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L50 PeCOD® COD ANALYZER
Operation Manual

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1. Introduction

1.1 The L50 PeCOD® COD Analyzer

Thank you for purchasing the L50 PeCOD® COD Analyzer. The L50 PeCOD® COD Analyzer has been specifically designed for quantifying the organic content using a patented photo-electrochemical technique to determine the Chemical Oxygen Demand (COD). No toxic reagents are required, making this technique an environmentally friendly method for COD and rapid screening of Biological Oxygen Demand (BOD).

MANTECH products are manufactured, tested and calibrated to meet published standard specifications under our strict quality assurance guidelines. The main components consist of the sensor, electrode block, light source, and three ports (one each for sample, blank solutions and waste).

Please read this manual thoroughly before operating your L50 analyzer.
The L50 analyzer is designed to be used only by properly qualified and trained personnel.

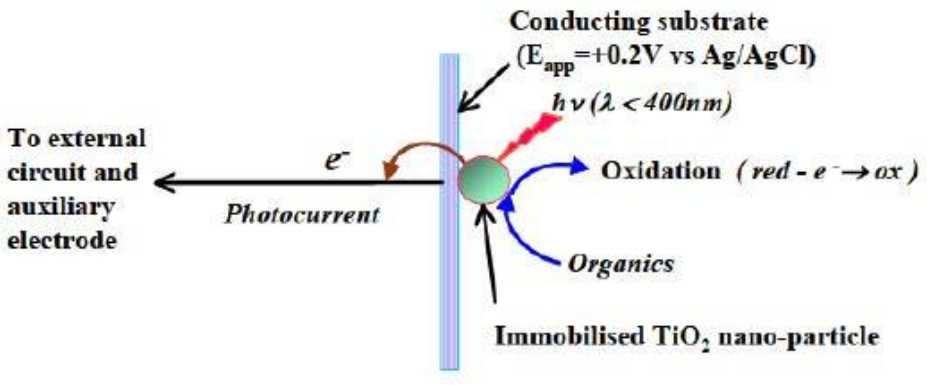
1.2 Theory of Operation Mechanism

Photocatalytic Oxidation

The PeCOD® L50 analyzer employs a unique patented technology that can directly measure photocurrent originating from the oxidation of organic species contained in a sample. The core of the technology is the PeCOD® sensor, which consists of a UV-activated nano-particulate TiO_2 (titanium dioxide) photocatalyst coupled to an external circuit.

The sample is introduced into a microcell containing the sensor. The TiO_2 is irradiated by UV light, and a potential bias is applied. The UV light creates a photo hole in the TiO_2 sensor with a very high oxidizing power (3.1V) and organic contents in the cell are oxidized (the chemical potential of the dichromate method is only 1.6V). The PeCOD® COD analyzer exhaustively oxidizes organics and counts the electrons that are liberated to provide a direct measure of equivalent COD.

The following figure illustrates the photo-electrocatalytic process involved in the analytical signal generation.



The PeCOD® L50 analyzer gives a direct measurement of the oxidation of organic compounds, thus providing a real measurement of organic pollutants and not an inferred one. The reaction produces mainly carbon dioxide & water from organic C, H, and O.

1.3 Technical and General Specifications

** Specifications are subject to change without notice*

ANALYSIS DATA	
Oxidation process	Photocatalytic oxidation
Catalyst	Titanium Dioxide (TiO_2)
Method Detection Limit	*0.7ppm
Reproducibility	≤+/- 10%
Light source	UV LED

*MDL determined for Advanced Blue range

GENERAL SPECIFICATIONS	
Construction	Powder coated metal
Dimensions (approximate L x W x H)	205 mm x 285mm x 280mm
Weight	< 7 kg
Security	4 digit pin (optional)
Parameter(s)	COD (unit of measurement: ppm or mg/L) BOD (ppm or mg/L)
Measurement	Dilution ≤ 15,000 ppm

ELECTRICAL AND STANDARDS CONFORMITY	
Power Requirements	100V to 240V AC / 45 to 65 Hz INPUT – 24V DC X Amp OUTPUT, Optional battery pack for field use
Current Consumption	2.0 A (maximum)
Enclosure	IP55 to EN60529
Protection Class	Continuous short circuit protection. CEC Level IV compliant. UL compliant
EMC Emission and Noise Immunity	EN61326-1:2006 FCC Part 15 Subparts A and B
Certification	CE. FCC
Environmental conditions	Ambient Operating Temperature: 10 to 30 °C
	Storage Temperature: 5 to 40 °C
	Relative Humidity: Max 90% non-condensing

DATA DISPLAY, INPUTS AND OUTPUTS	
Display	4 x 20 characters
Keypad	Splash resistant capacitive touch user interface
Data Presentation	Alpha Numeric
Data Logging	Up to 200,000 measurements, events and faults
Fault Monitoring	Error code reporting of faulty conditions
Computer Interface	USB for data and control

2. General Information

2.1 Safety Information

Please read this entire manual before unpacking, setting up, and operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in damage to the equipment.

To ensure that the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that specified in this manual.

In addition to the instructions in this manual, users must comply with the national general safety and accident prevention regulations of the country in which the instrument is used.

The UV light is automatically cut off when the analyzer head is open. However, as a safety measure, do not look directly into the UV light source at any time.

Use of hazard information throughout this manual:

CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury.

IMPORTANT NOTE
Information that requires special emphasis.

NOTE
Information that supplements points in the main text.

Precautionary Labels

Read all labels and tags attached to the instrument. Although highly unlikely, personal injury or damage to the instrument could occur if not observed.

2.2 Overview of Product and Function

The L50 analyzer is comprised of the following major components:

- Sensor: contains the cell and TiO_2 (working electrode) and is the location for photocatalytic activity.
- Electrode block: contains the reference and auxiliary electrodes.
- UV LED as the light source: 400nm wavelength
- Detector (potentiostat)
- Port A and Port B for sample and blank solutions, respectively.
- Port W for waste solution

The L50 employs a unique nanotechnology-based photo-electrochemical technique for the determination of COD in natural and wastewater samples in laboratory and field analyses. It is:

- fast (a typical analysis takes less than 10 minutes),
- sensitive (detection limit at 0.7 ppm level in Advanced Blue range),
- environmentally friendly (does not require any toxic / hazardous chemicals),
- robust, and
- free of the matrix effect due to the highly effective photo-electrochemical system employed that is capable of fully oxidizing a wide spectrum of organics.

The photocurrent generated is detected with a potentiostat.

The L50 analyzer provides digital readout of COD in ppm or mg/L units. It also provides the equivalent BOD value (if this function is selected during the parameter set up).

When a user-generated or programmed method is selected, the on-screen menus and prompts direct the user through the test. The L50 analyser can be connected to a PC with pre-installed software using a USB cable. See "Note:" in Section 3.5

User Interface (front panel)
The L50 analyzer has nine touch keys on its splash proof keypad;
POWER, MENU, RUN, EXIT, ENTER, UP, DOWN, LEFT and RIGHT arrow touch keys.
In addition to this, it also has a status indicator for 'READY' (Green), 'FAULT' (Red), and 'BUSY' (Yellow).

3. Installation

Caution: Only qualified personnel should conduct the tasks described in this section of the manual.

3.1 Unpacking the Instrument

Please refer to the standard packing list included with your L50 for a complete list of L50 accessories and items. If any of these items are missing or damaged, contact MANTECH or your local authorized MANTECH representative immediately.

Important Note: Retain the original packaging materials. Instruments returned for service should be shipped in the original packaging material to protect against damage during transportation.

3.2 Operating Environment

The following conditions are necessary to ensure correct instrument operation and accurate results:

- Place the instrument firmly on an even surface. Do not place any objects above or under the instrument.
- Maintain an ambient temperature of 10ºC to 30ºC for proper instrument operation.
- The relative humidity should be less than 90%; moisture should not condense on the instrument.
- Leave at least a 15 cm (6 in.) clearance at the top and on all sides for air circulation to avoid overheating of electrical parts.
- Do not operate or store the instrument in extremely dusty, damp or wet locations.
- Keep the surface of the instrument, the cell compartment, and all accessories clean and dry. Splashes or spills on and in the instrument should be cleaned up immediately.

Important Note: Protect the instrument from temperature extremes, including heaters, direct sunlight, and other heat sources.

3.3 Power Connections

Plug the power supply into the appropriate connector on the back panel of the analyzer, then plug the power cord into a power outlet (100 – 240 V~ / 45 – 60 Hz). Press the power key on the top left of the analyzer to turn the instrument on.

3.4 Battery Power

The L50 can also be powered using a battery pack (intended for portable field use). The battery pack is plugged into the power input at the back of the PeCOD. *Please refer to section **5.2 Battery Pack** for more information on battery charging*.

3.5 Personal Computer (PC) Connection

The L50 has one USB interface located on the back of the analyzer. This is used for communication with a PC. The software is supplied preinstalled on laptop PC and is available for purchase from MANTECH or one of its authorized distributors.

***Note*:** USB cables must not be longer than 3 meters (10 feet).

4. System Operations

4.1 Overview

The following are the steps involved in setting up the L50 analyzer for sample analysis:

1. Preparation of solutions (calibration/reference, blank and sample).
2. Priming lines and analyzer assembly.
3. Pre-conditioning of sensor/calibration.
4. PeCOD® menu structure

The L50 analyzer operates according to four COD ranges as per the following table:

	COD range (ppm)
Advanced Blue	< 25
Green	< 150
Yellow	< 1,500
Red	< 15,000

4.2 Getting Started – Powering the Analyzer On

1. Place the L50 analyzer on a stable, level surface.
2. Plug the power supply into the appropriate connector on the back panel of the analyzer, then plug the power cord into a power outlet (100 – 240 V~ / 45 – 60 Hz).
3. Press the power key on the top left of the analyzer to turn the instrument on. The LCD screen will be displayed after several seconds and the green 'READY' light will turn on.

4.3 Preparation of Solutions

For samples with a known COD range, the original sample should be diluted with the appropriate electrolyte as per the table below. The calibration and blank solutions should also be prepared using the same dilution factor as was used for the sample.

The following table lists the four COD ranges available and their corresponding dilution factors:

	COD Range (ppm)	Dilution	Dilution Factor
Advanced Blue	0.2 - 20	3 parts **X** : 1 parts Advanced Blue electrolyte	1.33
Green	40 – 200	1 part **X** : 1 part Green Electrolyte	2
Yellow	200 - 2,000	1 part **X** : 9 parts Yellow Electrolyte	10
Red	2,000- 15,000	1 part **X** : 49 parts Red Electrolyte	50

Note: *(i) For the sample: X= the original sample*
(ii) For the blank solution: X=COD free water
(iii) For the Reference/Calibration solution: X= the original calibrant solution supplied by MANTECH

For example, if you are analysing in the Yellow range;

1. Mix 1 part of your original sample with 9 parts Yellow Electrolyte
2. Mix 1 part of COD-free water with 9 parts Yellow Electrolyte to make your blank solution
3. Mix 1 part of the original Calibrant solution (supplied by MANTECH), with 9 parts Yellow Electrolyte to make your "reference" or "calibration" solution

Ensure you prepare sufficient amounts of each solution, taking into account the volume required for priming (~2mL per prime), calibration and sample analysis. It is recommended to prepare a total minimum volume of 20mL for each sample, and 250mL and 500mL of pre-mixed calibrant and blank, respectively.

4.4 Priming of Lines

Always prime both Port A and Port B lines 3 times before any analysis to ensure that both lines are filled with liquid and there are no air bubbles present. This can be confirmed by visually checking all flow lines. For automated system, 6 primes of Port A are required to accommodate the longer sampling line.

To prime the lines manually from the touchpad:

1. Press MENU.
2. Arrow down to select Operation and press ENTER.
3. In the Operation menu, select Prime Lines and press ENTER.
4. In the Prime Lines menu, select Prime Port A and press ENTER. The solution will flow in through the tube connected into Port A and flow out through the tube connected to Port W. The analyzer will beep twice at the end. Repeat two more times.
5. In the Prime Lines menu, arrow down to select Prime Port B and press ENTER.
   The solution will flow in through the tube connected into Port B and flow out through the tube connected to Port W. The analyser will beep twice at the end. Repeat two more times.

4.5 New Sensor Routine and Calibration

Important Note: It is recommended that the system be calibrated a minimum of two times each day it is in use to ensure that the sensor is fully conditioned before running samples. The "New Sensor Routine" can be used to speed up the process of "breaking-in" a new sensor.

To run a new sensor routine manually from the touchpad:

1. Press MENU.
2. Arrow down to select Set up and press ENTER.
3. In the Set-up menu, arrow down to select Sensor Operation and press ENTER.
4. Select New Sensor and press ENTER.
5. At the prompt "Confirm new sensor?", press ENTER. The PeCOD® will now begin the new sensor routine, which comprises of a normalization and burn-in phase of Port B.
6. After 2.5 minutes, the analyzer will beep and ask the user to verify the COD range. Press ENTER to confirm the range. The PeCOD® will now do a full calibration.
7. Partway through the calibration, the system will beep again. Press ENTER to continue.
8. Repeat the new sensor routine once more. If the M and C meet the passing criteria in section as shown in the box below, the sensor is ready to analyze samples.

To run a calibration manually from the touchpad:

1. Press MENU.
2. Arrow down to select Operation and press ENTER.
3. In the Operation menu, arrow down to select Run Calibration and press ENTER.
4. The analyzer will beep. Check to ensure that the flow line from Port A is placed in the vial containing your Calibration solution, and that the correct COD range is selected. Press ENTER.
5. Partway through the calibration, the system will beep again. Press ENTER to continue.
6. Repeat these steps to perform the second calibration.

An M value will be displayed on the screen upon calibration completion. Pressing the left arrow button will display the C value. Verify that the M and C values are within the recommended ranges prior to running samples (see box below). Note that M and C values vary from sensor to sensor and will fluctuate with sensor age. The M and C values should be consistent between daily calibrations (i.e. M +/- 0.03, C +/- 50uC). A third calibration may be required if M and C values vary beyond these limits.

0.02 < M < 0.06
Advanced Blue: 50 < C < 300
Green: 150 < C < 700
Yellow: 200 < C < 750
Red: 250 < C < 800

M and C values are also stored in the calibration log.

To access the Calibration Log manually from the touchpad:

1) Press MENU, select Data and press ENTER.
2) In the Data menu, select Calibration Log and press ENTER.

4.6 PeCOD® Menu Structure

The menu structure is classified into the following four categories:

1. Data
2. Operation
3. Set up
4. Diagnostics

Each of the above categories contains sub level functions / parameters, as listed in the following tables.

DATA

LEVEL 1	DESCRIPTION
Result Log	Data display. Presents result data for previous samples.

	Use the Up, Down, Left & Right arrow touch keys to move within each individual log.
Event Log	Data display. Presents event data for previous samples. Use the Up, Down, Left & Right arrow touch keys to move within each individual log
Calibration Log	Data display. Presents calibration data for previous samples. Use the Up, Down, Left & Right arrow touch keys to move within each individual log

OPERATION

LEVEL 1	LEVEL 2	DESCRIPTION
Prime Lines	Prime Port A	Primes Port A.
	Prime Port B	Primes Port B.
	*Check Seals	Checks that the PeCOD® fluidics are sealed.
Run Sample		Commences operation of the analyser.
Run Calibration		Commences the calibration routine.
Run Standby		Commences standby operation which primes Port B using a repeat cycle time as specified.
*Run Wash		Commences the wash routine.
*Open Analyser		Purges line to allow analyser to be opened and sensor to be removed.

*Feature which is not implemented in current L50 practises

SET UP

LEVEL 1	LEVEL 2	LEVEL 3	DESCRIPTION
Analysis Method	COD Range		Choice of: Advanced Blue (<20 ppm analysis); *Blue (<20 ppm analysis); Green (<150 ppm analysis) Yellow (<1,500 ppm analysis); Red (<15,000 ppm analysis) Use the Up & Down arrow touch keys to select COD range. *Blue range is not currently implemented in L50 practises
	*Set Algorithm	Normal or Pulsed.	Normal method is continuous oxidation. This is the default method. Pulsed method is used for specific applications. Use the Up & Down arrow touch keys to select method.
	Set Precision	Precise or Rapid.	Choice of Rapid or Precise mode. Rapid mode: uncertainty of >5% (1σ). Precise mode: uncertainty of ≤ 5% (1σ).

LEVEL 1	LEVEL 2	LEVEL 3	DESCRIPTION
			Use the Up & Down arrow touch keys to select analysis mode.
	Sample Replicates		Default value is 1 (1 replicate = 1 measurement per sample). Valid values are 1, 2 or 3. Note that an average COD value is reported. Use the Up & Down arrow keys to change value.
	Cal. Replicates		Default setting is 1. Analyse blank once, then analyse calibration solution once. Record values for C and M to be used for future determinations. Valid values are 1, 2 or 3. Use the Up & Down arrow touch keys to change value.
	*Pulse Settings	Set Pulse Duration.	Sets the time period for LED ON in seconds. Minimum value: 0.1 s. Maximum value: 9.9 s. Use the Up & Down arrow touch keys to change value.
		Set Pulse Interval.	Sets the time period for LED OFF in seconds. Minimum value: 0.1 s. Maximum value: 9.9 s. Use the Up & Down arrow touch keys to change value.
Sensor Operation	New Sensor	YES or NO.	YES begins pre-treatment process. NO exits to previous menu level. Press ENTER key for YES or EXIT key for NO.
	Set Baseline		Sets the LED intensity to achieve an Iterm value. Use Up & Down arrow touch keys to change value.
Periodic Actions	*Cal. Interval	Cal. Cycles.	Not for use for L50
	*Wash Interval	Wash Cycles.	Not for use for L50
	Standby Interval	Standby (HH:MM)	Default value set to 00:00 (hours: minutes). Change value to set standby mode interval time. Use the Up & Down arrow touch keys to change value.
Reference	Reference		Input to set calibrant concentration. Valid values

LEVEL 1	LEVEL 2	LEVEL 3	DESCRIPTION
Solution			are from 0.0 to 99999.9. Note: this is the concentration prior to dilution with electrolyte. Use the Up & Down arrow touch keys to set the value.
Set Date and Time	YYYY/MM/DD HH:MM:SS		Input to set up date and time or to change. Use the Up & Down arrow keys to set date/time.
Display Units	COD Units	COD units.	Choice of "ppm or mg/L". Use the Up & Down arrow touch keys to choose display units.
	Equiv. BOD Units	BOD Factor.	If set to Zero then no BOD data is displayed. Minimum value: 0.00 Maximum value: 9.99 Use the Up & Down arrow touch keys to enter COD to BOD multiplication factor.

*Feature which is not implemented in current L50 practises

DIAGNOSTICS

LEVEL 1	LEVEL 2	DESCRIPTION
Factory Settings	Reset to factory settings.	Resets all parameters to factory settings (default values). Select YES or NO.
System Reset		Restarts the analyzer.
Set Pin Number		Default PIN = 0000 In this setting, security is switched to OFF. Use the Up & Down arrow touch keys to change value.
Erase Logs	Erase Result Log	Erases result log.
	Erase Event Log	Erases event log.
	Erase Cal. Log	Erases calibration log.

Analysis of a typical sample manually from the touchpad:

The following parameters should be selected:

1. **COD range:** Advanced Blue / Green / Yellow / Red, select the appropriate range based on the original concentration of sample/analyte.

2. **Reference Solution:** only if the reference solution (Calibrant) provided is not used. Enter the value for your own solution

3. **Display units for COD**: ppm or mg/L

4.7 Running a Sample

A complete analysis consists of the following steps:

i. Pre-conditioning of blank (Pre-Burn, Port B) – ensures that the sensor and electrodes are stable.

ii. Pre-burn of sample (Pre-Burn, Port A) – preconditions the sensor to the sample matrix.

iii. Oxidation of sample (Oxidation, Port A) – a small amount of sample is advanced into the cell and is analyzed to obtain the COD value. The instrument is measuring the charge liberated from the oxidation reactions.

To run a sample manually from the touchpad:

1. Press RUN.
2. The analyzer will beep. Check that the flow line from Port A is placed in the vial containing your sample and confirm that the correct COD range is selected.
3. Press ENTER to begin analysis.

The COD value will be displayed at the end of the analysis.

All COD values are stored in the Result Log, until cleared manually or overwritten by new entries.

To access the Result Log manually from the touchpad:

1. Press MENU, select Data and press ENTER.
2. In the Data menu, select Result Log and press ENTER.
3. The COD value for the most recent analysis will be displayed. Use the left and right arrow touch keys to access previous COD values.

Each result log entry will contain the sample number, COD value, date and time. If an error had occurred during the sample run, the event log will store the error code and corresponding date and time.

4.8 Other Operational Functions

Event Log

Please refer to section 6, Troubleshooting

Run Standby

This function can be activated when the L50 is not in use and ensures that the instrument is primed and maintains calibration for the next sample, when left inactive for several hours during the day. When this function is enabled, the L50 analyzer will prime Port B.

To set “Periodic Standby” manually from the touchpad:

1. Press MENU.
2. Arrow down to select Set Up and press ENTER.
3. In the Set Up menu, arrow down to select Periodic Actions and press ENTER.
4. In the Periodic Actions menu, select Standby Interval and press ENTER.

5. Use the Up, Down, Left and Right arrow touch keys to set the value for standby interval time in hours: minutes format.
6. Press ENTER.

To run Standby manually from the touchpad:

1. Press MENU.
2. Arrow down to select Operation and press ENTER.
3. In Operation menu, arrow down to select Run Standby and press ENTER.

The analyzer will perform the run standby function periodically according to the interval time set in step (5), starting from the time the function was activated.

4.9 Diagnostic Functions

Factory Settings

The operational values can be reset back to default (factory) settings at any time.

To reset operational values back to factory settings manually from the touchpad:

1. Press MENU.
2. Arrow down to select Diagnostics and press ENTER.
3. In Diagnostics menu, select Factory Settings and press ENTER.

System Reset

The system can be reset at any time.

To reset system manually from the touchpad:

1. Press MENU.
2. Arrow down to select Diagnostics and press ENTER.
3. In Diagnostics menu, arrow down to select System Reset and press ENTER.

Set PIN Number

The user can set a PIN number for added security for the operational settings of the L50 analyser. Once this function is enabled, other users will not be able to change the parameter settings without the PIN number but will still be able to run analysis or access data logs.

To set PIN number manually from the touchpad:

1. Press MENU.
2. Arrow down to select Diagnostics and press ENTER.
3. In Diagnostics menu, arrow down to select Set PIN Number and press ENTER.
4. Use the Up and Down arrow touch keys to set the value.

Note: Default value is set to 0000 and security is disabled.

Erase Logs

To erase logs manually from the touchpad:

1. Press MENU.
2. Arrow down to select Diagnostics and press ENTER.
3. In Diagnostics menu, arrow down to select Erase Logs and press ENTER.
4. In the Erase Log menu, select:

   a) Erase Result Log (to clear the result log), or
   b) Erase Event Log (to clear the event log), or
   c) Erase Cal. Log (to clear the calibration log) and press ENTER.

Note that it is recommended that the logs be deleted every time the sensor is changed to prevent data build up and slow log response. The logs can be downloaded as a .csv file from the PeCOD® prior to deletion for record keeping. Logs are downloaded to a PC using the PeCOD® software supplied by MANTECH.

5. Preventative Maintenance

5.1 Cleaning Requirements

Caution: *Always check that the instrument is switched off, the power cord is unplugged, and the analyzer has cooled before proceeding with preventative maintenance tasks.*

Tubing and Fluidics

When the PeCOD® will not be in use for several hours, prime Port A with DI water. The block and sensor can remain in the PeCOD® for up to three weeks stored in this way. External tubing can be purchased as a PM kit. Contact your local PeCOD® representative for more details on PM kits suitable for your configuration.

Analyzer

To clean the external surface; wipe with a soft, damp cloth and a mild household grade detergent (if necessary). Make sure no water penetrates the analyzer.

Sensor

Use a lint free tissue to clean or dry surfaces.

5.2 Battery Pack

An optional battery pack for portable field use is available from MANTECH and your local MANTECH authorized representative. This battery pack should be plugged into the power input on the back of the L50 (for field use); the PeCOD cannot be connected to the battery and an external power supply simultaneously. The battery pack must be recharged using an external charger. The pack will provide up to 8 hours of continuous operation. Please follow the instructions provided with the battery pack for proper operation and charging.

5.3 System Storage

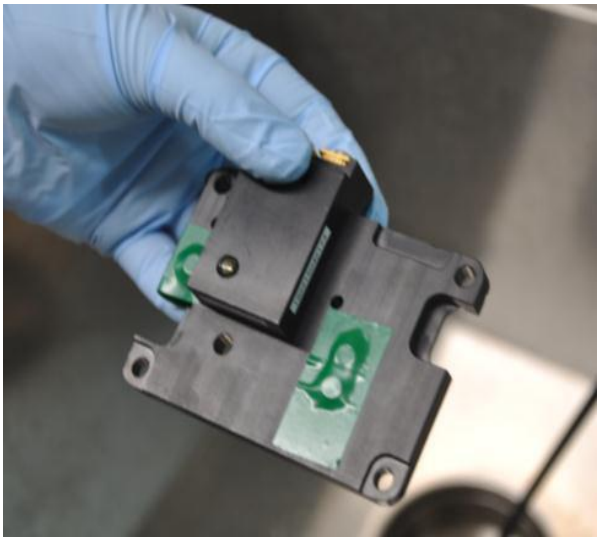
General Guidelines

The sensor and electrode block may be stored in the PeCOD® for up to three weeks, ensure that the PeCOD® has been primed with DI water to keep the electrode block hydrated. If the unit will not be used for more than three weeks:

- Prime Port A and Port B with DI water, three times. Repeat with air, priming three times. This ensures that the fluidics lines are free of liquid.
- Remove the electrode block and sensor, and fill the block with deionized water (see below). Place the sensor in its original package when not in use as it is light sensitive.

Flushing and Storing the Electrode Block

1. The electrode block should always be kept hydrated. Flushing with DI water is a general preventative maintenance and troubleshooting procedure to maintain the life of the electrode block and is necessary for short term storage. Long term storage requires the block to be filled with 3M NaCl.
2. Using the syringe and tips provided in the starter kit, fill the syringe with DI water and find the appropriate sized tip for the hole indicated below. Push DI water through the hole. This will flush out the internal channel and come out the other side. Refill the syringe and repeat the process 5-6 times.
3. Place electrical tape over one hole to prevent the DI / NaCl from draining out of the internal channel and fill with the appropriate solution for storage. Once filled, tape over the second hole and write the type of solution inside and the date it was stored. Tape the O-rings down to prevent them from getting lost.



6. Troubleshooting

6.1 System Diagnostics

System errors are reported and stored in the event log. The following table lists the error codes and description of possible cause for the error and suggested action to rectify the error.

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. No further action required.
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 re-do the calibration also.
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. If necessary, 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

Error Group	Sub Code	Name	Description of Problem	Suggested actions
				be replaced.
4	1	Calibration failure	Calibration failed	• Redo calibration
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.
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	3	Sensor absent	Sensor absent or not detected	• Ensure sensor is present and correctly seated on the electrode block analyser
11	4	Vaux 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. • The current and voltage applied may be too high, try decreasing the set baseline and recalibrate. • Check electrical contacts between the connection pins on analyser board with the electrode block. If necessary, very gently clean using isopropanol and a lint free

Error Group	Sub Code	Name	Description of Problem	Suggested actions
				cloth. • If the above do not rectify the problem, the sensor or electrode block may need to be replaced.
11	6	I_{work} out of range	Current is overrange	• Make sure there are no bubbles present in the line; prime lines, and then re-run analysis. • The current and voltage applied may be too high, try decreasing the set baseline and recalibrate. • Check electrical contacts between the connection pins on analyser board with the electrode block. If necessary, 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.
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. If in doubt, remake solutions. • The current and voltage applied may be too high, try decreasing the set baseline and recalibrate. • Check electrical contacts between the connection pins on analyser board with the electrode block. If necessary, very gently clean using isopropanol and a lint free cloth.

Error Group	Sub Code	Name	Description of Problem	Suggested actions
				• If the above do not rectify the problem, the sensor or electrode block may need to be replaced.
11	10	FIFO Overrun	Too much processor activity	• Erase logs and try to re-run sample.
11	14	COD Out of Range	Sensor calibration did not achieve reproducibility target	• Make sure there are no bubbles present in the line; prime lines, and then re-calibrate.
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 your sample. Note: you will need to re-do the calibration also.
14	1	Burn-in Failed	System failed to stabilize.	• Try to re-run sample. • Increase set baseline and re-calibrate. • 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): 0.1, 2.27, 8.2, 8.3, 9.1, 9.2, 9.3, 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. Contact MANTECH at support@mantech-inc.com if these error codes cannot be rectified.

To access the event log:

1) Press MENU, select Data and press ENTER.
2) In the Data menu, select Event Log and press ENTER.

The most recent event log will be displayed. Each log will contain the event number, an error code, a brief description corresponding to that error code, date and time. Use the Up and Down arrow touch keys to scroll through each log, and the Left and Right arrow touch keys to move from one log to another.

The PeCOD® L50 may shut down or loose partial display functionality if subjected to electrostatic discharge. In the event that this occurs, the user can restore normal operation by restarting the unit.

6.2 Removing Blockages from the PeCOD® Analyzer

The PeCOD® utilizes nanotechnology and the internal fluid lines may become obstructed by particles larger than 50uM in size. It is important to filter or settle samples containing particles large enough to block the internal components of the PeCOD®. However, should a blockage occur, back flushing Ports A and B will clear the blockage in most cases.

1. Obtain the syringe and tip kit supplied with the PeCOD® and fill a syringe with DI water. Use the appropriate sized tip for the hole indicated below.
2. Open the PeCOD® lid and remove the sensor.
3. Place the Port A tubing into a waste container as shown.
4. Insert the syringe with a narrow tip into the back, left hole as shown, the tip should fit snuggly into the hole so that no air is introduced.
5. Select MENU/ OPERATION / PRIME LINES / PRIME PORT A
6. 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 tubing and note any particles that are expelled into the waste beaker. Stop pushing the plunger when you hear the pump stop.
7. Repeat Step 6 a few times and ensure the flow out of Port A is strong.
8. Repeat the same process for Port B, using the same syringe tip and hole position.
9. Prime as normal to verify that the blockage has been removed.

7. Replacement Parts, Accessories and Consumables

Please contact:

MANTECH INC.
5473 Highway 6 North
Guelph, Ontario, Canada N1H 6J2
(519) 763-4245
www.mantech-inc.com
support@mantech-inc.com

Appendix 1 Warranty

Warranty

1.1 In addition to rights under statute, MANTECH warrants (to the original purchaser) that all instruments manufactured by MANTECH will be free from defects in materials and workmanship for a period of one year from the date of installation.

1.2 To the extent permitted by law, you will not be eligible to claim during the Warranty Period with respect to any instrument manufactured by MANTECH unless you complete the accompanying Instrument Registration Card and return it to the address specified within 30 days of installation.

1.3 In the event that you discover a defect in materials or workmanship during the Warranty Period, MANTECH will (at its option) repair or replace instruments or consumables returned to: MANTECH, 5473 Highway 6 North, Guelph, Ontario, Canada, N1H 6J2. Please contact MANTECH or an authorized representative to obtain an authorization report number before returning any instrument or consumable back to MANTECH. Non-MANTECH manufactured products are excluded from this warranty.

1.4 Any instruments or consumables repaired or replaced under this warranty will be warranted for the balance of the Warranty Period only. Replacement parts may be new, reconditioned, refurbished, re-manufactured or functionally equivalent and will be provided on an exchange basis only. Returned parts, replaced by MANTECH under warranty, become MANTECH's property upon receipt.

1.5 You will be responsible for any applicable import duties and tariffs and insure the instruments or consumables in transit back to MANTECH or accept the risk of loss or damage during such transportation. MANTECH will ship the repaired or replacement instruments or consumables to you freight prepaid but you will be responsible for all charges incurred in returning any defective instruments or consumables to MANTECH (and all costs associated with on-site warranty repair).

1.6 This warranty does not cover repair or reuse of consumables (or instruments in contact with biohazardous or hazardous materials) or damage, fault, failure or malfunction due to: installation, handling, use, storage, alteration, modification, maintenance or repair contrary to MANTECH's instructions (as set out in the accompanying operation manual); external causes, including misuse, abuse, accident or neglect; problems with electrical power or your hardware or software or any interface; failure by you to perform required preventive maintenance; normal wear and tear; acts of God, fire, flood, war, acts of violence or any similar occurrence; any attempt by a person not authorized by MANTECH to adjust, repair or support an instrument; and problems caused by use of parts not supplied by MANTECH.

1.7 You must ensure that all instruments that are in contact with biohazardous or hazardous materials are decontaminated prior to the return of those products to MANTECH under warranty.

1.8 To the extent permitted by law, MANTECH excludes all warranties (including, without limitation, any warranty as to merchantability or fitness for purpose), rights, remedies and liabilities (other than the warranty in clause 1) to you or any third party. Where implied conditions and warranties cannot be excluded, but can be limited, the liability of MANTECH for breach of such conditions and warranties is

limited, at MANTECH's option, to the repair or replacement of the instrument or consumable on the basis set out in these warranty terms.

Change to specifications

2.1 MANTECH reserves the right to alter the design and other technical specifications (and general description) of its instruments and consumables at any time. You accept that this may result in differences between the specification of instruments and consumables delivered to you (and the description and specification of Products ordered by you) from MANTECH or its authorized distributors.

Liability

3.1 You acknowledge and agree that MANTECH's liability to you or any third party and your rights against MANTECH are limited to those set out in these warranty terms and under statute.

3.2 To the extent permitted by law, you acknowledge and agree that MANTECH is not liable to you or any third party (in contract or tort or otherwise) for any loss or damage suffered in connection with:

a) instruments or consumables not being available for use;
b) data that is lost, corrupted, deleted or altered;
c) loss of (or failure to realize) anticipated savings, profits, revenues or data or other consequential or non-economic loss;
d) delays or business interruption (beyond the reasonable control of MANTECH); or
e) any exemplary or punitive damages, incurred by or awarded against you arising in any way out of the supply of an instrument or consumable by MANTECH (including as a result of MANTECH's negligence or any third party even if MANTECH has been advised of their possibility).

Appendix 2 Glossary of Terms

Baseline – the sensor baseline (µA) provides a target current background

Blank – a specific ratio mixture of DI water and PeCOD® electrolyte solution used as a 0ppm reference

BOD – biochemical oxygen demand

C Value - the C value (µC) is the raw charge generated during the blank oxidation

Calibrant – a known COD reference standard manufactured by MANTECH and mixed with PeCOD® electrolyte solution in a specific ratio

COD – chemical oxygen demand

Deionized water – water free of ions

Electrolyte – a salt solution manufactured by MANTECH, required to complete the PeCOD® oxidation reaction

Imax - the maximum Iwork value reached during a calibration or sample analysis

Iterm - the Iwork at the end of each oxidation curve as it reaches the baseline

Iwork - the measure of the current charge

LED – the LED (mA) is set during the first 90 seconds of a calibration

M Value – the M value (COD/µC) is a ratio of the expected COD to the charge generated during the reference oxidation of the calibrant solution

mg/L – milligrams per Litre

PeCOD® – a COD analyzer specifically designed for quantifying the organic content using a patented photo-electrochemical technique to determine COD

Potentiostat - the electronic hardware required to control a three-electrode cell

ppm – parts per million

PreBurn - designed to clean out any impurities or oxidation by-products present in the sensor cell prior to oxidation

touch key – active area on the user interface that acts as a button

Document Change Log

Version	Date	Author	Changes
2	7-Aug-2019	Heather Jasumani	• Document ID assigned • Formatting

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