cleaning instructions to partially disassemble the sensor head assembly.
2. Use a 3/32-in hex key to remove the two screws from the front of the aluminum block.
3. Firmly pull the aluminum block away from the rest of the sensor head. The aluminum block should pull free from the black plastic sensor assembly.
4. Clean the aluminum block thoroughly with alcohol or other solvent and a swab or cloth.

   In extreme cases, soak the aluminum block in alcohol to dissolve contamination before scrubbing and rinsing.

   NOTE: Do not allow the black plastic sensor assembly to be exposed to solvent vapors or the sensors can be damaged.
5. Let the aluminum block dry completely.

6. Align the half-circle tab on the lower edge of the black plastic sensor assembly with the half-circle cutout on the aluminum block (Figure 56).

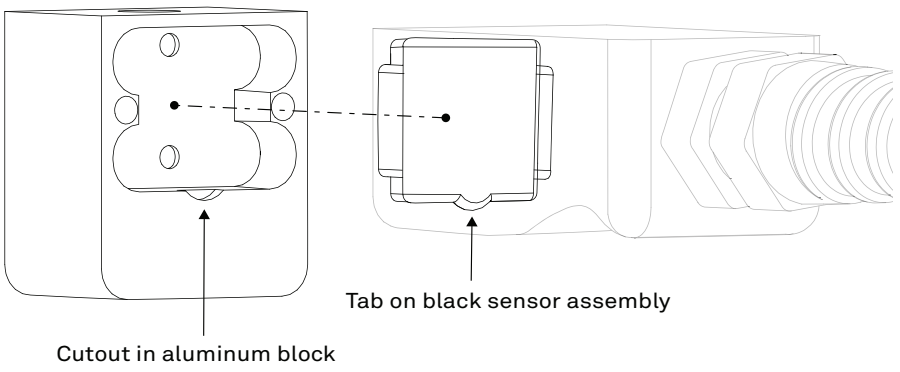

Figure 56 Align tab and notch

7. Firmly press the aluminum block back onto the black plastic sensor assembly. Fully seat the two pieces together to ensure a good seal.
8. Replace the machine screws and tighten until the aluminum block seats tightly to the with plastic leaf clip.

   DO NOT OVERTIGHTEN. The machine screws are threading into plastic, and overtightening will strip the plastic threads.
9. Follow step 12 through step 22 in the previous cleaning instructions to reassemble the sensor head and calibrate.

4.2.3 REPLACE LEAF PADS

Leaf pads can fall off or become damaged. When the sensor head is cleaned, check the condition of the pads. They should make full contact with the leaf. A spare set of pads is included in the SC-1 kit. Contact Customer Support if more leaf pads are needed.

To replace a leaf pad, use the following steps.

1. Remove the old leaf pad from the leaf clip, using tweezers, if necessary.
2. Clean any residue, dirt, or soil particles from the sensor block with a slightly damp cloth.
3. Peel the adhesive paper off the back of the new leaf pad.
4. Carefully place the new leaf pad on the leaf clip and press firmly.

4.3 TROUBLESHOOTING

The SC-1 is a high-performance, low-maintenance instrument, designed to have few problems if used with care. Table 1 lists common problems and their solutions. If the problem is not listed or these solutions do not solve the issue, contact Customer Support.

Table 1 Troubleshooting the SC-1

Problem	Possible Solutions
The SC-1 does not turn on	Check that the batteries are inserted correctly. Replace the batteries.
Display is difficult to see	Adjust the contrast. • Navigate to the Configuration tab. • Scroll down to `Contrast`. • Use the **UP** and **DOWN** to adjust screen contrast level.
`Sensor Head Failure` **error**	Verify the sensor head is securely connected to the serial port receptacle. Restart the reading. If this screen reappears, the cable or sensor may be faulty. • Navigate to the Configuration tab. • Select `Diagnostics`. • Press **ENTER** to save a Scan record. • Contact Customer Support with the Scan record results ready for review.
Low battery message	Check that the batteries are inserted correctly. Replace the batteries.
`Date and time were reset!` **message**	This message may appear after changing the batteries or loading new firmware onto an instrument. Follow instructions in Section 2.1 to correct the date and time.
`Error: Invalid Cal Num` **screen**	Either perform a user-initiated calibration by following instructions in Section 4.1 or restore the default calibration by using these steps: • Navigate to the Configuration tab • Select `Calibration`. • Select `Restore Defaults`. • Press **ENTER** on the confirmation screen.
`Missing bootstrap loader!` **error**	The instrument cannot download new firmware updates. The instrument must be serviced by METER. Contact Customer Support.

Table 1 Troubleshooting the SC-1 (continued)

Problem	Possible Solutions
`Firmware is corrupted!` error	The firmware was not loaded properly or an update is needed. Check metergroup.com/sc1-support if a new firmware version is available. **NOTE: Saved data records will be lost when new firmware is installed. Download any data before reloading the new firmware.** If a newer firmware version is not available, contact Customer Support.
The USB-to-serial adapter is not showing as an option in the communication port dropdown	Check that the device driver is properly installed. Reinstall the METER driver by downloading it (software.metergroup.com/drivers/METER_USB_Driver_Installer-8.0.exe) and running the installer. **NOTE: Ensure the appropriate device driver is installed for third-party USB-to-serial adapter cables.**
Downloading data stops in the middle with an error message saying the connection was lost	A noisy serial connection can disrupt the connection between the Leaf Porometer Utility and the SC-1. If this error happens regularly, change the Leaf Porometer Utility Communication preferences. • Go to `Edit` > `Preferences`. • Select the Communication tab. • Decrease the Maximum Baud Rate value or increase the Command Retries value. • Click `Close`.
Conductance readings are not what was expected	Verify porometer accuracy (Section 4.1.1) Recalibrate the sensor head (Section 4.1.2). Clean the sensor head (Section 4.2.2). The Teflon filter also may be wet or dirty. Replace the filter. The RH sensors may require repairs. Contact Customer Support.
`Too much drift` error	Stable calibration readings were not achieved in 10 readings. Leave the sensor head at ambient conditions for a 15 min and try again. If this message continues to appear after two or three calibration attempts, contact Customer Support.
The SC-1 will not calibrate, even after multiple attempts	The SC-1 is not in thermal equilibrium. Leave the sensor head at ambient conditions for 15 min and try again. Clean the diffusion path and replace the Teflon filter (Section 4.2.2). The RH sensors may have been contaminated. Contact Customer Support.

Table 1 Troubleshooting the SC-1 (continued)

Problem	Possible Solutions
`Desiccant not detected` error	This displays only if the calibration was conducted using desiccant and the internal sensors have now equilibrated to RH >10%. Ensure that desiccant is in place or replace with a fresh batch.
`Desiccant exhausted or not present` error	This displays when the internal sensors have equilibrated at >10% RH. METER recommends to always use the desiccant chamber, but most importantly when ambient RH is > 30%. Ensure that desiccant is in place or replace with a fresh batch if taking measurements with desiccant. Press **ENTER** to proceed with measurements without desiccant.
Bead retention screen missing	Replace bead retention screen: • Remove the top of the leaf clip. • Place the bead retention screen over the diffusion path hole, with the concave side up. • Gently push the edges into the diffusion path. • Gently push the middle downward. The screen should sit snugly at the top of the diffusion path. If the screen continues to fall out, contact Customer Support.
Bead retention screen is protruding out of the diffusion path and touching the leaf pad	Reinstall bead retention screen: • Place the bead retention screen in the calibration plate hole. • Push snug with a finger. • Use the calibration plate to seat the screen firmly in the sensor head. It is critical to recess the bead retention screen in the diffusion path. If the screen extends out of the diffusion path, it will cut the leaf and cause erroneously high conductance measurements.
`Initial conductance is too high` message persists	Close the leaf clip and shake the sensor head briskly in a vertical orientation to equilibrate. Replace the Teflon filter (Section 4.2.2). An air leak may have developed, allowing high RH air to leak into the measurement chamber. • Check the integrity of the round rubber seal that caps the measurement chamber. • Test for leaks by placing fresh desiccant in the desiccant chamber and leaving the sensor head undisturbed for 2–3 days. Use the diagnostics screen to check the RH of the unopened sensor head. If the RH is >10%, there is a leak. Contact Customer Support.

Table 1 Troubleshooting the SC-1 (continued)

Problem	Possible Solutions
Equilibration shake down period between measurements extends past 75 s.	Replace the Teflon filter (Section 4.2.2). An air leak may have developed, allowing high RH air to leak into the measurement chamber. • Check the integrity of the round rubber seal that caps the measurement chamber. • Test for leaks by placing fresh desiccant in the desiccant chamber and leaving the sensor head undisturbed for 2–3 days. Use the diagnostics screen to check the RH of the unopened sensor head. If the RH is >10%, there is a leak. Contact Customer Support. Contamination in the diffusion path can cause slow equilibration times. Clean the sensor head (Section 4.2.2).
`High RH reading` error persists	Check the desiccant and replace, if needed. The Teflon filter may be clogged. Replace the filter as described in Section 4.2.2. If the problem persists, contact Customer Support.
An infinity symbol appears in the place of the measurement	The stomatal conductance measurement is greater than or equal to 6,000 mmol/(m^2s). Most often, the excessively high values are caused by water on the leaf surface. Remove water from the leaf and repeat the measurement.

4.4 CUSTOMER SUPPORT

NORTH AMERICA

Customer service representatives are available for questions, problems, or feedback Monday through Friday, 7:00 am to 5:00 pm Pacific time.

Email: support.environment@metergroup.com
sales.environment@metergroup.com

Phone: +1.509.332.5600

Fax: +1.509.332.5158

Website: metergroup.com

EUROPE

Customer service representatives are available for questions, problems, or feedback Monday through Friday, 8:00 to 17:00 Central European time.

Email: support.europe@metergroup.com
sales.europe@metergroup.com

Phone: +49 89 12 66 52 0

Fax: +49 89 12 66 52 20

Website: metergroup.de

If contacting METER by email, please include the following information:

Name	Email address
Address	Instrument serial number
Phone	Description of the problem

NOTE: For products purchased through a distributor, please contact the distributor directly for assistance.

4.5 TERMS AND CONDITIONS

By using METER instruments and documentation, you agree to abide by the METER Group, Inc. USA Terms and Conditions. Please refer to metergroup.com/terms-conditions for details.

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