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RAYO S600

Miniaturized Plate Reader

RAY-S600

600nm

Operating Manual

Table of Contents

1. Introduction

1.1 About the Manual

The current edition of the manual applies to the following models and versions:

Product	SKU
S600, 600nm	RAY-S600
S600 Adapter	APT-S600

1.2 About the Rayo S600

The Rayo S600 plate reader provides high-quality endpoint and continuous real-time optical density measurements with 6, 12, and 96-well plates and the Cerillo Co-culture Duet plate. Continuous measurements can be set at user determined time intervals. The Rayo S600 provides a single measurement mode (absorbance) at a single wavelength (model-dependent). The Rayo S600 is functional in a broad range of environments including anaerobic chambers, shakers, heated and humidified incubators, and remote field settings.

2. Safety Precautions

Caution!

Make sure you have fully read and understood the present manual before using the equipment.

2.1 General Safety

- Protect the unit from shocks or falling.
- Before using any cleaning or decontamination methods except those recommended by the manufacturer (see Sections 2.4 and 7.3), check with the manufacturer that the proposed method will not damage the equipment.
- Do not make design modifications to the unit.

2.2 Electrical Safety

- Connect only to power supply with voltage corresponding to that on the serial number label on the bottom of the instrument.
- Use only the external power supply provided with this product or one approved by the manufacturer. Always ensure compatibility of the power source.
- Ensure the external power supply is easily accessible during use.
- Disconnect the unit before moving it unless the device is connected to a battery pack.
- Turn off the unit by disconnecting the external power supply from the power source.
- Always use caution with liquid and avoid spills as they can damage the equipment. If liquid penetrates the unit, immediately disconnect it from the external power supply, blot-dry the exterior, and let the unit air dry for 24-48 hours. Contact customer support at support@cerillo.bio in case of concerns.
- Operating conditions of the unit are defined in *Section 5.0 Specifications*.

2.3 During Operation

- Do not move the unit while it's reading. Stabilize the unit while shaking. On larger incubators, shake between 200-350 RPM. Shake between 300-500 RPM on a single-plate shaker.*
- Do not operate the unit in environments with explosive chemical mixtures. Review *Section 5.2 Measurement Specifications* for acceptable environmental conditions; otherwise please contact the manufacturer for possible operation of the unit in specific atmospheres.
- Do not operate the unit if it is faulty or installed incorrectly.

2.4 Biological Safety

- It is the user's responsibility to carry out appropriate decontamination if hazardous material is spilled on or penetrates inside of the equipment.
- For decontamination, the manufacturer recommends using ETO gas, or wiping down the unit with 10% bleach-based solution or Cavicide. Any streaking can be cleaned off with 70% ethanol.

*Supported RPMs cannot be guaranteed and vary per equipment used; reach out to our support team at support@cerillo.bio for specific recommendations.

3. General Information

The Rayo S600 package includes one Rayo S600 plate reader with microSD card inserted, one USB cable, and one power adapter.

3.1 Purpose

The unit is designed to take optical density (OD) readings with a detection range between 0.0 and 2.5. We recommend designing endpoint experiments in the measurement range between 0.0 and 2.0.

3.2 General Use and Features

The Rayo S600 plate reader allows for measurement collection in small spaces, on shared or modular benchtops, in restrictive environments, like anaerobic or microaerophilic chambers and incubators, and in remote field settings. The Rayo S600 can be placed almost anywhere and does not require direct connection to a computer while collecting data.

3.2.1 Features

- Endpoint measurements of optical density
- Available in 450 or 600 nm
- Fits standard 96, 12, and 6-well plates and the Cerillo Co-culture duet plate
- Small footprint and stackable
- No moving parts; minimal maintenance
- Functional in a broad range of environments
- Includes a free version of the user-friendly Cerillo Labrador software
- Operable without a computer connection
- Compatible with the Cerillo Canopy for wireless operation

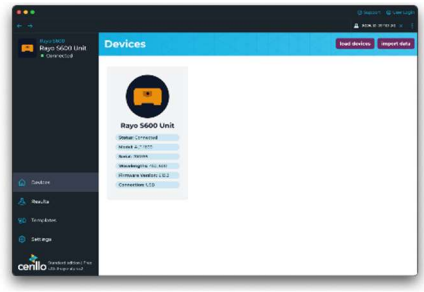
4. Getting Started & Operation

4.1 Upon Receipt

Carefully remove packing materials and retain them for future shipment or storage of the unit. Confirm receipt of all components described and examine the unit carefully for any damage incurred during transit. A microSD card will already be installed in the Rayo S600.

4.2 Downloading Software and Connecting the Device

Download Cerillo's Labrador software at: https://info.cerillo.bio/labrador-download. Use the provided USB cable to connect your Rayo S600 plate reader or Canopy device to your computer. Open Labrador and click "load devices" to detect your device. If connecting your Rayo S600 wirelessly through a Canopy, be sure to connect the Rayo S600 to a power source (more details in *Section 4.4 Powering the Device*). To set up your device, click on your device in Labrador and open the settings window denoted by the gear icon. Refer to Sections 4.6 and 4.8 for more detailed instructions.



Note: Please only use the provided cord; not all USB cables are capable of seamless data transfer between the Rayo S600 and a computer.

4.3 Location

Place your Rayo S600 where you'd like to collect measurements. You can collect measurements in almost any environment of interest— in an incubator, anaerobic chamber, benchtop, hood, etc. Equilibrate your Rayo S600 to any new environmental conditions for 4 hours, while connected to power, prior to running a new experiment. For specific instructions on using your Rayo S600 in different environments, refer to *Section 4.10 Using Rayo S600 in environmental chambers*. For limitations and environmental tolerances, refer to *Section 5.2 Measurement Specifications*.

4.4 Powering the Device

Before powering your device or collecting data, first verify that the microSD card is already inserted in your Rayo S600 plate reader. Your Rayo S600 plate reader can be powered using the provided USB cable and connecting with your computer, a Cerillo-recommended battery pack, or the provided adapter and a standard wall outlet.

To control your Rayo S600 through the Labrador software, refer to *Section 4.2 Downloading the Software and Connecting the Device*. The software enables direct control, data access, and configuration of your Rayo S600.

Always insert the microSD card with the Rayo S600 unplugged; otherwise, the card can become corrupted and future data might not be recorded. Ensure the microSD card is inserted for the entire duration that the Rayo S600 is booting and powered.

4.5 Controls

The “start” (left) button has two functions. Start an endpoint read by *pressing and quickly releasing* the “start” button. To start a kinetic read, *press and hold* the “start” button until the status light (center) flashes white. At this point, the Rayo S600 will perform an automatic calibration to the plate and sample (cyan light) and then automatically begin readings at the designated time intervals (default five minutes; green light).

The “stop/calibrate” button also has two functions. If *pressed and quickly released*, the Rayo S600 will complete the experiment and halt measurements (red light). For samples at high OD and/or high shaking RPM, the Rayo S600 may take up to 2 seconds to stop after pressing. If *pressed and held* when an experiment is not running, the Rayo S600 will perform a device calibration (cyan light).

4.6 Starting an experiment

Readings occur every 5 minutes by default. To customize read times prior to running an experiment, select your device in Labrador and then select Settings (gear icon in the top-right corner of screen). The Rayo S600 will retain these settings when unplugged and plugged into a wall outlet or battery source. It is recommended to use Labrador to set a plate layout after your experiment. Labrador can also be used to start and stop an experiment while the device is connected. Further instructions can be found at labradormanual.cerillo.bio.

Samples with OD > 2.5 are not recommended for the Rayo S600, as they may extend the amount of time it takes for the Rayo S600 to take a measurement. In this case, the interval between reads may be larger than you originally set (though the reads will be recorded with accurate timestamps throughout data collection). Additionally, readings above 2.5 OD are outside the linear range of the instrument and are therefore not recommended for quantitative analysis.

The Rayo S600 should remain at a constant temperature throughout the experiment, especially during calibration. Equilibrate your Rayo S600 to new environmental conditions for 4 hours, while connected to power, prior to running a new experiment. Overnight equilibration, for example by setting the Rayo S600 in an incubator after inoculating your starter culture, can be helpful. Once your plate is prepped, let the plate also equilibrate in the environment where you plan to run your experiment, if possible. **Your device and plate should complete both environmental equilibration and device calibration before your first measurement.**

Following environmental equilibration, measurements can begin. If you are about to start a kinetic experiment with kinetic auto-calibration enabled, you do not need to manually calibrate the device prior to starting measurement.

While measurements can be taken with a plate lid, without a plate lid, or with a breathable membrane, data is most reliable when collected with a

breathable membrane. Membranes (such as a Breathe-Easy membrane) most effectively prevent measurement errors due to condensation and evaporation during long experiments. The Rayo S600 should be at a constant temperature and should not be opened or relocated for the duration of the experiment.

4.6.1 Quick-start, manual operation:

Formatting your plate layout/data in Labrador is not required before running an experiment; the following instructions describe how to use the instrument with only its buttons.

Endpoint measurements (calibrate while empty):

For an endpoint measurement, the Rayo S600 must perform its device calibration while empty. After completing the environmental equilibration, ensure the device is empty, close the lid, then hold down the "stop/calibrate" button (right) until the status light flashes white, then release to perform the device calibration (cyan status light). After calibration, put your plate into the reader and press the "start" button (left). The status light will briefly illuminate green to indicate the experiment has started. The light will then turn yellow and then turn off when the Rayo S600 has completed collecting data.

Kinetic measurements (auto-calibrate with plate):

By default, kinetic experiments on the Rayo S600 begin with auto-calibration, which will zero all wells and require that the plate be in the reader. Place your experimental plate in the Rayo S600. Press and hold the "start" button until the status light flashes white. Once the button is released, the status light will turn cyan during calibration, and then green during measurement. The Rayo S600 will automatically continue with measurements after calibration. Note that if the device's "enable kinetic auto-calibration" setting has been unchecked in Labrador, auto-calibration will not take place, in which case manual calibration before starting is necessary; see below for details.

Kinetic measurements (calibrate while empty):

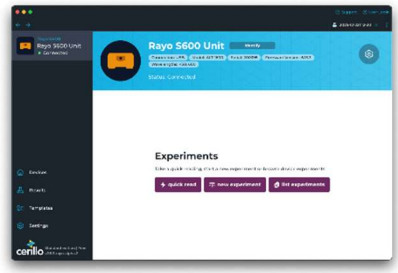
If you do not want all wells normalized to zero when beginning a kinetic experiment, it is first necessary to disable kinetic auto-calibration. In Labrador, navigate to your device, click the gear icon to access settings, uncheck "enable kinetic auto-calibration," and click "save." Your device will no longer automatically calibrate before starting kinetic experiments. To conduct a kinetic experiment, press and hold the stop button until the status light turns cyan to calibrate. Once calibration is complete, insert your experimental plate. Press and hold the "start" button to start the kinetic experiment as described

above. The device will immediately begin taking measurements, as indicated by a green status light.

Ending an experiment:

To stop a reading in progress, press the “stop” button. The status light will turn red. If the Rayo S600 is mid-reading, you may need to press the “stop” button again and hold until the light turns red.

4.6.2 Measurements through Labrador:



To perform a rapid 96-well read within the Labrador software, click on the device of interest, and then click “quick read.” You will be prompted to calibrate or proceed with the read. If you would like to specify any non-default endpoint settings, such as plate type, layout, name, etc., select “new experiment” and select either “endpoint” or “kinetic”. At this point, you can name your experiment and select well groupings under the “plate layout” tab. Click “start” to begin your experiment. For more information on Labrador functionality, reference the Labrador user manual at labradormanual.cerillo.bio.

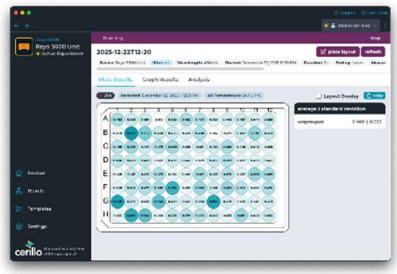
4.6.3 Wireless control through Labrador:

The Cerillo Canopy can be used to connect remotely with up to 5 devices. Use the USB cable provided with the Canopy to plug it directly into your computer (up to 15 meters from the Rayo S600). Power your Rayo S600 through a power outlet or battery pack. Follow the instructions from the Canopy Quick Start Guide to set up and confirm communication between Labrador, Canopy, and the Rayo S600. Follow the instructions for *Section 4.6.1 Quick-start, manual operation* or *Section 4.6.2 Measurements through Labrador* to start an experiment. All methods of starting experiments are available for Canopy-connected Rayo S600 devices.

4.7 Accessing data

Data collected is automatically stored on the on-board microSD card. *Inserting or removing the microSD card while the device is powered can corrupt the card, rendering it incapable of recording future data.* Data stored on the microSD card can be accessed by directly connecting the Rayo S600 to your computer using the provided USB cable and using Labrador, plugging the card into any commercially available microSD card adapter, or wireless

transfer to Labrador through Cerillo's Canopy. When viewing data directly on the microSD card, data files are found in the "experiments" folder, in a subfolder corresponding to the experiment name. The supplied microSD card is 16GB and is sufficient to hold 4 weeks of continuous data at the maximum sampling rate. Any standard microSD card capable of storing 32GB or less is compatible with the Rayo S600, but it must be formatted as a FAT32 drive.



Experiment files are saved as standard .csv files on the microSD card. Data can be viewed using the Labrador software or .csv or .xlsx files can be exported and opened in any spreadsheet or data analysis software. To export a file, navigate to "Results" and wait for experiments to load. Click on the download arrow on the right for the experiment of interest. A popup window will signal that the download is complete. The figure on the right shows what an experiment looks like in the software. See labradormanual.cerillo.bio for more information.

4.8 Adjusting device settings

To change the kinetic measurement interval, use the Cerillo Labrador software and follow instructions in *Section 4.6 Starting an experiment*. The Rayo S600 will recall custom measurement intervals, even when unplugged and plugged into a wall outlet or battery source, until this setting is changed in the Labrador software. Wiping the microSD card memory will revert the interval time back to 5 minutes. For further instructions on adjusting device settings, please refer to the Labrador user manual at labradormanual.cerillo.bio.

4.9 Using the Rayo S600 with shaking

The Cerillo Microplate Shaker securely fastens to the Rayo S600 by tightening the shaker's thumb screws into paired recesses in the Rayo S600's casing. The Rayo S600 is also compatible with most commercially available shakers via the Rayo S600 Adapter.

Ensure the device is securely affixed to avoid liquid spills. If the Rayo S600 is not well secured to the shaker, it can move excessively or irregularly, which can disrupt the measurements. When securely fastened to the shaker, the device can measure while shaking. There is no need to program the shaker to stop shaking during measurement. Shaking should not be interrupted and shaking

speed should not change during an experiment. When setting up the Rayo S600 on a shaker, ensure that there is slack provided in the power cable to avoid the device becoming unplugged.

4.10 Using the Rayo S600 in environmental chambers

4.10.1 Anaerobic, Microaerophilic, and CO_2 chambers

The Rayo S600 is designed to be robust to environmental conditions common in anaerobic, microaerophilic, and CO_2 chambers. The Rayo S600 can be transferred through chamber airlocks (as size allows) and stored within chambers intermittently for days or weeks. While the Rayo S600 itself is stable within an anaerobic chamber, some microbes produce gases, such as H_2S, which can deteriorate the electronics over time, so occasional removal to fresh air is recommended. Refer to *Section 5.2 Measurement specifications* for compatible gas concentrations.

4.10.2 Incubators and refrigerators

Since the Rayo S600 does not make its own environmental conditions, it is common to place the device within an environmental control chamber to achieve the conditions of interest. The Rayo S600 has been tested from 0° - 50° C and is operable within that range. Note: When the device is placed in heated or cooled environments, best results will be achieved when the device is equilibrated to that environment for at least 4 hours prior to starting a measurement, as detailed in *Section 4.6 Starting an Experiment*. In some instances, equilibration can take longer, in which case the device may benefit from being left in the incubator overnight prior to the experiment.

5. Specifications

5.1 General

Detection Method	Absorbance
Detection Mode	Kinetic, Endpoint
Plate Types	6, 12, 96-well plates, Cerillo Co-culture Duet plate
Dimensions	W: 15.0 cm D: 13.3 cm H: 7.2 cm
Weight	800 g

Power Input	5 V, 500 mA USB-C receptacle

5.2 Measurement

Environmental Tolerance	Temp: 0-50° C, Humidity: 0-99%, O_2 Concentration: 0-21%, CO_2 Concentration: 0-25%
Wavelength	Single Wavelength: 600 nm, 450 nm
Light Source	Monochromatic LEDs
Resolution	0.001 OD
Detection Range	0.000 – 4.000 OD
Linearity	< ±1% (0.000 - 2.500 OD)
Accuracy	Endpoint: < ±1% and ±0.02 OD (0.000 - 2.500 OD) Kinetic: < ±0.25% and ±0.005 OD (0.000 - 2.500 OD)
Repeatability	< ±0.25% and ±0.005 OD (0.000 - 2.500 OD)
Data Storage	microSD; up to 32 GB (16 GB card provided)

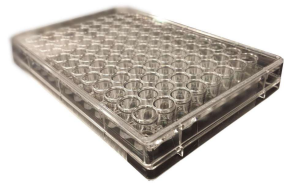
5.3 Software

Operating System	macOS: 11 (Big Sur), 12 (Monterey) Windows: 10, 11
Data Format	.csv (on-board), .xlsx (some Labrador exports)

5.4 Compatible Accessories

5.4.1 Multiwell Plates

The Rayo S600 is compatible with all flat-bottom, standard well format plates, including tissue culture and non-tissue-culture treated plates (6, 12, and 96 wells), and the Cerillo Co-Culture Duet plate.



5.4.2 Battery/Power bank

The Rayo S600 can be connected to a power bank. The Rayo S600 operates well when connected to Anker brand power adapters. The Anker 10000 mAh

batteries will power the Rayo S600 for 48-72 hours depending on the temperature and measurement interval.

5.4.3 Plate sealing film

While a variety of plate sealing films are suitable for the Rayo S600, Diversified Biotech's "Breathe-Easy" brand membranes (catalog number BEM-1) have been extensively validated for use with the Rayo S600. If using other membranes, ensure they are transparent.

5.4.4 Cerillo Microplate Shaker

The Rayo S600 can take readings while shaking; the instrument must be firmly secured to avoid spills and ensure there is no wobble or irregular movement, which would add variability to data. We recommend the Cerillo Microplate Shaker for Rayo S600 shaking experiments. The Rayo S600 is secured to the Cerillo Microplate Shaker by tightening the shaker's thumb screws into paired recesses in the Rayo S600 casing.

5.4.5 Rayo S600 Adapter

The Rayo S600 is compatible with a variety of different shaking platforms, in addition to Cerillo's Microplate Shaker. Cerillo's Rayo S600 adapter might be necessary to secure the Rayo S600 to non-Cerillo shakers. While shaking, the device must be securely affixed to avoid liquid spills, wobble, or irregular movement around the shaking platform. When setting up the Rayo S600 on a shaker, ensure that there is slack provided in the power cable to avoid the device becoming unplugged.

5.5 Data Storage

Data is automatically stored on the microSD card that comes with the device. Once you have copied data from your Rayo S600 to your computer, you can safely delete the corresponding experiment folders in the "experiments" directory on the card. Data can only be deleted by accessing data on the microSD card directly, not through Labrador. Please note: your data will not be recoverable once deleted and keeping a backup copy on the card may help with future troubleshooting.

6. Resources

- Further documentation can be found at https://cerillo.bio/resources/
- The Labrador user manual can be accessed at labradormanual.cerillo.bio

7. Guarantee and Service

7.1 Guarantee

When used in laboratory conditions and according to these working instructions, this product is guaranteed for two years against faulty materials or workmanship.

7.2 Service and maintenance

There are no user-serviceable parts inside the unit. For all repairs (except as outlined below) contact our service department at support@cerillo.bio.

7.3 Cleaning and disinfection

The Rayo S600 can be disinfected by wiping with a lint free or microfiber cloth and a 10% bleach-based solution or Cavicide followed by 70% ethanol to remove any residue. Do not spray solutions as excess liquid can enter perforations in the device. Instead, spray a lint free or microfiber cloth with the cleaner and wipe the device. The exterior color of your device may rub off on your cloth for the first few cleanings.

Note: no parts of the unit can be safely autoclaved.

8. Compliance

The Rayo S600 is RoHS compliant, CE marked, made in the USA, compliant with various national and international safety and electromagnetic compatibility standards, and has a two-year warranty.
Declarations of Conformity for various jurisdictions are available upon request.

The Rayo S600 complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Contains FCC ID: MCQ-S2CTH or MCQ-XBEE3

The Rayo S600 complies with CAN ICES-001(A) / NNB-001(A)

Contains IC: 1846A-S2CTH or 1846A-XBEE3

All of the products covered by this manual comply with the requirements of the EU harmonized legislation verified using the following standards

EMC Directive (2014/30/EU) for Electromagnetic compatibility	LVS EN 61326-1
RoHS Directive (Directive 2011/65/EU including 2015/863) for Hazardous substances	LVS EN 50581
Radio Equipment Directive (2014/53/EU)	EN 62311

The Rayo S600 complies with relevant provisions of the Japan Radio Law.

Contains 210-105563 or 210-119309

9. More Information & Troubleshooting

9.1 Troubleshooting

9.1.1 Rayo S600 device not recognized by computer

1. Restart Software
2. If the device is not responsive to pressing the buttons, follow device recovery instructions: labradormanual.cerillo.bio > Troubleshooting > Device Recovery

9.1.2 Difficulty installing software

For installation instructions, you can access the Cerillo Labrador software instructions at labradormanual.cerillo.bio or email support@cerillo.bio.

9.1.3 Rayo S600 stops taking readings mid-way through an experiment

Primary causes:

1. Battery power ran out or the device became unplugged.
2. The experiment reached this planned duration, applied under device settings, and stopped.
3. Device took an endpoint reading. The “start” button must be held until light flashes to start a continuous read.

9.1.4 Data issues or missing files

Primary causes:

1. The device was powered on without the microSD card, or the microSD card was inserted while the device remained powered. If the device is plugged in when the microSD card is inserted, it will not recognize the microSD card, preventing recording of data.
    a. Solution: Ensure that the Rayo S600 is unplugged whenever the microSD card is inserted in the device. If the device is already on, it will not recognize the microSD card. If the device is powered on without an SD card, the device will have a red status light.
2. An incompatible microSD card is used. Only use the supplied microSD card. If a replacement card is needed, be sure to format to FAT32 prior to using and only use cards under 32 GB capacity.
3. Corruption of the microSD card (data is unreadable).
    a. Reformat the microSD card on Windows:
        i. Insert the microSD card directly into your computer or utilize an adapter if your computer does not have a microSD card slot.
        ii. Back up any important data from the microSD card.
        iii. Open File Explorer.
        iv. Right-click on the microSD card drive, select “Format.”
        v. A formatting window will pop up. Under the file system drop down, select FAT32.
        vi. Uncheck “Perform a Quick Format.”
        vii. Select OK.
    b. Reformat the microSD card on macOS:
        i. Insert the microSD card directly into your computer or utilize an adapter if your computer does not have a microSD card slot.
        ii. Back up any data on the microSD card.
        iii. Open Disk Utility. It is available through the Applications Folder in a Utilities subfolder. You can also use Spotlight search to open it by name.
        iv. In the sidebar of Disk Utility, search for your memory card and select the volume. Typically, you'll find it under the name of the manufacturer of the memory card, and it will have a volume title that matches the name of the drive when it mounts, as well as matching capacity.
        v. Once you have established that you have selected the correct volume, click “Erase.”

vi. Enter a name for the memory card.
vii. Select the format for the memory card as FAT32.
viii. Click “Erase.”
ix. Once formatting has completed, click “Done.”

9.1.5 Increasing OD in blank samples

Increasing blank sample OD is most commonly due to temperature increase or condensation. Other possible mitigation steps include:

1. Ensure the plate reader equilibrates in experimental environment, plugged in, for 4 hours prior to starting an experiment. If readings still increase, consider overnight equilibration.
2. Minimize temperature change throughout the experiment.
3. Prior to placing the plate in the plate reader, shake it on an orbital shaker (~1000rpm) for a few seconds. If a small shaker is not available, tap your prepared plate on the lab bench a few times to break the surface tension of the samples. While not required, this helps normalize the liquid in the wells and can lead to better results.

9.1.6 Condensation issues leading to incorrect readings

Erratic increases in OD (from condensate on the film/lid) or drops in OD (due to condensate dropping into the well) are characteristic of condensation. Try the following to resolve condensation issues:

1. Ensure the plate is equilibrated to experimental conditions. Abrupt changes in temperature can cause condensation.
2. Minimize temperature change during the experiment. Changes in temperature can increase the likelihood of condensation.
3. Try using a breathable membrane instead of a plate lid.
4. Increase ventilation in the environment.

9.1.7 How to get support

To report a software bug or get technical support, email our technical team at support@cerillo.bio.

107 east water street
charlottesville, va 22902
www.cerillo.bio
sales: sales@cerillo.bio
technical support: support@cerillo.bio
general information: info@cerillo.bio