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PeCOD Pro™

Operation Manual

For Benchtop PeCOD® COD Analyzers

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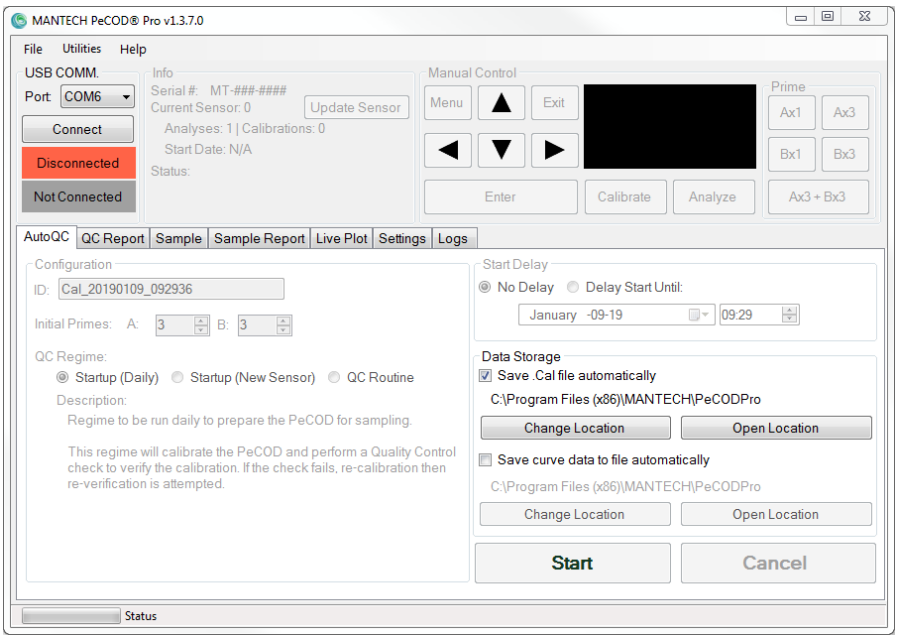
1.0 Getting Started

1.1 Introduction

The purpose of the PeCOD Pro™ Operation Manual is to streamline the calibration and sampling process for users by outlining recommended procedures. For further description on the functions of the PeCOD Pro™ software refer to the PeCOD Pro™ Documentation pdf included in the software folder. For instructions on installing PeCOD Pro™ software, refer to documentation PDF or the MANTECH YouTube channel: www.mantech-inc.com/PeCODProTutorials.

When the program is launched for the first time, it will show an "update tour" outlining new features in that version. This tour will be shown every time the program is launched unless the "Don't show tour again on program start" box is checked.

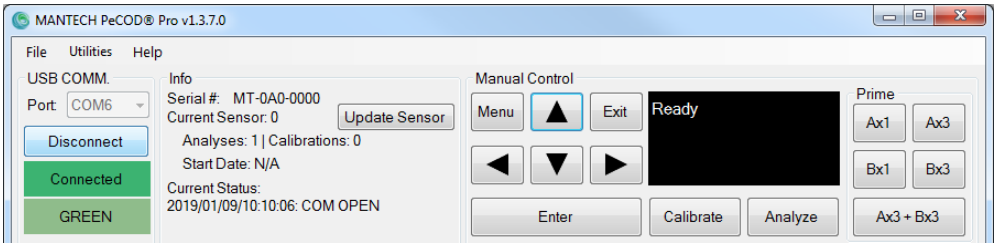
When the tour is closed, or on normal launch, the main window of the program will be shown. The functionality is fairly limited until connected to a PeCOD, but previous .CAL and .BATCH files can be loaded via the QC Report and Sample Report tabs, without connecting to a PeCOD.



1.2 Connecting to the PeCOD

1. Connect the PC to the PeCOD via USB cable. Make sure the PeCOD is on.
2. Select Port: **COM6** on the drop down selection.
3. Click **Connect**. As the program connects, it gets information from the PeCOD, and the progress will be displayed:

4. Once connected the progress panel will disappear, the **Connect** button will change text to: **Disconnect**, the status below the button will show “Connected” and the box below that will display the **COD range**:



5. After the software is connected, the QC Regime, Sampling, Settings, Logs, and additional functions become active and can be used.

2.0 Calibration and QC Regimes

The PeCOD should be calibrated each day before sample analysis. Calibrations can be setup to run unattended immediately or delayed to a user-specified date and time. Calibration times vary for each COD range.

The program is designed to run "QC Regimes" which are automated behaviours to preform the appropriate number of calibrations as well as analyzing calibrant as a QC-Check sample, to verify that the calibration was successful.

Approximate QC Regime durations are listed in Table 1 and are based on the *Startup (Daily) QC Regime*, using the default preferences. Calibration durations may vary by user based on customized parameters and QC Regime preferences.

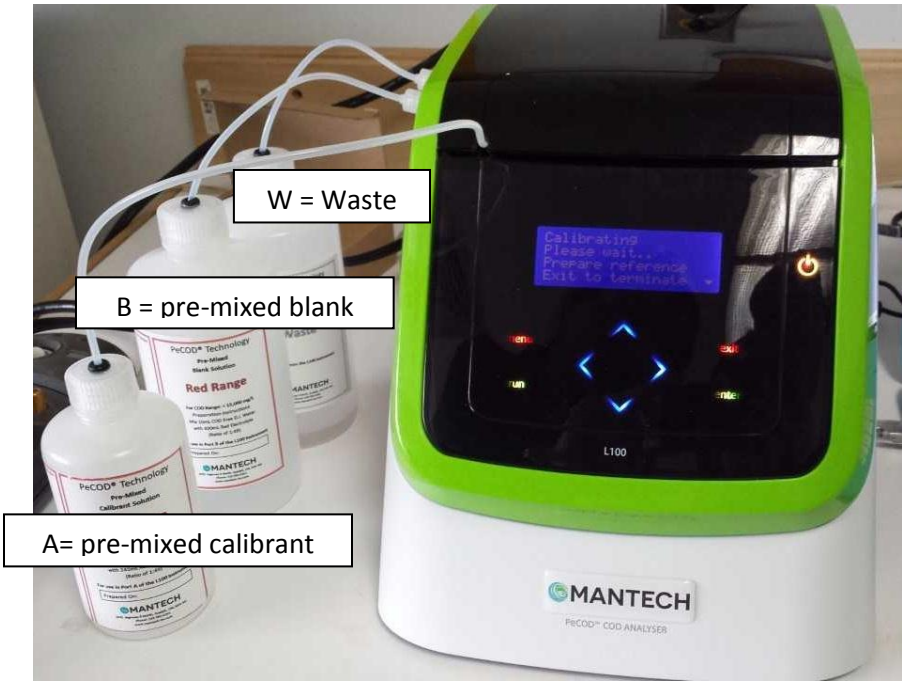
Table 1: Approximate times to complete Startup (Daily) QC Regime

COD Range	Approximate Time to Complete Startup (Daily) (mins)
ADVANCED BLUE	30
GREEN	45
YELLOW	55
RED	90

2.1 Hardware Setup

Ensure that the PeCOD matches the image below.

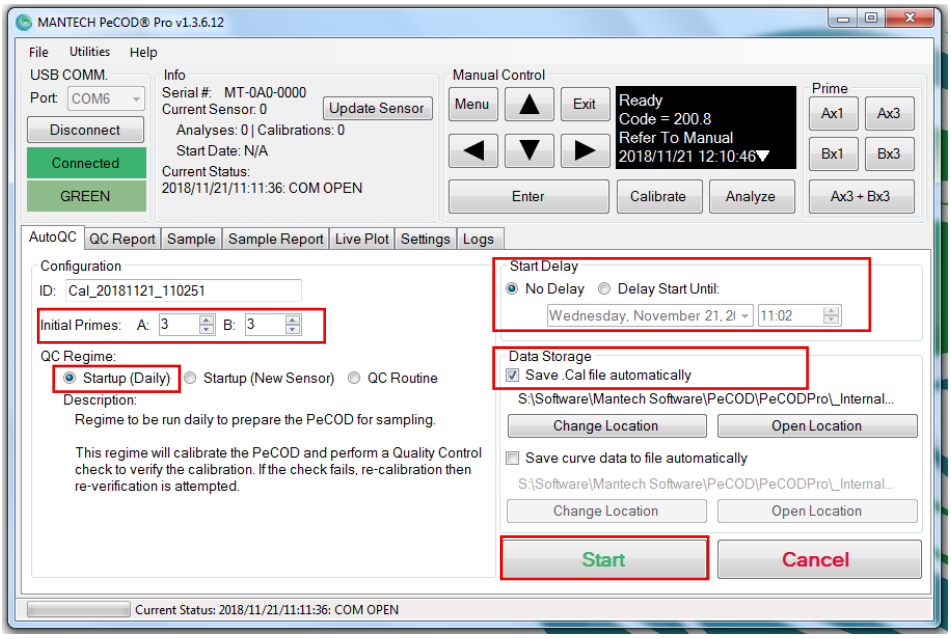
- **Port A** tubing in **pre-mixed calibrant bottle**
  - 8.0 Solution Preparation
- **Port B** tubing in **pre-mixed blank bottle**
  - 8.0 Solution Preparation
- **Port W** tubing into **waste Bottle** (ensure waste bottle is emptied).



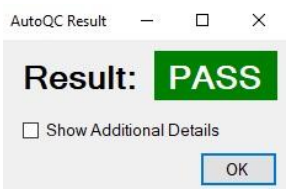
2.2 Software Setup

Ensure the PeCOD is connected to the computer and COM6 is connected in PeCOD Pro™ (See 1.1 Connecting to the PeCOD). Select the "AutoQC" tab from the main window. To run a QC Regime:

1. Set **Initial Primes** to **A: 3**, **B:3**.
2. Select the appropriate QC Regime type
   a. **Startup (Daily):** most commonly used, for daily calibrations with a previously used sensor.
   b. **Startup (New Sensor):** used when installing a new sensor. See special notes: 2.2.1 Startup (New Sensor)
   c. **QC Routine:** used after prolonged sample analysis or extended idling to determine if the daily calibration is still valid. See special notes: 2.2.2 QC Routine
3. **Start Delay**: Select either **No Delay** to begin QC Regime upon **Start**, or select **Delay Start Until** and set the date and time for the Regime to start.
4. **Data Storage**: Select **Save .Cal file automatically** and/or **Save curve data to file automatically**, to store the calibration data after completion. Note, saving the curve data can use large amounts of memory/storage on the computer. Saving the .Cal files and curve data is optional for the user, but not necessary for completing calibrations.



5. Click **Start** to begin the QC Regime, or to put the program into the mode which awaits the delayed start specified.
   a. While the QC Regime is running, the front of the PeCOD screen will blink yellow. Once the regime has finished, the front of the PeCOD screen will show a green light.
   b. Upon successful calibration, a pop-up window will display **PASS**. Select **OK** and proceed to the **QC Report** to view the calibration values, or to the **Sample** tab to begin sample analysis. If the pop-up window displays **FAIL,** the calibration isn't valid.

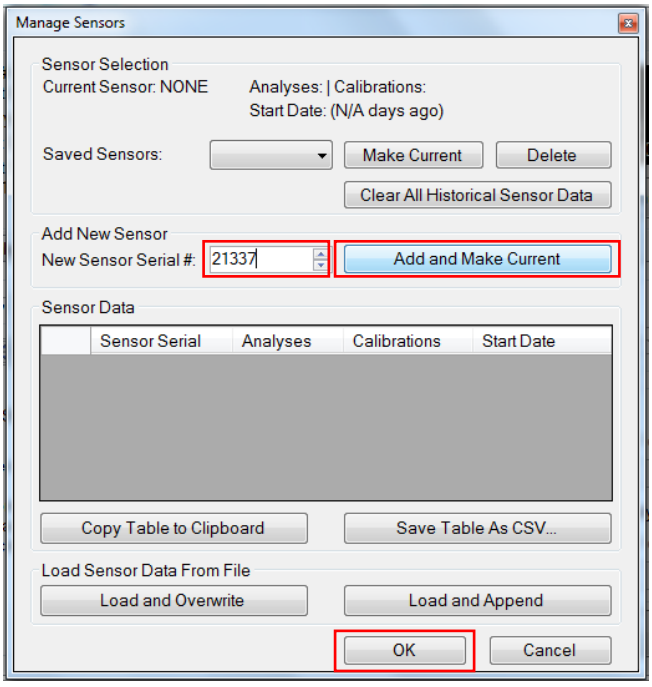


2.2.1 Startup (New Sensor)

Sensors are consumed by calibrations and analyses, as well as by contact with air and light. The user must replace the sensor once a used sensor has expired. The lifetime of a sensor varies by frequency of use and by the abrasive nature of the samples being analyzed. An approximation of sensor life is one month; however, a better indicator of an expired sensor is the calibration values. Calibration values are found in the **QC Report** tab of PeCOD Pro™. Each COD range has specific passing criteria for the calibration values. The passing criteria for each COD range is listed in Table *2*: Passing calibration criteria for each COD range.

When using "Startup (New Sensor)" as the QC Regime option:

- After clicking **Start**, a pop-up window will prompt for the sensor serial number.
- Select **OK** to add the sensor serial number located on the sensor package (this is recommended to track the lifetime of the sensor, which allows the user to determine the sensor life when used for the specific sample matrix).
- In the next window, enter the sensor serial number beside **New Sensor Serial #** and select **Add and Make Current**. Then select **OK**.

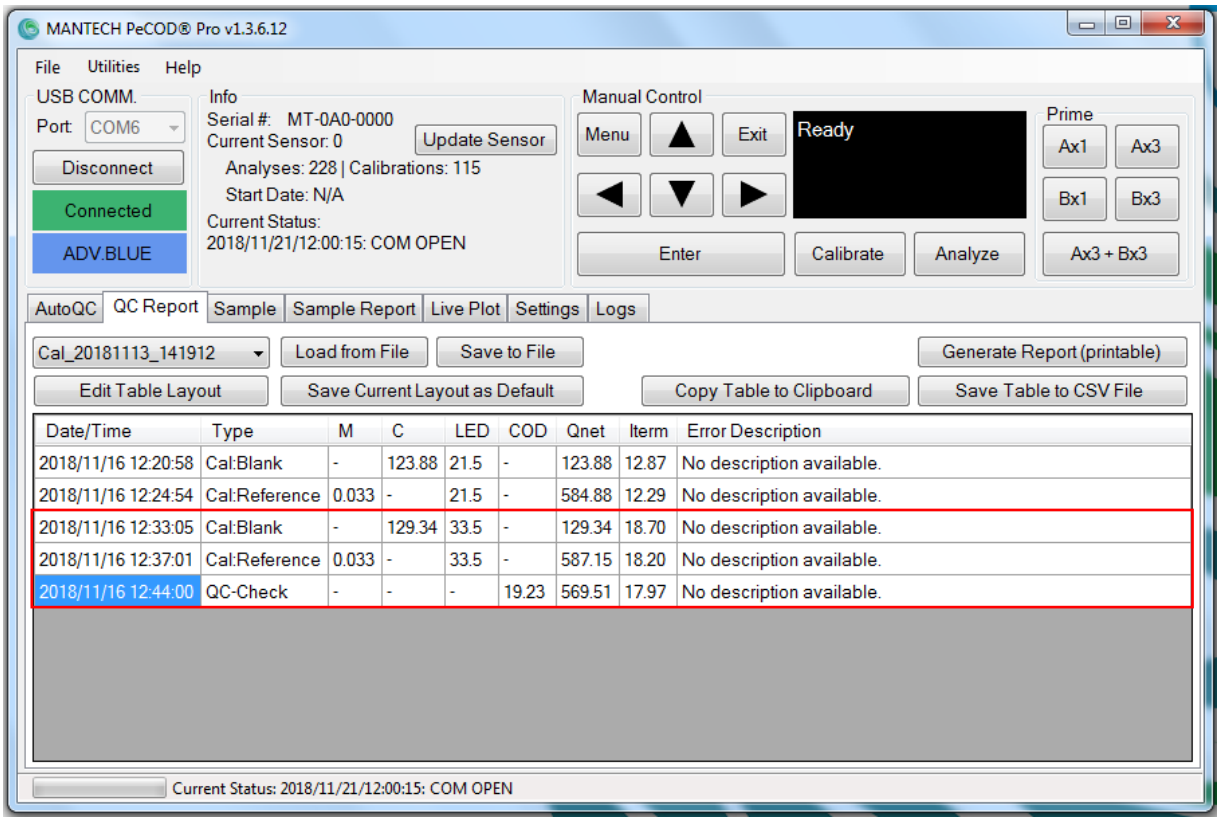


2.2.2 QC Routine

The QC Routine can be used to verify if the daily calibration is still valid. This function can be used after extensive sampling or if the PeCOD has sat idle for more than 2 hours. The QC Routine performs a QC Check using the pre-mixed calibrant solution. If the QC Check passes, then the calibration is valid and the PeCOD is ready to analyze samples. If the QC Check fails, the software will recalibrate the PeCOD and perform another QC Check following a successful calibration. Make sure port A is in Pre-Mixed Calibrant, as it is primed up to the sensor.

2.3 Calibration Results

1. Once the QC Regime is finished, click on the **QC Report** tab. The calibration results table displays the M, C, LED, Qnet, and Iterm values. The PeCOD Pro™ software evaluates the values from the last calibration, as well as the QC-Check result, to determine if the calibration is valid. The software notifies the user of a successful calibration with the **PASS** pop-up window. Passing calibration criteria are COD range-specific and are listed in *Table 2: Passing calibration criteria for each COD range.*
2. The QC Report tab allows a variety of output options:
    a. Save Table to a CSV File: Saves the table in its current arrangement to a CSV File
    b. Save to File: saves the QC Regime data to a .CAL file. This file type can be loaded back into the program on the QC Report tab and contains all the data collect (not just what is currently displayed in the table).
    c. Generate Report (printable): Will produce a printable HTML formatted report (will open in default browser) which includes the current table as well as a more organized summary of the QC Regime, passing values, etc. The report can be printed from the browser or saved to PDF.



3. To customize the information visible in the exported or printable report press **Edit Table Layout** to open the window shown below.
    a. Data driven columns can be shown/hidden by checking/unchecking the boxes.
    b. Custom (user fillable) columns can be added.
    c. Columns can be re-ordered.

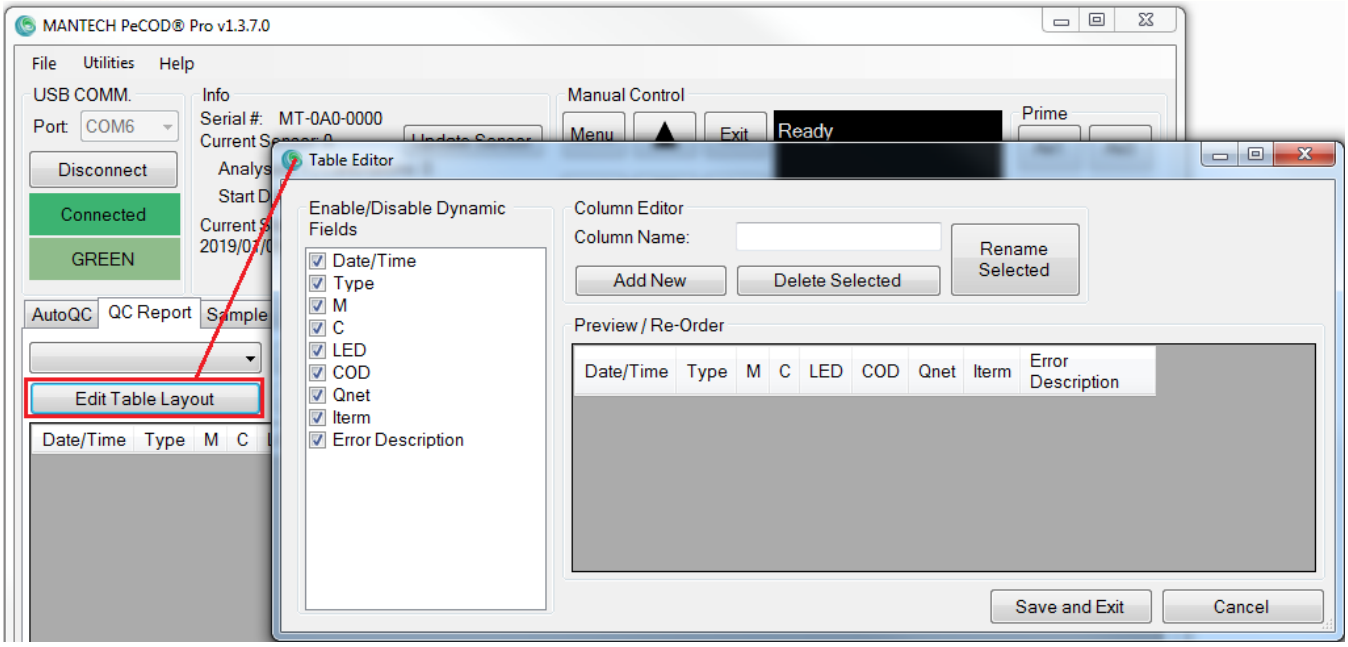


Table 2: Passing calibration criteria for each COD range

COD Range	M (COD/µC)	C (µC)	Iterm (µA)	QC-Check (mg/L)
ADVANCED BLUE	0.01 – 0.08	50 – 300	> 16	17 – 23
GREEN	0.02 – 0.06	150 – 700	> 16	115 – 125
YELLOW	0.02 – 0.06	200 – 750	> 14	1150 – 1250
RED	0.02 – 0.06	250 – 800	> 14	11500 – 12500

3.0 Samples

3.1 Sample Preparation

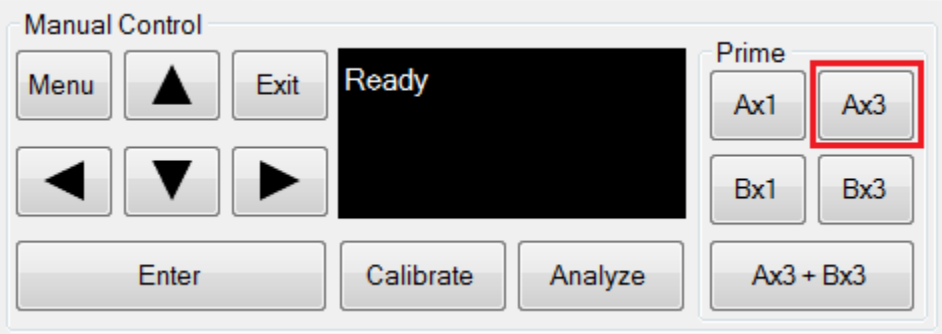
1. Ensure the sample **contains no particulates >50µm**, has a pH between 4 and 10, and the chloride concentration is within the limits outlined in 8.2 Allowable COD/Chloride Concentration Combinations for peCOD Analysis. For instructions on filtering samples, refer to: 8.3 Sample Filtering Guide for peCOD Analysis.
2. Prepare the sample according to the COD range mixing ratios listed in Table *3*: COD range mixing ratios for sample preparation. See 8.2 PeCOD Dilution Charts for Sample Preparation and/or 8.4 Using the Bottle Top Dispenser for Electrolyte Addition for Sample Preparation for additional detail.
3. Screw on a lid to the sample tube and invert several times to ensure the sample is well mixed.

Table 3: COD range mixing ratios for sample preparation

COD Range	Mixing ratio	Volume Sample (mL)	Volume Electrolyte (mL)
ADVANCED BLUE	**3:1**	**15**	**5**
GREEN	**1:1**	**10**	**10**
YELLOW	**1:9**	**2**	**18**
RED	**1:49**	**0.5**	**24.5**

3.2 Hardware Setup

1. Place Port A in a beaker of DI water.
2. Prime Port **A x 3**, to rinse the Port A tubing. This can be done using the Ax3 button in the Prime section of the Manual Control group.



3. Place the Port A tubing into the sample tube with the prepared sample. (Port B will remain in the pre-mixed blank bottle).

3.3 Software Setup

Go to the "Sample" tab of the software.

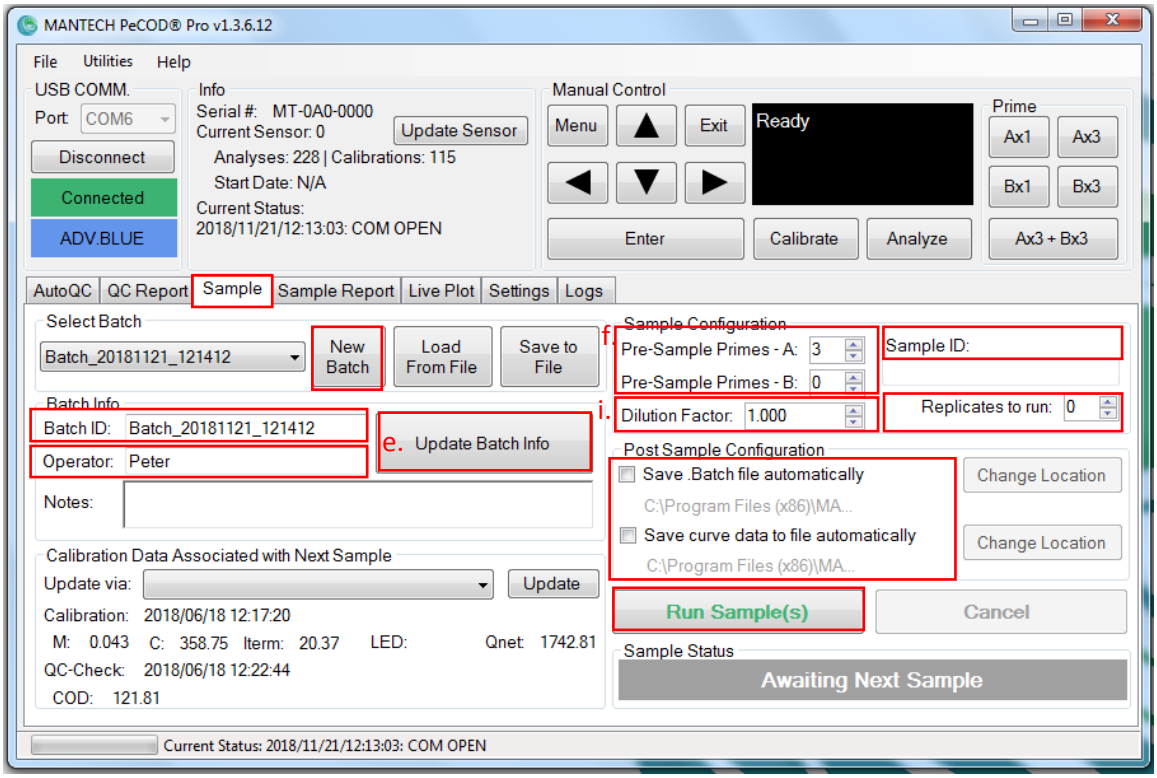
1. Match the computer screen to the image below to setup the sample analysis:
    a. Click on the **Sample** tab.
    b. Click **New Batch**.
    c. Beside **Batch ID**, type in the custom ID or leave as the default date and time.
    d. Enter the name of the **Operator** (optional), and/or **Notes** (optional).
    e. Click **Update Batch Info** to update the customized settings.
    f. **Pre-Sample Primes – A :3** and Pre-Sample Primes – **B: 0**.
    g. **Sample ID**: Enter sample name.

h. **Replicates**: Enter the number of replicates. Replicates = 1 will run the sample twice total and give an average value.

i. **Dilution Factor:** Enter the dilution factor of the sample. The dilution factor can be calculated by dividing the diluted sample volume before electrolyte is added by the pure sample volume.

j. Select the box beside **Save .Batch file automatically** and/or **Save curve data to file automatically** to store the sample data after completion. Note, saving the curve data uses large amounts of memory on the computer. Saving the .batch files and curve data is optional for the user, but not necessary for completing samples.

k. Click **Run Sample(s)** to start the sampling operation.



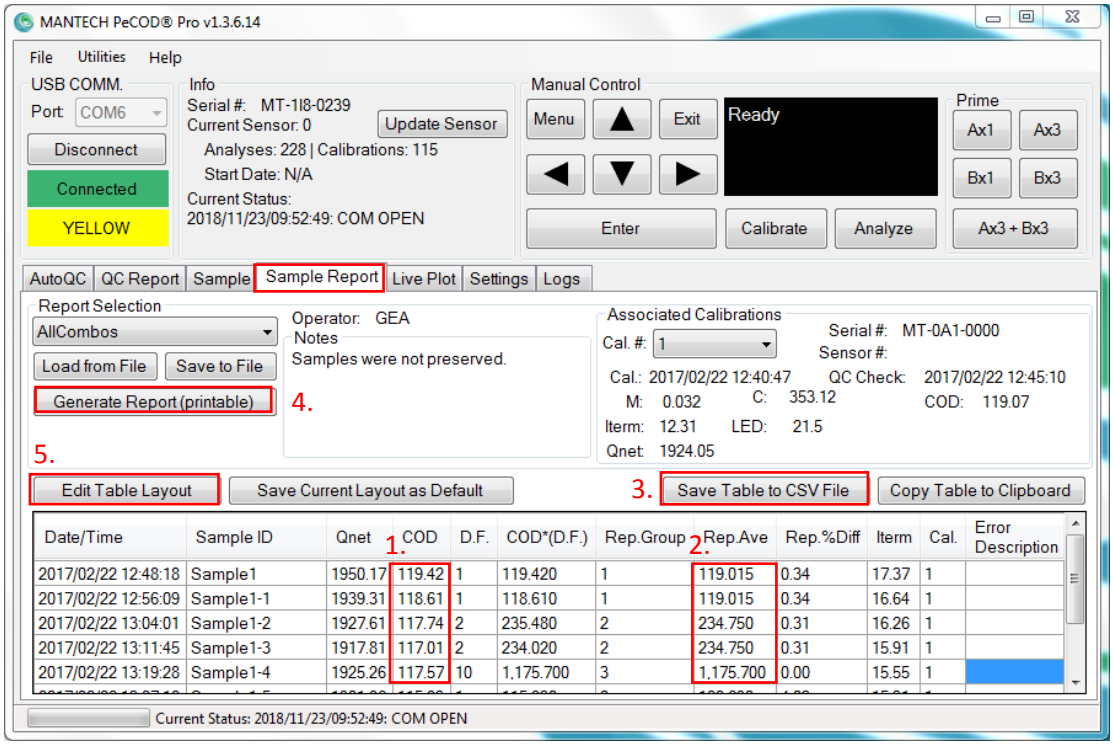
2. The PeCOD will begin by priming Port A with sample 3x and then begin COD analysis. A yellow status light will flash on the PeCOD while it's analyzing. After finishing the first sample, it will immediately begin the replicate, if applicable. Once completed, the PeCOD status light will remain green.

3.4 Sample Results

To view the sample results, select the **Sample Report** tab.

1. Look in the table to find the sample COD values. "COD" indicates the reading from the instrument and "COD(d)" indicates the reading, adjusted by the dilution factor ("D.F.").
   a. The dilution factor (**D.F.**) and the Replicate group (**Rep. Group**) can be edited after the samples have been run. Changing **D.F.** will change the factor that the measured **COD** value is multiplied by to calculate the diluted **COD*(D.F.)** The **Rep.Ave** and **Rep.%Diff** are calculated for each sample with the same **Rep.Group**; samples run as replicates are in the same **Rep.Group** by default. Results can be excluded from an average or percent difference calculation by assigning a new **Rep.Group** value to the results which should be included in the new calculation.

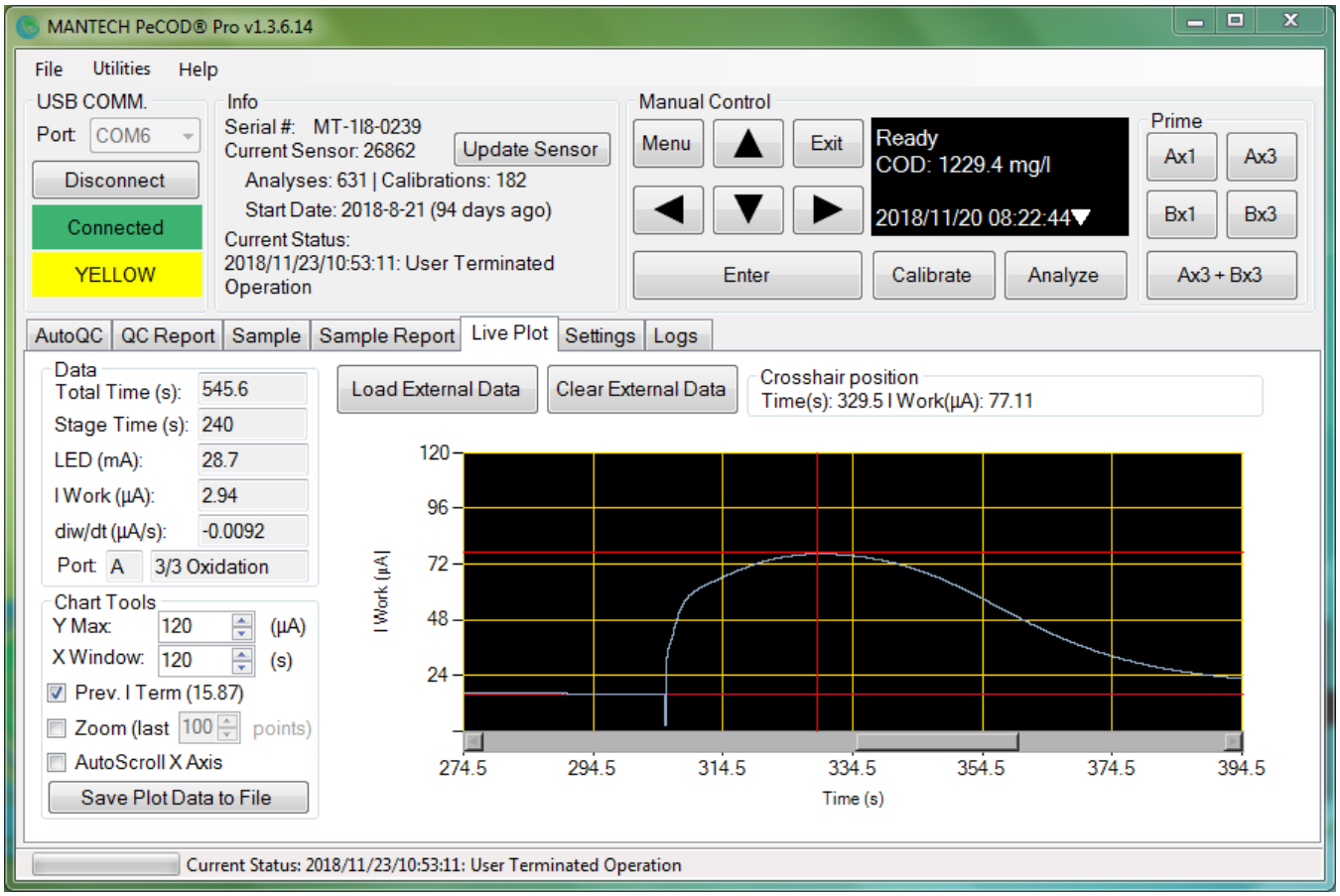
2. The average of the replicate samples is displayed under the **Rep. Ave**. column. The percent difference between the sample and the average is displayed under the **Rep %Diff** column.
3. To save the data to a CSV file, click **Save to CSV File**.
4. To generate a printable report, click **Generate Report (printable)**. The report will open in a browser as a HTML file.
5. To create a custom report, press the **Edit Table Layout.** Select the categories to display on the report.



4.0 Live Plot

The oxidation curves during a calibration or sample analysis can be viewed in the **Live Plot** tab.

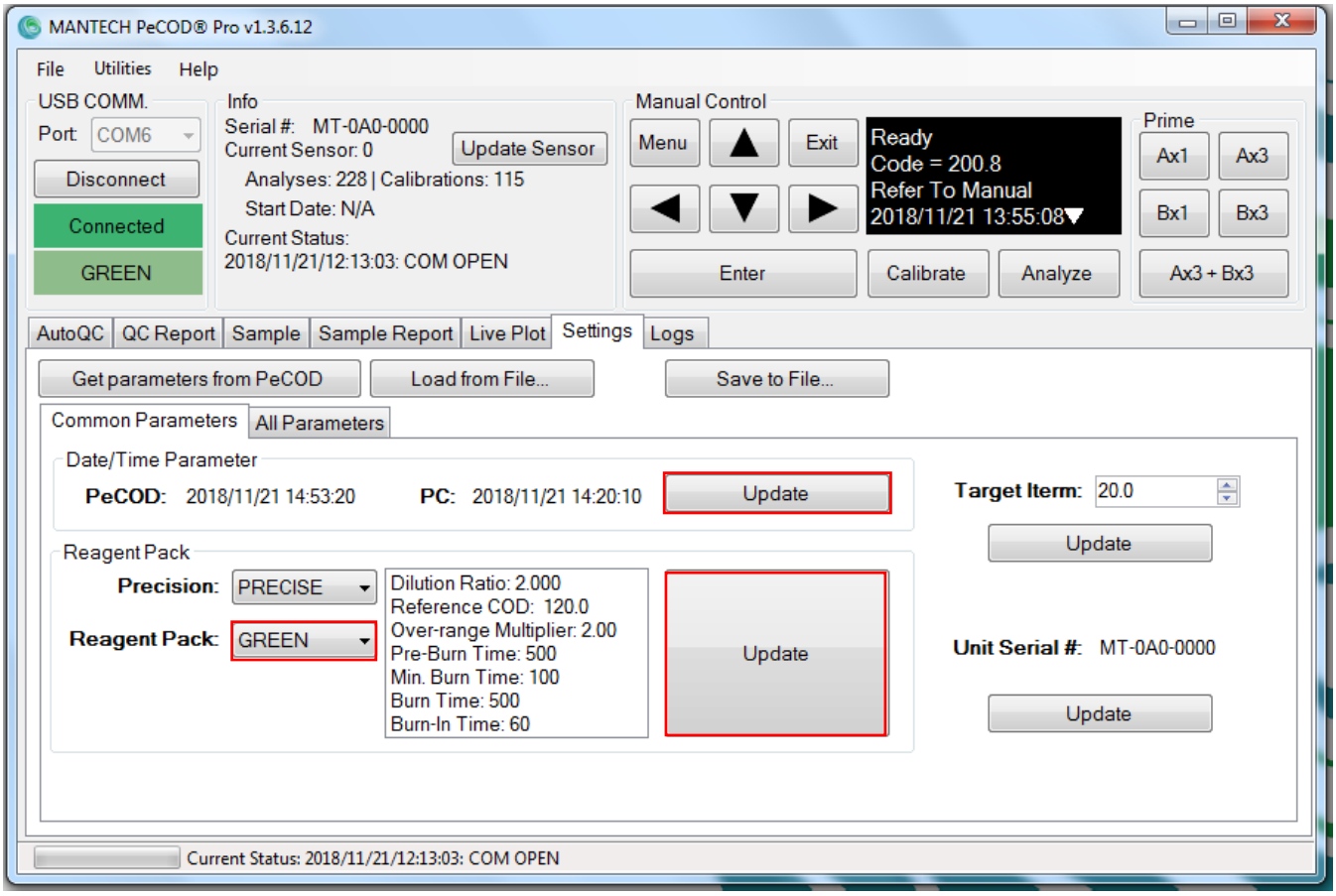
- Crosshair: The crosshair position can be placed to investigate the I Work at a specific time.
  - Click on the plot once to make the crosshair follow the mouse.
  - Click again to leave the crosshair in that position.
- Saving Data: The current plot can be saved to a CSV file by clicking the “Save Plot Data to File”
- Loading External Data: Previously saved CSV data of a plot can be loaded (for quick comparison/inspection) by clicking the “Load External Data” button.



5.0 Settings

The Settings tab can be used to update the PeCOD date and time, change the working COD range, and adjust PeCOD parameters.

1. To update the PeCOD date and time to the PC time, select **Update** under the Date/Time Parameter header.
2. To change the COD working range, click on the drop-down menu beside **Reagent Pack**, and select the desired COD range. Then click **Update**.
3. To reset the PeCOD parameters, refer to 7.4.2 Uploading PeCOD Parameters in PeCOD Pro™.

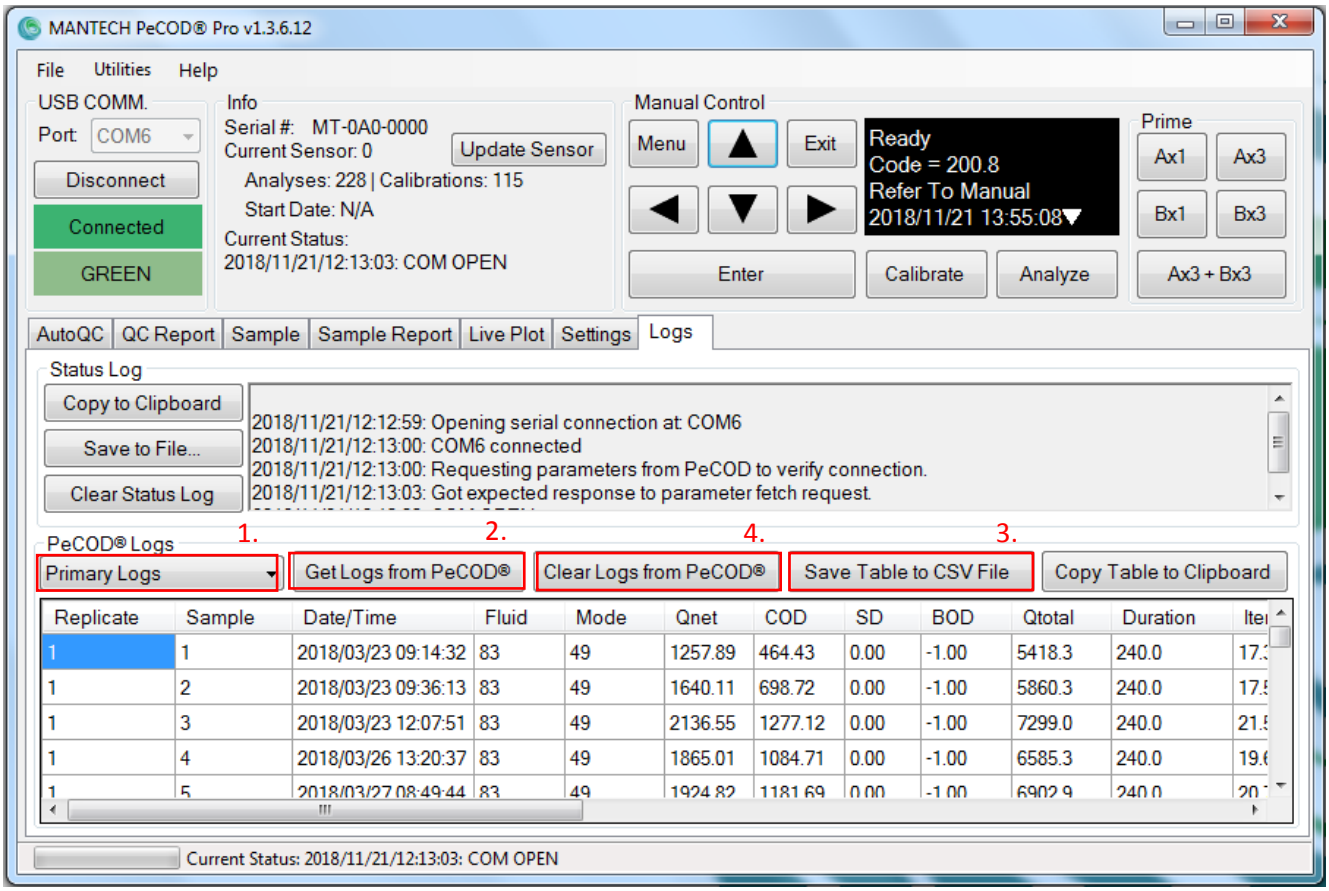


6.0 Logs

The **Logs** tab can be used to load, save, and erase data from the PeCOD. Calibration, sample, and error code data is stored in the peCOD and must be erased regularly to prevent the internal storage space from filling up. It is recommended to erase peCOD data each time the sensor is changed.

To load data from the PeCOD:

1. Go to the drop-down window below **PeCOD Logs** and select **Primary Logs**. Primary Logs refers to all sample analysis and QC Check data.
2. Click on **Get Logs from PeCOD**. A table of data should populate at the bottom of the window.
3. To save the Primary Logs from the peCOD, click on **Save Table to CSV File**, and save the files to the desired location.



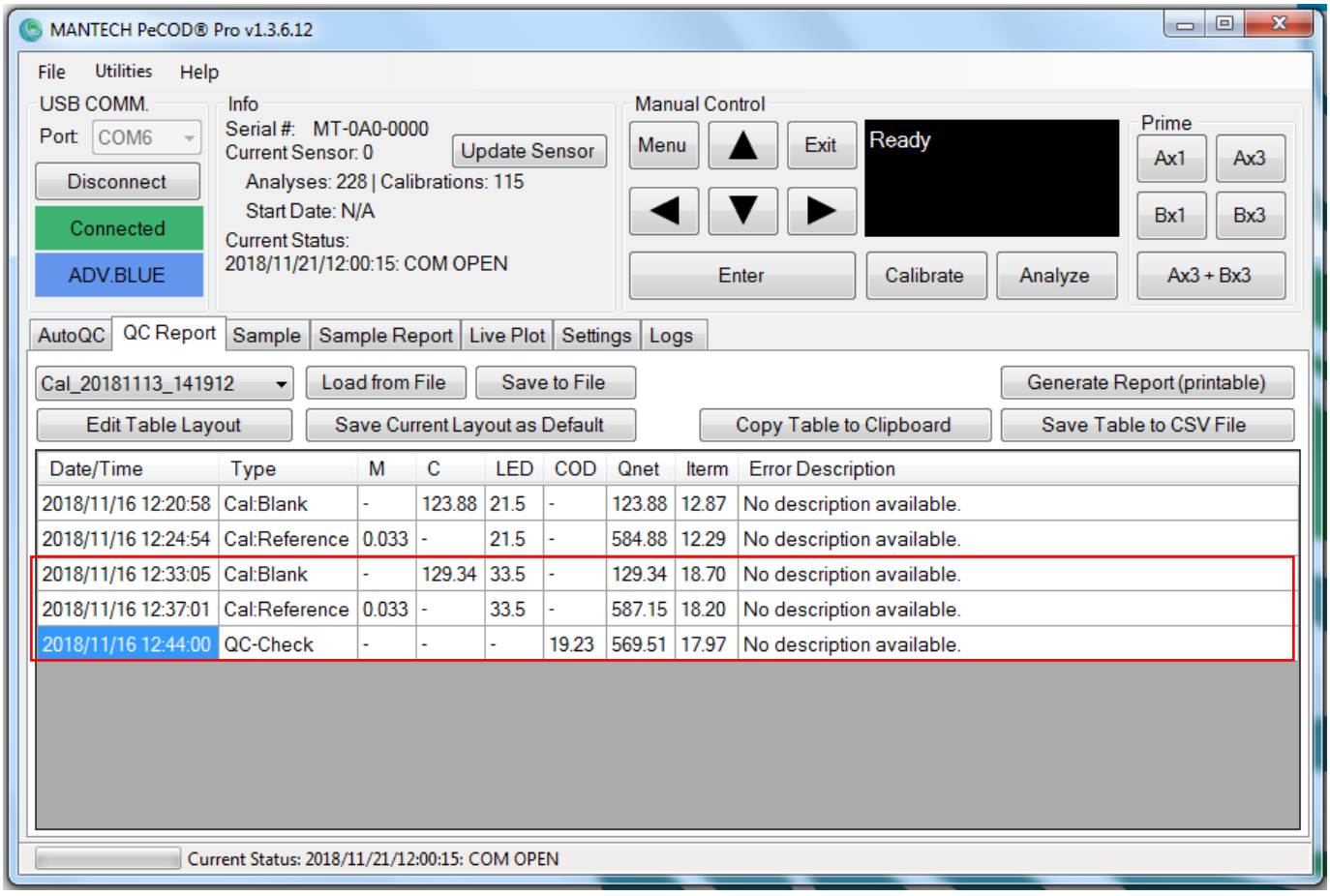
4. To erase the Primary Logs from the peCOD memory storage, click on **Clear Logs from PeCOD**.
5. Repeat Steps 1 to 4 with each of the peCOD Logs: **Secondary Logs**, **Calibration Logs**, and **Event Logs**. Note, loading the Secondary Logs may take a few minutes as it contains more data.
6. **IMPORTANT STEP**: After erasing the peCOD Logs, power the peCOD off and on again, using the power button on the peCOD screen.
7. Reconnect to PeCOD Pro™ and proceed with calibrations or analyses. Note, erasing the calibration logs may require the peCOD to be recalibrated prior to sample analysis.

7.0 Troubleshooting

7.1 Failed Calibration

If the pop-up window displays FAIL after performing a QC Regime, click **OK**, to close the window, and follow the steps below:

1. Navigate to the **QC Report** tab.
2. Examine the calibration values on the latest calibration and QC Check and verify if they're within the COD range-specific passing criteria listed in Table *2*: Passing calibration criteria for each COD range**.** If the M and/or C values are outside the passing criteria and the sensor has been used for approximately one month, or greater than 150 samples, the sensor may be expired. Install a new sensor and perform the 2.2.1 Startup (New Sensor).
3. If the values are within the range specified in Table *2*: Passing calibration criteria for each COD range, proceed to 7.6 Restoring the QC Regime Criteria to Default and then reattempt the Startup (Daily), following the steps from 2.2 Software Setup**.**
4. If the M and C values are outside the passing criteria, but the sensor is less than one month old and has analyzed less than 150 samples, remake the pre-mixed blank and pre-mixed calibrant solutions. Improper mixing and contamination of peCOD reagents can lead to failed calibrations and QC Checks.
5. Ensure that the reagent bottles have enough solution for the tubing to be submerged, and that no air is within the tubing.
6. Ensure there is no clogging or partial clogging within the PeCOD. Verify that each prime of Port A or Port B is between 1.8 and 2.5 mL. If the prime volume is less than 1.8mL or air remains within the tubing after priming each port 3 times, proceed to 7.3 Removing Blockages within the PeCOD® COD Analyzer.



7.2 PeCOD Error During Calibration or Sample Analysis

System errors are reported and stored in the event log. The following table lists the error codes and description of possible causes, as well as suggested actions to rectify the error. Error codes are reported as: (Error Group).(Sub Code) eg. “2.1".

Error Group	Sub Code	Name	Description of Problem	Suggested actions
2	1	Terminated by User	The exit button on the PeCOD display was selected	• Error indicating the user has terminated the current analysis. • If the error is generated when using MANTECH software, the time delay set for sample analysis is too short which is causing the analysis to be interrupted. Contact MANTECH or your local MANTECH distributor for assistance in increasing the time delay.
2	2	Sensor Uncalibrated	Error indicating the sensor is not calibrated	• Run new sensor routine or run calibration.
3	1	COD out of Range	Sample concentration is too high.	• Dilute original sample with COD free water and re-mix with electrolyte (remember to multiply this dilution factor to obtain the final COD value). • Alternatively, switch to using a different range electrolyte and re-prepare your sample. Note: you will need to recalibrate in the new range.
3	2	Reference < Blank	Reference (calibrant) solution charge obtained is less than zero solution.	• Check that calibrant solution is correctly mixed with electrolyte and re-calibrate.
3	3	COD Less Than Blank	COD result is less than the blank solution.	• Check that sample is mixed with electrolyte in proper ratio and that lines are primed. • Check blank solution for contamination. • Sample may be below the operating range. Switch to a lower range (e.g. blue), re-calibrate and then re-run sample
3	4	Failure Qnet < Zero	Resultant charge is too low (i.e. not enough signal detected)	• Ensure that sample is mixed with electrolyte in proper ratio and lines are primed. • Check electrical contacts between the connection pins on analyser board with the electrode block. Very gently clean using isopropanol and a lint free cloth. • If the above do not rectify the problem, the sensor or electrode block may need to be replaced.
7	1	Pump failure	Pump error	• Prime lines, and check sufficient solution is being expelled from the analyser. If this does not rectify the problem, please contact MANTECH or your local MANTECH authorised representative.

Error Group	Sub Code	Name	Description of Problem	Suggested actions
7	2	Pump did not initialize	Pump error	• Prime lines, and check sufficient solution is being expelled from the analyser. If this does not rectify the problem, please contact MANTECH or your local MANTECH authorised representative.
8	4	Sol'n not Presented	User did not press enter upon system prompt.	• Restart calibration and ensure to press enter within 6 minutes after prompt to avoid timeout.
11	2	Analyser Lid Open	Lid is open or not securely latched.	• Make sure analyser lid is closed and correctly secured via the front latch.
11	4	V_{aux} out of range	Auxiliary voltage is over range	• Make sure there are no bubbles present in the line; prime lines, and then re-run analysis. • Check electrical contacts between the connection pins on analyser board with the electrode block. Very gently clean using isopropanol and a lint free cloth. • Upload the peCOD parameters to ensure default parameter values are set; update the peCOD to the working COD range after loading default parameters. • If the above do not rectify the problem, replace the sensor and reattempt calibration.
11	6	I_{work} out of range	Current is over-range	• Make sure there are no bubbles present in the line; prime lines, and then re-run analysis. • Check electrical contacts between the connection pins on analyser board with the electrode block. Very gently clean using isopropanol and a lint free cloth. • Upload the peCOD parameters to ensure default parameter values are set; update the peCOD to the working COD range after loading default parameters. • If the above do not rectify the problem, replace the sensor and reattempt calibration.
11	9	LED Over Current	Occurs during normalization step of calibration. Too much current was applied to LED to obtain desired baseline.	• Make sure there are no bubbles present in the line; prime lines, and then re-run analysis. • Ensure that the solutions are mixed with electrolyte in appropriate ratios and the PeCOD is set to the correct operating range. • Check electrical contacts between the connection pins on analyser board with the electrode block. Very gently clean using isopropanol and a lint free cloth.

Error Group	Sub Code	Name	Description of Problem	Suggested actions
11	10	FIFO Overrun	Too much processor activity	• Erase logs, power cycle the PeCOD, and re-run sample. • If the calibration logs are erased, the PeCOD will require re-calibration; to avoid re-calibrating, erase only the Primary and Secondary Logs. • If error occurs on a calibration, erase all logs.
11	14	COD Out of Range	The COD concentration is too high to report in the working COD range.	• Dilute original sample with COD free water and re-mix with electrolyte (remember to multiply this dilution factor to the final COD value). • Alternatively, switch to using a higher range electrolyte and re-prepare the sample. Note: the peCOD will require recalibration in the new COD range
11	15	Incomplete oxidation	The sample concentration may be too high (sample oxidation did not complete)	• Dilute original sample with COD free water and re-mix with electrolyte (remember to multiply this dilution factor to the final COD value). • Alternatively, switch to using a higher range electrolyte and re-prepare the sample. Note: the peCOD will require recalibration in the new COD range
14	1	Burn-in Failed	System failed to stabilize.	• Try to re-calibrate or re-run sample. • If the problem persists, a new sensor may be required.

Additional Error Codes may appear when an internal communication error occurs. These errors will typically prompt the user to "Refer to Manual". Most often the error can be cleared by attempting to re-run the sample. Erasing all logs may also be necessary. Internal communication error codes may include (but are not limited to) codes:

0.1, 2.27, 8.2, 8.3, 9.1, 9.2, 10.1, 10.2, 11.1, 13.1, 13.2, 102.2, 203.1, 203.2, 204.1, 205.1, 205.2, 205.3, 205.4, 211.7, 215.1

7.3 Removing Blockages within the PeCOD® COD Analyzer

Samples with suspended solids can sometimes cause blockages in the PeCOD® COD Analyzer. The peCOD method only oxidizes dissolved organics; therefore, it is suggested to filter samples before analysis.

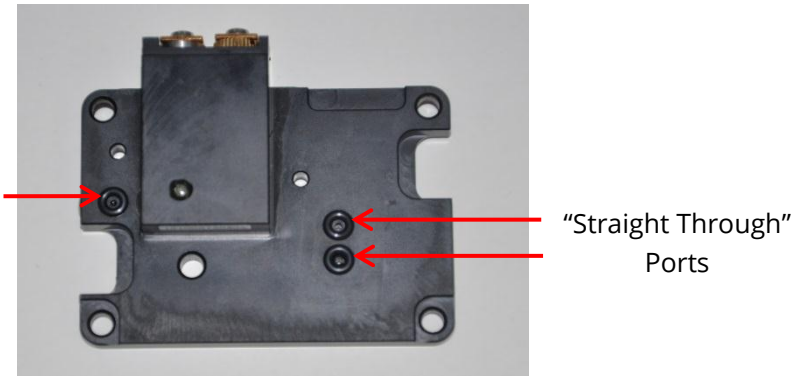
If there is no solution flowing from the waste port when priming Port A, there is likely an internal blockage within the fluidics path. Follow the instructions below to back flush the lines and clear the electrode block.

NOTE: If priming Port B does also not result in solution flowing from the waste port and/or you cannot hear the pump turning on, the blockage may be deeper into the fluidics which may require service from a MANTECH representative.

General Checks

1. Open the PeCOD lid and remove the sensor.
2. Look at the back of the sensor – all 3 holes should be completely clear and not partially obscured by the white rubber seals. (Example of a good sensor shown below).

3. Ensure that the electrode block is sitting flat in the analyzer block. If not, remove the 4 thumbscrews and make sure the 3 o-rings are seated at each port. When installing the electrode block back into the analyzer, ensure that each screw is tightened evenly.

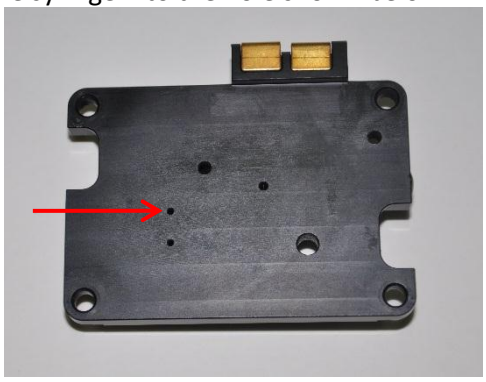


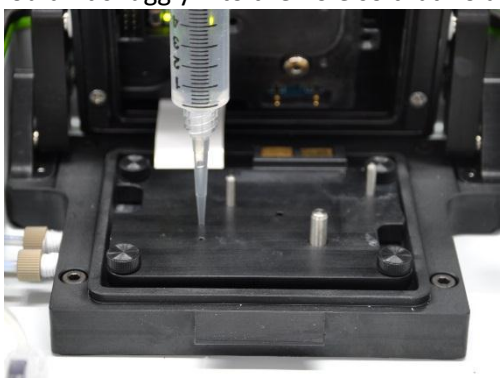
Back-flushing Port A

You will require a syringe fitted with a modified 200uL pipette tip to perform this operation. These have been provided with the PeCOD system, part number PQA-85014.

1. Fill the syringe with DI water, and attach the narrowest pipette tip.
2. Open the PeCOD lid and remove the sensor. Place Port A tubing into a waste container as shown below.

3. Insert the syringe into the hole shown below. The tip should fit snuggly into the hole so that no air gets in.





4. Go into MENU/OPERATION/PRIME LINES/PRIME PORT A. Press ENTER, and at the same time gently push on the plunger of the syringe. You must prime Port A to open the valves of the internal fluidics path. Observe the flow of water out of the Port A tube. Stop pushing the plunger when you hear the pump stop.
5. Repeat step 4 a few times to ensure the flow out of Port A is strong.
6. If there is no solution coming out the waste port while priming Port B, the same process can be repeated by selecting prime Port B instead of Port A. Use the same hole for the syringe tip, as shown in the picture above.

NOTE: This operation back-flushes fluid lines between the sensor inlet and Port A, which is the most likely place for particles to be lodged. This back-flushing procedure usually clears any blockages. A flow of water out of Port A during this operation indicates this part of the fluid path is clear. Verify this by placing the Port A line into a beaker of water and attempting to prime as usual. If this does not clear the blockage, continue to the next section.

Flushing the Electrode Block

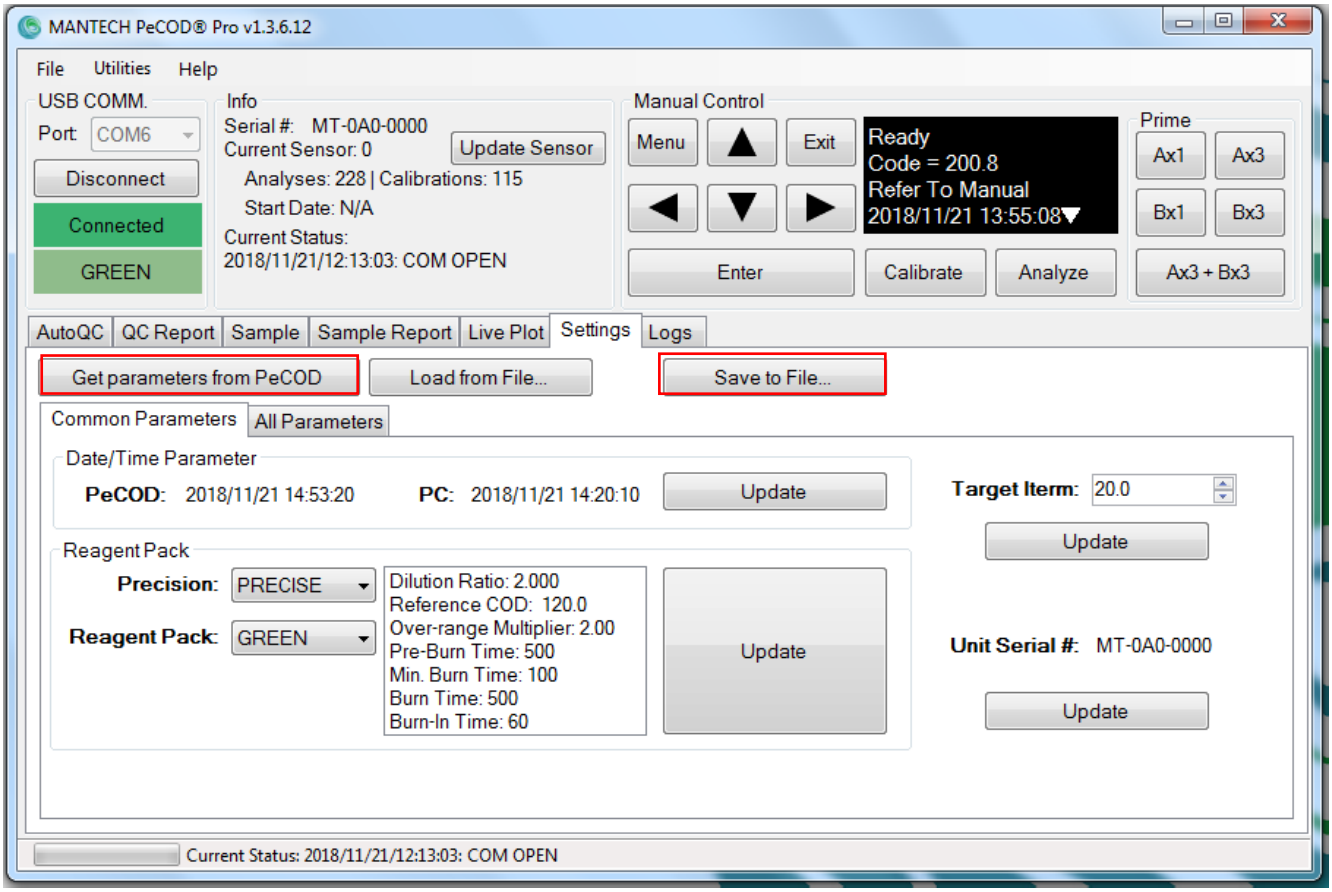
1. With a lint-free tissue wipe the top of the block to remove any liquid. If there are white salt deposits on the electrode block, gently wipe them off with lint-free tissue that has been dampened with DI water.
2. Remove the electrode block by unscrewing the 4 thumbscrews.
3. Observe the 3 fluid ports on the underside of the electrode block.
4. Fill a syringe with DI water and attach the larger pipette tip. Insert the tip into each hole to flush out the port.
5. Ensure there is a strong flow in both directions. Note that two of the ports are “straight through” and one is an “Internal Channel”.

If these procedures do not result in a steady flow of solution from the waste port during priming operations, please contact a MANTECH representative for assistance.

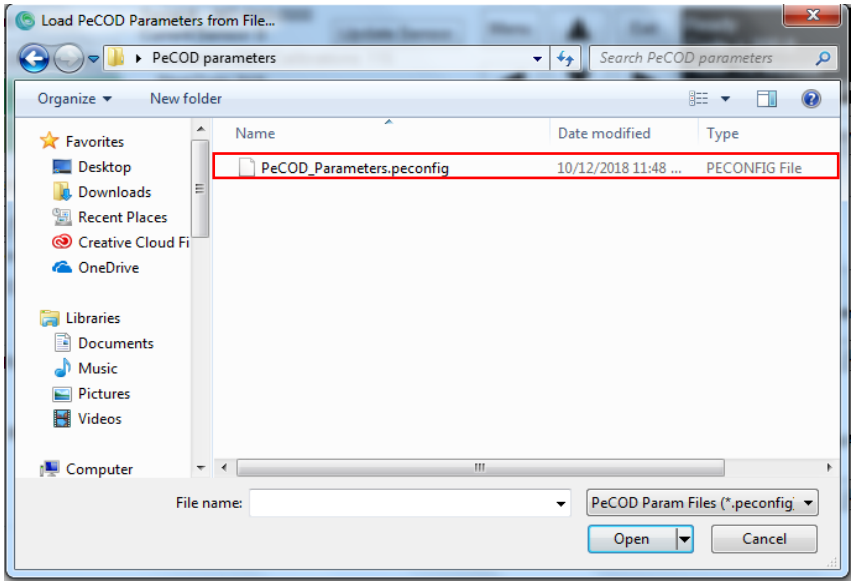
7.4 Resetting PeCOD Parameters to Default

7.4.1 Downloading peCOD Parameters in PeCOD Pro™

1. After connecting to the PeCOD, navigate to the **Settings** tab. Next, select **Get parameters from PeCOD** then select **Save to File.**

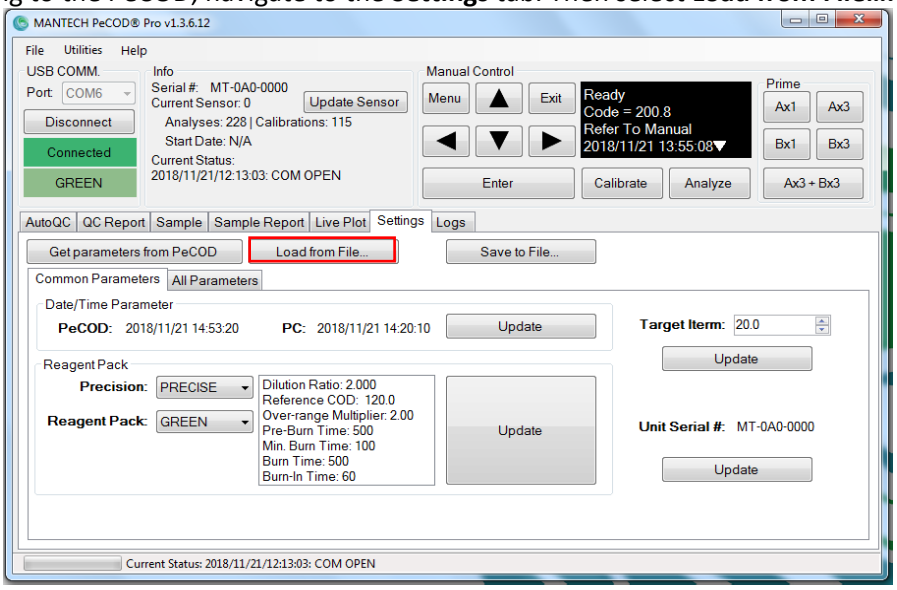


2. Give the file a unique name containing “Parameters” and save.
3. The PeCOD can now be used. Send the files to a MANTECH support member to facilitate troubleshooting, if required.



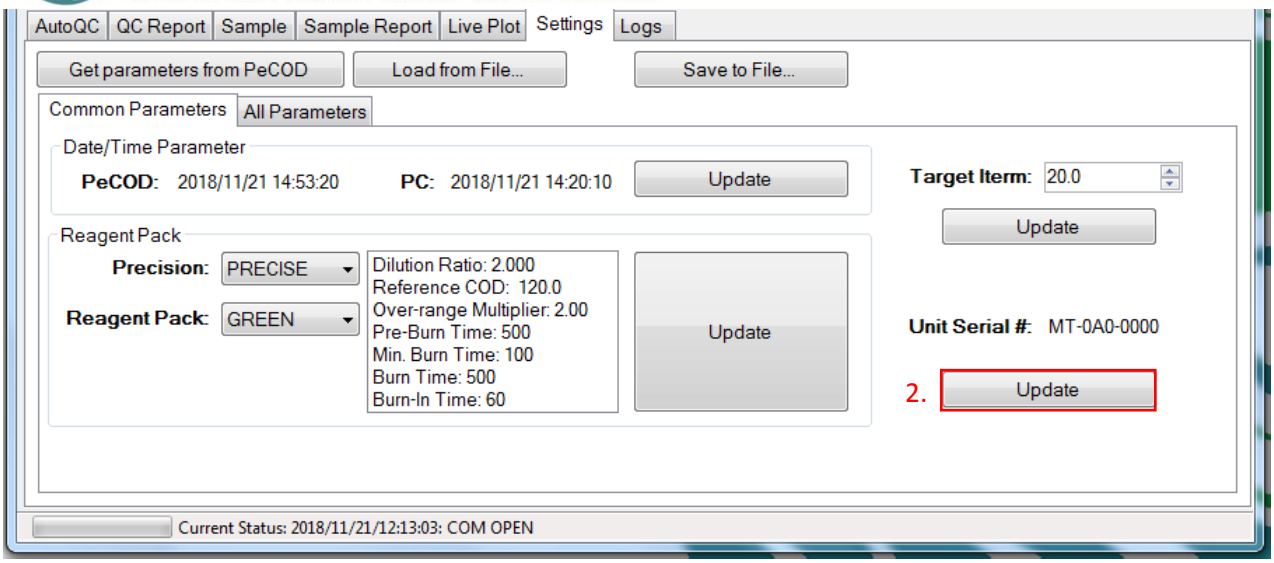
7.4.2 Uploading PeCOD Parameters in PeCOD Pro™

After connecting to the PeCOD, navigate to the **Settings** tab. Then select **Load from File….**

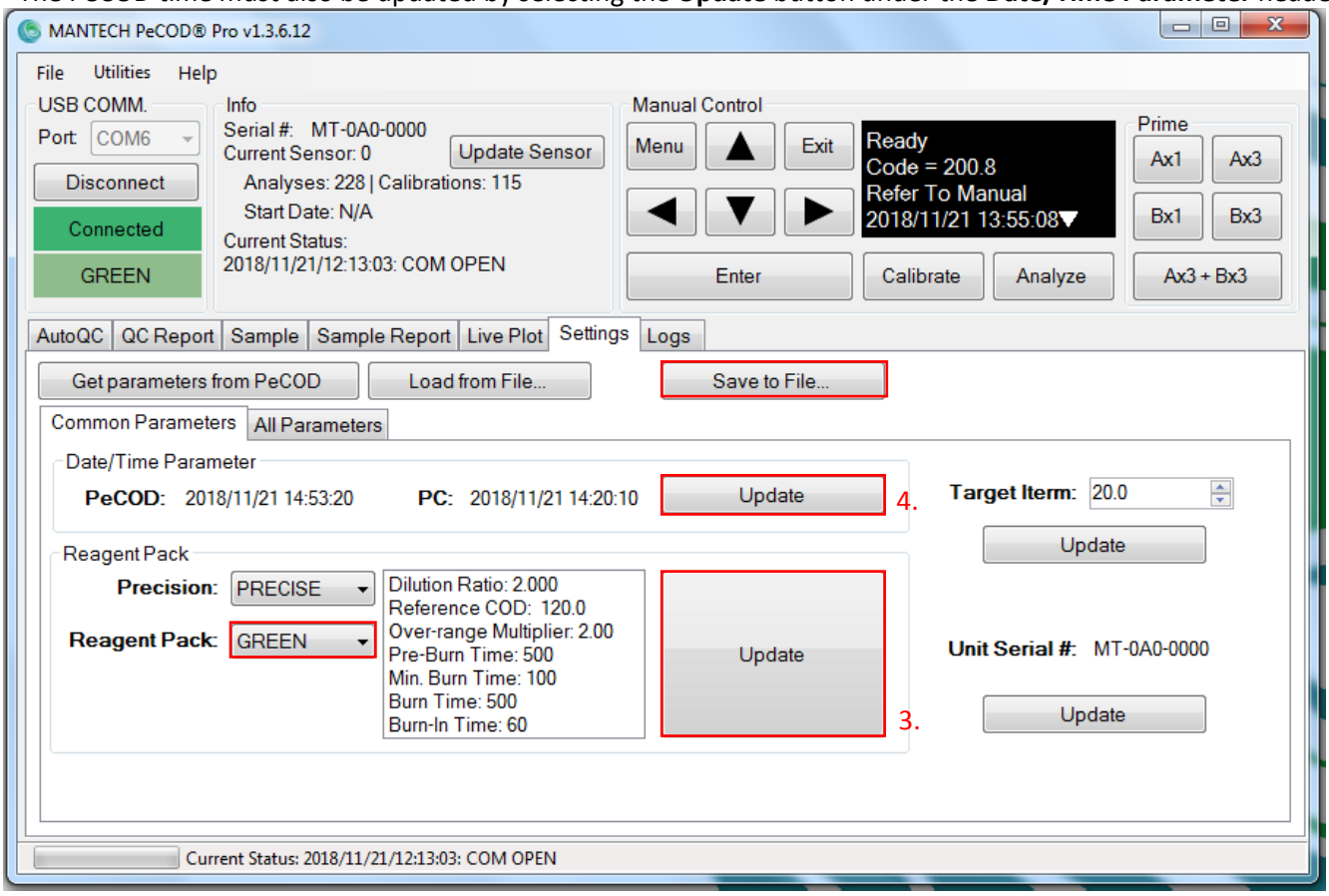


1. Select the **PeCOD_Parameters.peconfig** (or similar name) file supplied on the MANTECH USB or from a MANTECH support team member, and then **Open**.

2. The parameters in this file will be uploaded to the PeCOD. This may take several seconds. Once complete, the Serial number may need to be corrected. Press the **Update** button under the **Unit Serial #** header, and enter the number as shown on the back of the PeCOD, if applicable.



3. If required, select the appropriate Reagent Pack for the range of your samples (Advanced Blue, Green, Yellow or Red), followed by **Update.** To save these settings, select **Save to File…**.
4. The PeCOD time must also be updated by selecting the **Update** button under the **Date/Time Parameter** header.



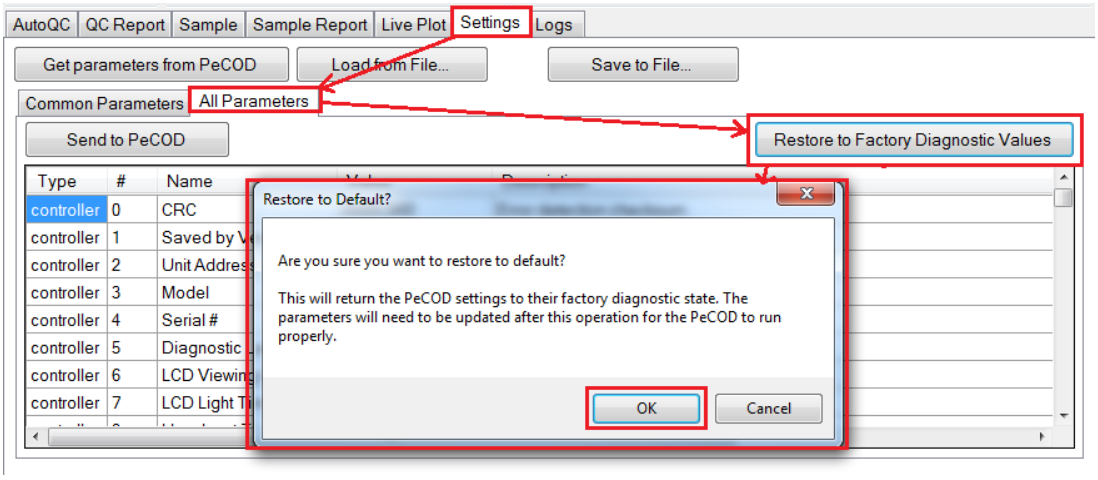
5. The PeCOD can now be used for normal operation.

7.4.3 Restore to Factory Diagnostic Values in PeCOD Pro™

Warning!: Parameters must be reset after this procedure. Refer to 7.4.2 Uploading PeCOD Parameters in PeCOD Pro™**,** prior to using the PeCOD after restoring Factory Diagnostic settings.

PeCOD Pro™ has a built-in function to return the factory diagnostic settings. This clears a variety of internal settings, but also resets the parameters to their factory settings. This is a useful function to recover from certain error states but the parameters which are populated, will not be the current recommended parameters. As such, after using the factory diagnostic reset, the parameters should be updated to the most recent "good set".

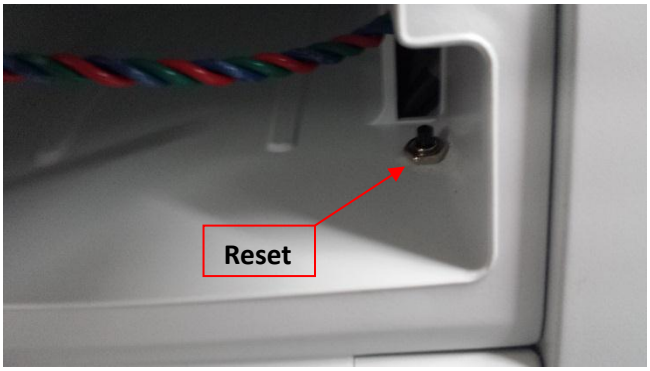
1. Select the **Settings** tab, and then the **All Parameters** sub-tab.
2. Click "Restore to Factory Diagnostic Values" button. A message will appear to confirm the action. Press OK and the action will occur.
3. Follow the instructions from 7.4.2 Uploading PeCOD Parameters in PeCOD Pro™ to upload a "good" set of parameters.



7.5 Applying a Hard Reset

After applying a hard reset to the PeCOD, the PeCOD parameters must be reset! Refer to 7.4.2 Uploading PeCOD Parameters in PeCOD Pro™**,** prior to using the PeCOD after a hard reset.

1. Disconnect the USB cord between the PeCOD and computer.
2. Rotate the PeCOD so that the back is facing forward.
3. Lift the top flap on the back of the PeCOD. In the compartment below the flap is a connection for the optional battery and reset button.

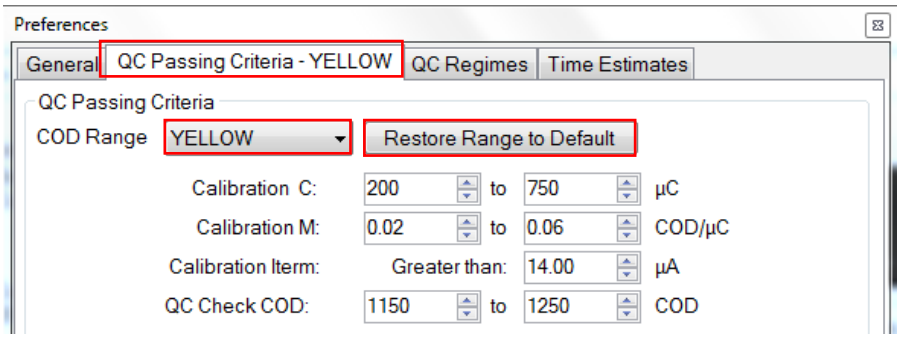


4. With the PeCOD plugged into power, hold down the reset button for 1 second.
5. Upon releasing the reset button, a beep should sound and the PeCOD will power on.
6. Proceed with 7.4.2 Uploading PeCOD Parameters in PeCOD Pro™**.**

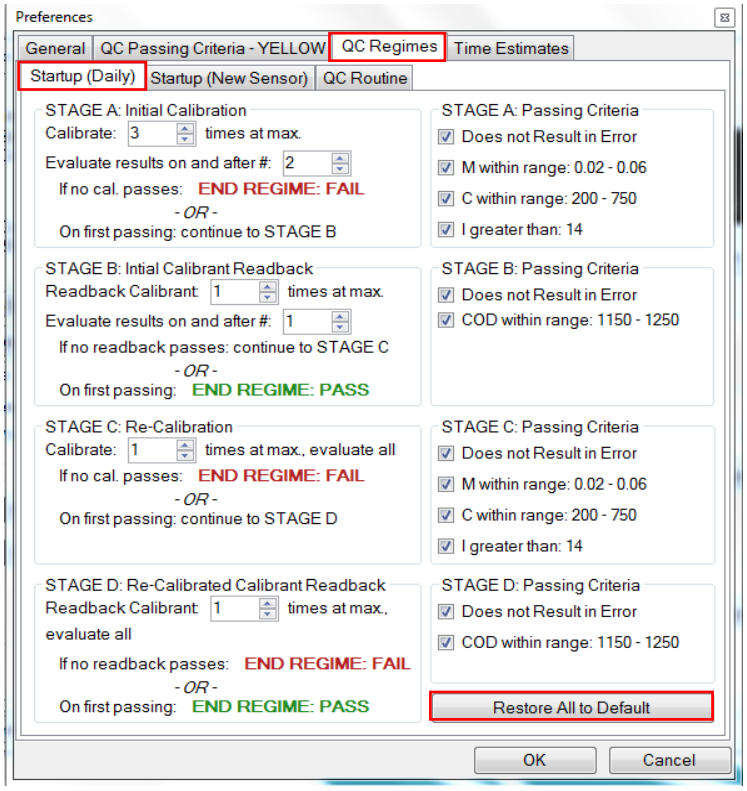
7.6 Restoring the QC Regime Criteria to Default

The QC Regime passing criteria, as well as behaviour (number of repetitions/reattempts, etc) can be customized by the user. To restore these behaviours to the default value:

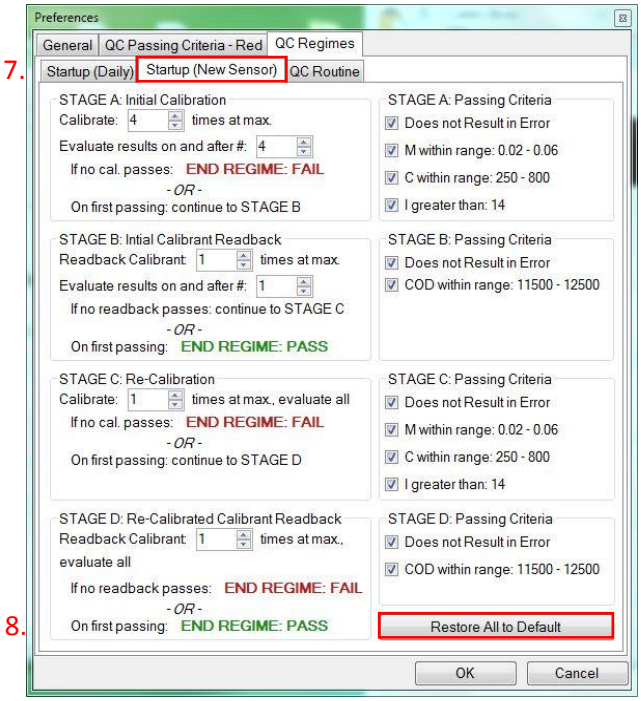
1. Select **File** and **Preferences** from the top left corner of the PeCOD Pro™ window.
2. Select **QC Passing Criteria**.
3. Ensure the correct **COD Range** is selected, and then click **Restore Range to Default**.



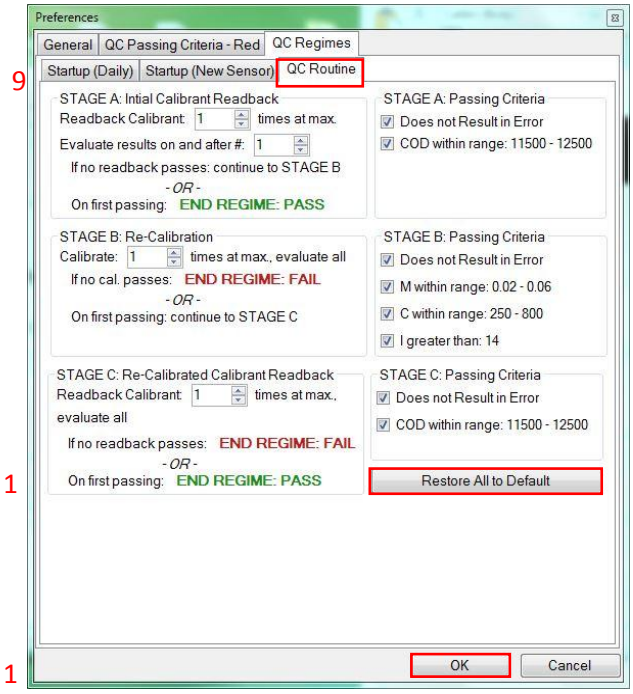
4. Select **QC Regimes**.
5. Select the **Startup (Daily)** tab.
6. Select **Restore All to Default**.



7. Select the **Startup (New Sensor)** tab.



8. Select **Restore All to Default**.
9. Select the **QC Routine** tab.
10. Select **Restore All to Default**.
11. Select **OK** to close the window and return to the main screen.



8.0 Solution Preparation

This section outlines the solution preparation required to operate the PeCOD.

8.1 COD Solution Preparation Instructions

Select the appropriate electrolyte for your COD range. Blank, Calibrant and Sample solutions must be mixed with the same color electrolyte, and in specified ratios:

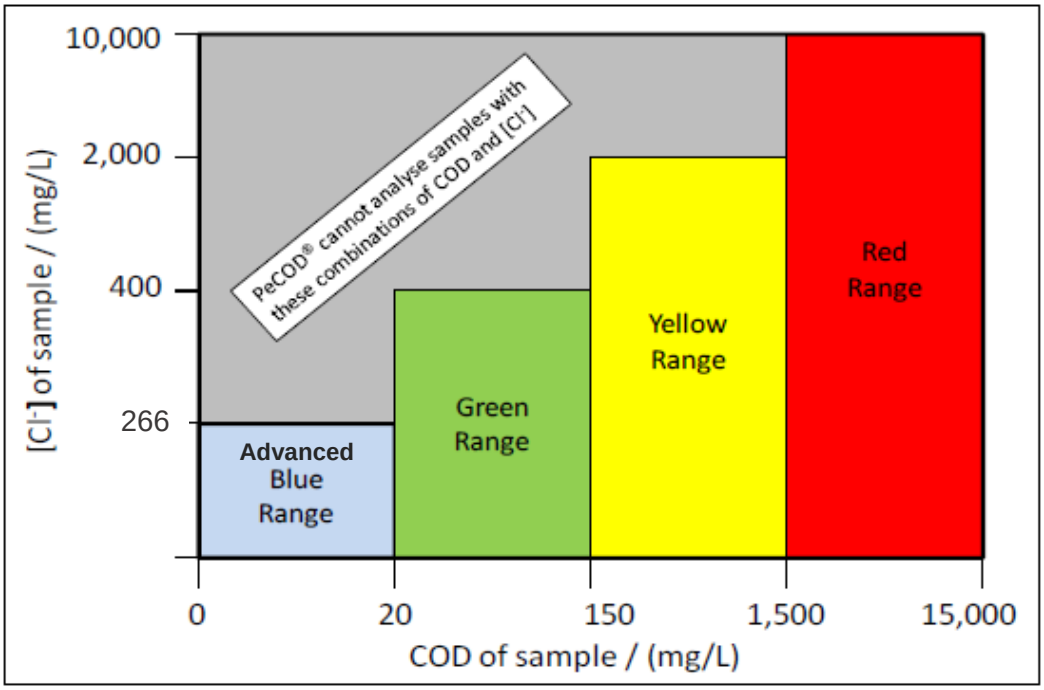
RANGE	Expected COD Concentration (mg/L)	Mixing Ratio	
		Blank, Calibrant, or Sample	Electrolyte
ADVANCED BLUE	<25 Drinking Water	3	1
GREEN	<150	1	1
YELLOW	<1,500	1	9
RED	< 15,000	1	49

RANGE	Blank Solution (500mL)	Calibrant Solution (~250mL)	Sample (recommend ~20mL per analysis)
ADVANCED BLUE	375mL DI Water + 125mL Blue Electrolyte	180mL Original Calibrant + 60mL Blue Electrolyte	15mL Sample + 5mL Blue Electrolyte
GREEN	250mL DI Water + 250mL Green Electrolyte	125mL Original Calibrant + 125mL Green Electrolyte	10mL Sample + 10mL Green Electrolyte
YELLOW	50mL DI Water + 450mL Yellow Electrolyte	25mL Original Calibrant + 225mL Yellow Electrolyte	2mL Sample + 18mL Yellow Electrolyte
RED	10mL DI Water + 490mL Red Electrolyte	5mL Original Calibrant + 245mL Red Electrolyte	0.5mL Sample + 24.5mL Red Electrolyte

8.2 Allowable COD/Chloride Concentration Combinations for peCOD Analysis

High chloride can interfere with both the dichromate and peCOD techniques. While the dichromate method makes use of the hazardous compound mercuric sulfate to bind chloride, the peCOD method employs a special “doping” effect in the sensor to reduce its sensitivity to the ion. There are still limitations; therefore, to reduce its effect on peCOD analysis, ensure that, after dilution with electrolyte, the chloride concentration is <200mg/L. This means that the allowable chloride concentration of the original sample varies depending on the COD range (outlined in the chart below). If necessary, do a pre-dilution of sample with deionized water before mixing with electrolyte.

Note that the central sensor element of a chloride-tolerant sensor appears black in color. A white sensor element indicates that the sensor has lost some/all chloride tolerance, even if the sensor is passing calibrations. To test whether a sensor has lost its chloride tolerance, one may wish to spike a known COD standard with a chloride solution to check recovery.



Recommended COD/[Cl-] Combinations for peCOD analysis. The coloured regions indicate the allowed combinations of COD & [Cl-] for the different measurement ranges. The grey region indicates those combinations of COD & [Cl-] that are not suitable for analysis by peCOD without prior pre-dilution.

8.3 PeCOD Dilution Charts for Sample Preparation

Please consult the subsection of the appropriate range.

8.3.1 Advanced Blue Range

Dilution Factor (D.F.)	Volume (mL)			
	Sample	COD-Free Water**	Electrolyte	Total
1	15.0	0.0	5.0	20.0
2	*7.5	*7.5	5.0	20.0
3	5.0	10.0	5.0	20.0
5	*3.0	12.0	5.0	20.0
6	*2.5	*12.5	5.0	20.0
7.5	*2.0	13.0	5.0	20.0
15	*1.0	14.0	5.0	20.0

*It is recommended to use a 1mL variable pipette for measuring volumes less than 4mL.
**Ensure that dilution water is free of COD, i.e. deionized, distilled, or ultrapure.

The ratio of sample to electrolyte must be 3:1, for Advanced Blue Range. For example, if 15mL of sample are used, 5mL of electrolyte must be added to the sample, for a total of 20mL.

$$Dilution\ Factor\ =\ Total\ Volume\ /\ Initial\ Volume$$
$$For\ example, when\ Dilution\ Factor\ =\ 2$$
$$2\ =\ 7.5\ mL\ of\ sample/Total\ Volume$$
$$Volume\ total\ =\ 7.5\ ml * 2$$
$$Volume\ total\ =\ 15\ mL$$
$$Volume\ of\ COD\_Free\ Water\ =\ Volume\ total\ -\ Sample\ Volume$$
$$Volume\ of\ COD\_Free\ Water\ =\ 15\ mL\ -\ 7.5\ mL$$
$$Volume\ of\ COD\_Free\ Water\ =\ 7.5\ mL$$

When performing dilutions, the **total sample volume** is the **volume of sample** plus the **volume of COD-free water.** For example, when preparing a 2x dilution, pipette 7.5mL of sample and 7.5mL of COD-free water (for 15mL of total sample), then mix with 5mL of electrolyte for a total volume of 20mL.

Ensure samples are well mixed with the electrolyte prior to running analysis. To calculate the final COD result, multiply the COD value by the D.F., or include the D.F. in the setup of the sample tab, following the steps in 3.3 Software Setup**.**

8.3.2 Green Range

Dilution Factor (D.F.)	Volume (mL)			
	Sample	COD-Free Water**	Electrolyte	Total
1	10.0	0.0	10.0	20.0
2	5.0	5.0	10.0	20.0
4	*2.5	*7.5	10.0	20.0
5	*2.0	8.0	10.0	20.0
10	*1.0	9.0	10.0	20.0

*It's recommended to use a 1mL variable pipette for measuring volumes less than 4mL.
**Ensure that dilution water is free of COD, i.e. deionized, distilled, or ultrapure.

The ratio of sample to electrolyte must be 1:1, for Green Range. For example, if 10mL of sample are used, 10mL of electrolyte must be added to the sample, for a total of 20mL.

$$Dilution\ factor\ =\ Total\ Volume\ /\ Initial\ Volume$$
$$For\ example, when\ Dilution\ Factor\ =\ 2$$
$$2\ =\ Total\ Volume/5\ ml$$
$$Volume\ total\ =\ 2 * 5\ ml$$
$$Volume\ total\ =\ 10\ mL$$
$$Volume\ of\ COD\_Free\ Water\ =\ Volume\ total\ -\ Sample\ Volume$$
$$Volume\ of\ COD\_Free\ Water\ =\ 10\ mL\ -\ 5\ mL$$
$$Volume\ of\ COD\_Free\ Water\ =\ 5\ mL$$

When performing dilutions, the **total sample volume** is the **volume of sample** plus the **volume of COD-free water.** For example, when preparing a 2x dilution, pipette 5mL of sample and 5mL of COD-free water (for 10mL of total sample), then mix with 10mL of electrolyte for a total volume of 20mL.

To calculate the final COD result, multiply the COD value by the D.F., or include the D.F. in the setup of the sample tab, following the steps in 3.3 Software Setup**.**

8.3.3 Yellow Range

Dilution Factor (D.F.)	Volume (mL)			
	Sample	COD-Free Water*	Electrolyte	Total
1	2.0	0.0	18.0	20.0
2	1.0	1.0	18.0	20.0
3	0.5	1.0	13.5	15.0
4	0.5	1.5	18.0	20.0
5	0.4	1.6	18.0	20.0
10	0.2	1.8	18.0	20.0

*Ensure that dilution water is free of COD, i.e. deionized, distilled, or ultrapure.

Note, the volumes for DF =3, uses 13.5mL of electrolyte, which is not the set volume on the dispense pump. To do a 3x dilution, pipette the 13.5mL of electrolyte, or reset the dispense pump to 13.5mL. Return the dispense to 18mL after finishing sample preparation to prevent mixing ratio issues for the next use.

The ratio of sample to electrolyte must be 1:9, for Yellow Range. For example, if 2mL of sample are used, 18mL of electrolyte must be added to the sample, for a total of 20mL.

$$Dilution\ factor\ = \frac{Total\ Volume}{Initial\ Volume}$$

$For\ example, when\ Dilution\ Factor\ = 2$

$2\ =\ 1mL\ of\ Total\ Volume/Initial\ Volume$

$Volume\ total\ =\ 2 * 1\ ml$

$Volume\ total\ =\ 2\ mL$

$Volume\ of\ COD\_Free\ Water\ =\ Volume\ total\ -\ Sample\ Volume$

$Volume\ of\ COD\_Free\ Water\ =\ 2\ mL\ -\ 1\ mL$

$Volume\ of\ COD\_Free\ Water\ =\ 1\ mL$

When performing dilutions, the **total sample volume** is the **volume of sample** plus the **volume of COD-free water.** For example, when preparing a 2x dilution, pipette 1mL of sample and 1mL of COD-free water (for 2mL of total sample), then mix with 18mL of electrolyte for a total volume of 20mL.

To calculate the final COD result, multiply the COD value by the D.F., or include the D.F. in the setup of the sample tab, following the steps in 3.3 Software Setup**.**

8.3.4 Red Range

Dilution Factor (D.F.)	Volume (mL)			
	Sample	COD-Free Water*	Electrolyte	Total
1	0.5	0.0	24.5	25.0
2	0.5	0.5	49.0	50.0
2.5	0.2	0.3	24.5	25.0
5	0.2	0.8	49.0	50.0
10	0.2	1.8	98.0	100.0

*Ensure that dilution water is free of COD, i.e. deionized, distilled, or ultrapure.

Note, the volumes for D.F. equal to 2, 5, and 10 use more electrolyte. If using the dispense pump set to 24.5mL; D.F. 2 and 5 require 2 pumps (49mL) and D.F. 10 requires 4 pumps (98mL).

The ratio of sample to electrolyte must be 1:49, for Red Range. For example, if 0.5mL of sample are used, 24.5mL of electrolyte must be added to the sample, for a total of 25mL.

$$Dilution\ factor\ = \frac{Total\ Volume}{Initial\ Volume}$$
$$For\ example, when\ Dilution\ Factor\ = 2$$
$$2\ = Total\ Volume/0.5\ ml$$
$$Volume\ total\ = 2 * 0.5\ ml$$
$$Volume\ total\ = 1\ mL$$
$$Volume\ of\ COD\_Free\ Water = Volume\ total - Sample\ Volume$$
$$Volume\ of\ COD\_Free\ Water\ = 1\ mL - 0.5\ mL$$
$$Volume\ of\ COD\_Free\ Water\ = 0.5\ mL$$

When performing dilutions, the **total sample volume** is the **volume of sample** plus the **volume of COD-free water.** For example, when preparing a 2x dilution, pipette 0.5mL of sample and 0.5mL of COD-free water (for 1mL of total sample), then mix with 49mL of electrolyte for a total volume of 50mL.

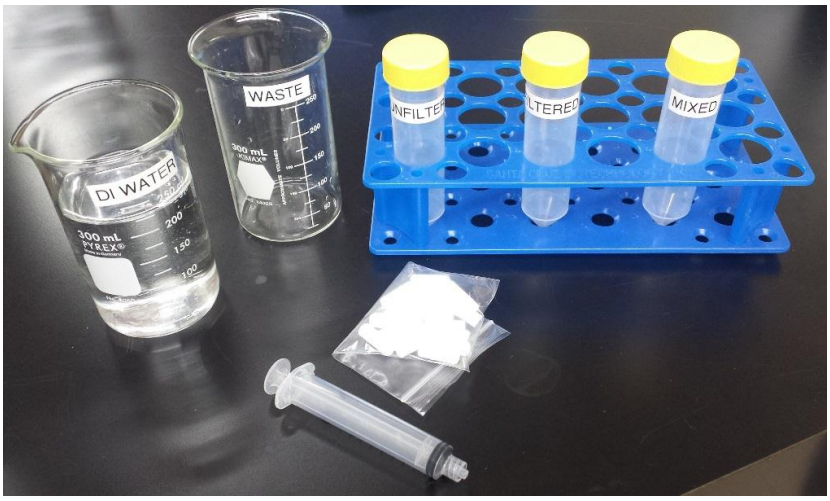
To calculate the final COD result, multiply the COD value by the D.F., or include the D.F. in the setup of the sample tab, following the steps in 3.3 Software Setup**.**

8.4 Sample Filtering Guide for peCOD Analysis

Samples must be filtered prior to peCOD analysis to ensure that no particulates greater than 50µm are primed into the PeCOD. Particulates larger than 50µm can cause clogging, which can lead to damage of the internal fluidics of the machine. For pulp and paper and wastewater applications, MANTECH recommends using a 35µm polyethylene (PE) syringe filter. These filters can contribute trace amounts of organics, which are negligible for wastewater applications. For drinking and source water applications it's important to use a filter that does not contribute organics to the filtered sample. One of MANTECH's research partners has recommended a 0.45µm polyethersulfone (PES) filter; however, other filter types may also be acceptable, if no organics are contributed by the filter. Since these applications traditionally see less particulates, having a smaller pore size filter hasn't shown an impact on the peCOD results.

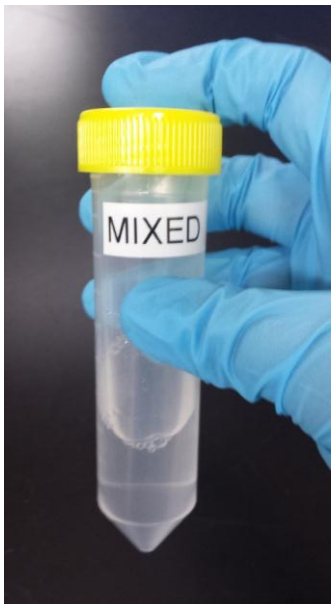
To prevent clogging and damage, follow the steps below:

1. Gather the following supplies: 10mL syringes, 35µm PE syringe filters (or similar filter that doesn't contribute COD to the samples), sample tubes and lids, and the unfiltered samples.



2. Fill the syringe with the unfiltered sample. **Attach the filter** and ensure that it is fastened securily. Push the sample through into a new tube labeled Filtered. *Please note, if samples are to be diluted, ensure that the sample is filtered before diluting with DI water.*

3. Once there is sufficient filtered sample, measure the correct volume of sample for the working COD range into a new sample tube, labeled Mixed. Add the correct volume of electrolyte for the COD working range to the Mixed tube. For mixing ratios of each working COD range, refer to Table *3*: COD range mixing ratios for sample preparation. Screw on the sample tube lid and invert several times to mix the sample.

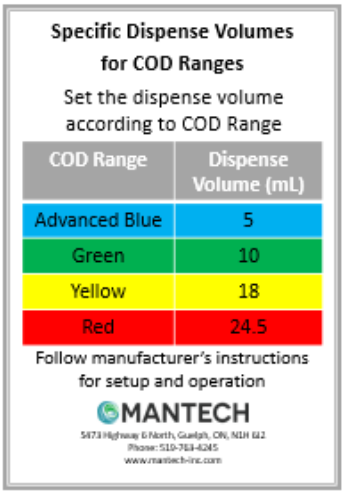


4. Once the samples are filtered and mixed at the correct ratio with the electrolyte, proceed with sample analysis.

8.5 Using the Bottle Top Dispenser for Electrolyte Addition for Sample Preparation

8.5.1 Setting up the Bottle Top Dispenser

1. Unpack the bottle top dispenser and follow the manufacturer's instructions for setup.
2. Following the MANTECH label provided on the bottle top dispenser box, set the dispense volume according to the desired COD range.



Specific Dispense Volumes for COD Ranges

Set the dispense volume according to COD Range

COD Range	Dispense Volume (mL)
Advanced Blue	5
Green	10
Yellow	18
Red	24.5

Follow manufacturer's instructions for setup and operation

MANTECH

3. For example, if the PeCOD is operating in Red range, set the dispense volume to 24.5mL.

8.5.2 Priming the Bottle Top Dispenser Before Use

1. Pour **100% electrolyte** into the 1L glass bottle provided.
2. Attach the bottle top dispenser onto the bottle (the adapters provided with in the box won't be needed for the 1L glass bottle). Cut the filling tube attached to the dispenser so that the top can screw completely onto the bottle and the tube is close to the bottom of the inside of the bottle.
3. Ensure that the dispense volume is set to the correct measurement according to COD range (provided in the label on the bottle top dispenser box).
4. Remove the stopper cap and place a waste beaker directly below to catch the solution dispensed while priming.

5. Push the top of the dispense pump down completely.
6. Release to pump slowly until it's raised approximately 30mm before pushing down quickly again.
7. Repeat step 6. five times or until no bubbles remain inside the dispense pump (a few bubbles smaller than 1mm are permissible).



8.5.3 Preparing Samples with the Bottle Top Dispenser

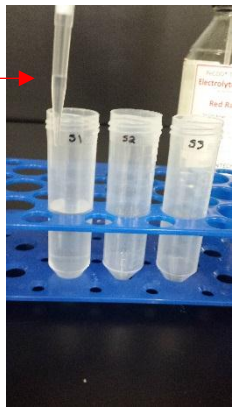
1. Place a clean sample tube underneath the dispenser and press down to dispense the electrolyte into the tube. The accurate volume should be dispensed in one pump.
2. Next, measure the correct sample volume into the tube with the electrolyte. Depending on the COD operating range, use either a pipette, or graduated cylinder and disposable pipettes, to measure the accurate sample volume. The required volumes are listed in Table *4*: Volumes of sample and electrolyte for each COD range.
3. Screw on a sample tube lid and invert the sample several times until it's well mixed.

Table 4: Volumes of sample and electrolyte for each COD range

COD Range	Volume of Electrolyte (mL)	Volume of Sample (mL)
ADVANCED BLUE	**5**	**15**
GREEN	**10**	**10**
YELLOW	**18**	**2**
RED	**24.5**	**0.5**

Pump the electrolyte into the sample tube.

Measure the correct sample volume into the sample tube.

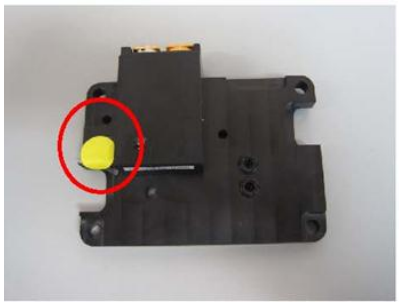


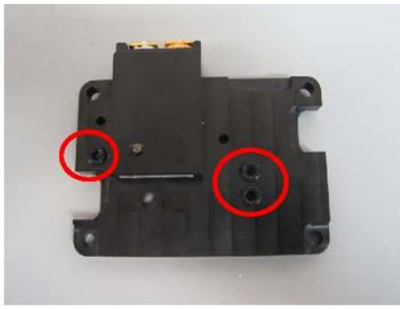
9.0 Electrode Block and Sensor Installation and Storage

Caution: Always keep the internal channel of the Electrode Block filled with solution; do not leave it dry. Deionized water is most suitable for storage up to 4 weeks. For longer storage, use 3M NaCl solution.

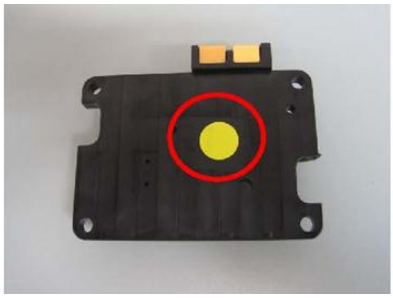
9.1 Installation

1. Unpack the electrode Block. There should be one electrode block, three spare O-rings and 4 thumbscrews.
2. Peel off the tape that seals the end of the internal channel. Make sure the 3 O-rings are placed properly in the cavities and that they aren't stuck to the tape.

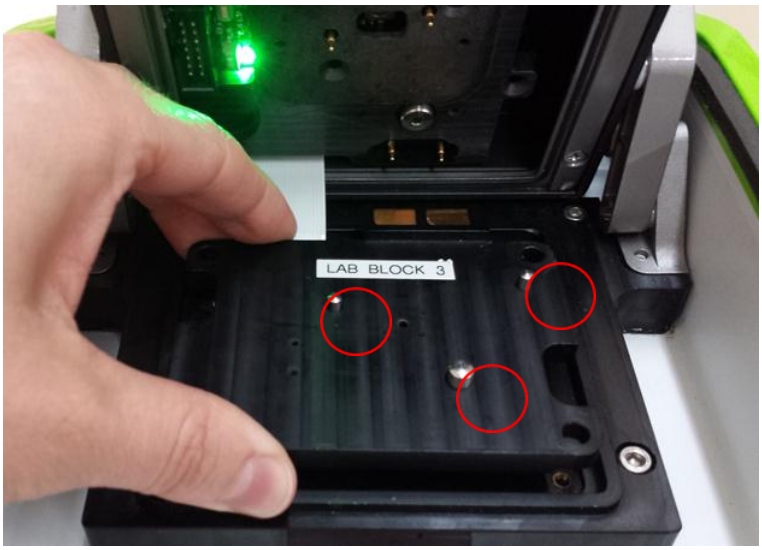




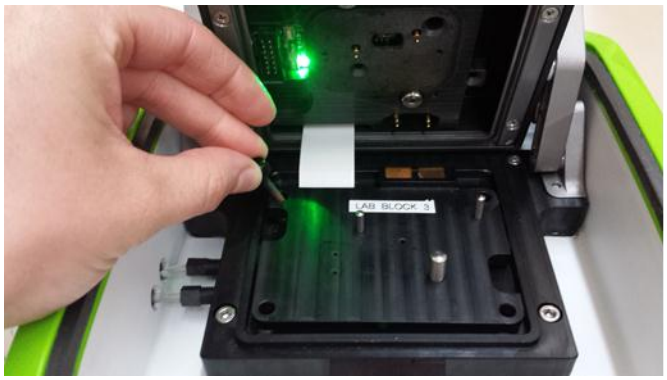
3. Peel off the tape that seals the other end of the internal channel on the other side of the electrode block.

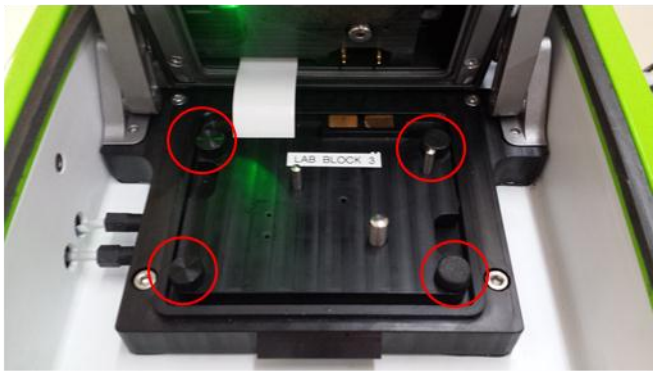


4. Open the analyzer head and place the electrode block inside. The electrode block can only be installed in one orientation using the 3 different-sized metal pins.



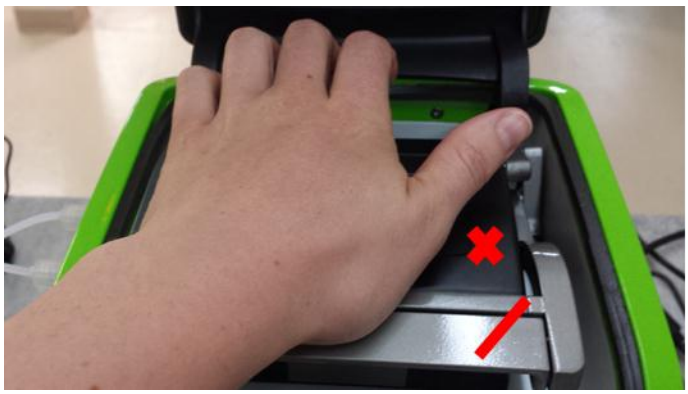
5. Use the 4 thumbscrews to secure each corner the electrode block inside of the analyzer head.





6. Install the sensor by placing it directly on top of the electrode block. With the blue side facing up, the sensor can only be installed in one orientation using the two different-sized metal pins.

7. Close the analyzer head lid securely by using the palm of your hand to push down on the fixed bar and latch (not the analyzer head itself). Ensure the lid is shut completely by listening for a click sound. Then, gently push down on the outer lid until it clicks closed.



9.2 Storage

To store the system after daily use, ensure that the system is thoroughly rinsed with deionized water, to flush out any excess sample. Prime Port A three times to confirm that the internal channels of the electrode block remain in a wet condition.

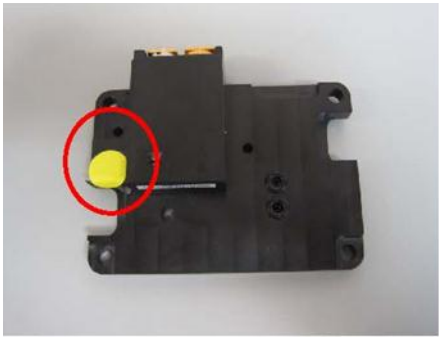
9.2.1 Short Term Storage (i.e. up to 14 days)

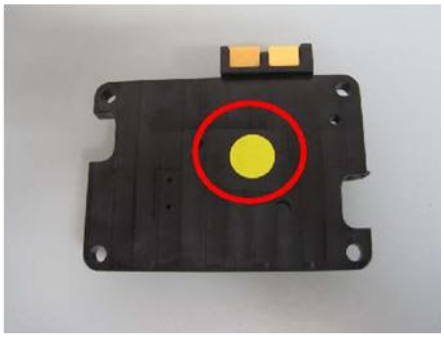
1. Prime Port A several times with DI Water.
2. Prime Port B with DI water or the pre-mixed blank solution.
3. The sensor and electrode block can be left in the unit. If the seal is broken, i.e. the analyzer lid is opened, re-prime Ports A and B.

9.2.2 Long Term Storage (i.e. greater than 14 days)

1. After priming both Ports, A and B, several times with DI water, remove the sensor and electrode block from the peCOD.
2. Using a syringe with a narrow tip attached, flush the internal channel of the electrode block with 10mL of DI water, as shown below.

3. Push more DI water through the channel and ensure that the channel is filled to keep the block hydrated.
4. Tape each end of the channel with electrical tape to store the DI water inside.





5. Tape the O-rings to the block so they are not lost.

9.3 Shipping Requirements

Should the peCOD ever need to be shipped somewhere (e.g. sending in for service), all solution should be drained from the system, and the sensor and electrode block removed and stored following the long-term sensor and electrode block storage requirements described above

Document Change Log

Version	Date	Author	Changes
1.1	Jan. 9th 2019	Graham Ashby	• Document updated to reflect changes between software version 1.3.6.0 to 1.3.7.0 • Added change notes table
1.1	Jan. 10th, 2019	Maggie Grierson	• Edits to error codes 11.4, 11.6, 11.10, 11.14
1.2	May 22, 2019	Maggie Grierson	• Section 9 added
2	Aug 7th, 2019	Heather Jasumani	• Doc ID and formatting

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