ECO Fluorometer

ECO FL

User's Guide

The user's guide is an evolving document. If you find sections that are unclear, or missing information, please let us know. Please check our website periodically for updates.

WET Labs, Inc.
P.O. Box 518
Philomath, OR 97370
541-929-5650
fax: 541-929-5277
www.wetlabs.com

Attention!

Return Policy for Instruments with Anti-fouling Treatment

WET Labs cannot accept instruments for servicing or repair that are treated with anti-fouling compound(s). This includes but is not limited to tri-butyl tin (TBT), marine anti-fouling paint, ablative coatings, etc.

Please ensure any anti-fouling treatment has been removed prior to returning instruments to WET Labs for service or repair.

ECO Sensor Warranty

This unit is guaranteed against defects in materials and workmanship for one year from the original date of purchase. Warranty is void if the factory determines the unit was subjected to abuse or neglect beyond the normal wear and tear of field deployment, or in the event the pressure housing has been opened by the customer.

To return the instrument, contact WET Labs for a Return Merchandise Authorization (RMA) and ship in the original container. WET Labs is not responsible for damage to instruments during the return shipment to the factory. WET Labs will supply all replacement parts and labor and pay for return via 3rd day air shipping in honoring this warranty.

Shipping Requirements for Warranty and Out-of-warranty Instruments

1. Please retain the original shipping material. We design the shipping container to meet stringent shipping and insurance requirements, and to keep your meter functional.

2. To avoid additional repackaging charges, use the original box (or WET Labs-approved container) with its custom-cut packing foam and anti-static bag to return the instrument.
   - If using alternative container, use at least 2 in. of foam (NOT bubble wrap or Styrofoam “peanuts”) to fully surround the instrument.
   - Minimum repacking charge for ECO meters: $25.00.

3. Clearly mark the RMA number on the outside of your shipping container and on all packing lists.

4. Return instruments using 3rd day air shipping or better: do **not** ship via ground.

Table of Contents

1. Overview

WET Labs offers a range of the *Environmental Characterization Optics* (***ECO)*** series fluorometers for the following measurements: chlorophyll, Colored Dissolved Organic Matter, uranine, rhodamine, and phycoerythrin. This section includes meter and connector specifications, delivered items and descriptions of features, including internal batteries and *bio-wiper*™.

1.1 Specifications

FL(RT)—Provides analog or RS-232 serial output with 4,000-count range. This unit provides continuous operation when powered.
FL(RT)D—Provides the capabilities of the FL(RT) with 6,000-meter depth rating.
FL—Provides the capabilities of the FL(RT) with periodic sampling.
FLS—Provides the capabilities of the FL with an integrated anti-fouling *bio-wiper*™.
FLB—Provides the capabilities of the FL with internal batteries for autonomous operation.
FLB—Provides the capabilities of the FLS with internal batteries for autonomous operation.

	FL(RT)	FL(RT)D	FL	FLS	FLB	FLSB
Mechanical						
Diameter	2.48 in (6.3 cm)					
Length	5.0 in (12.7 cm)	7 in (17.8 cm)	5.0 in (12.7 cm)	5.25 in (13.3 cm)	10.0 in (25.4 cm)	10.25 in (26.0 cm)
Weight (in air)	0.9 lbs (0.4 kg)	2.86 lbs (1.3 kg)	0.9 lbs (0.4 kg)	1.1 lbs (0.5 kg)	2.1 lbs (0.96 kg)	
Weight (in water)	0.05 lbs (0.02 kg)	1.66 lbs (0.75 kg)	0.05 lbs (0.02 kg)	0.19 lbs (0.08 kg)	0.3 lbs (0.14 kg)	
Pressure housing	acetal	titanium	Acetal copolymer			
Environmental						
Temperature range	0–30 deg C					
Depth rating	600 m	6000 m	600 m	300 m		
Optional pressure sensor	--	--				
Optional thermistor						
Electrical						
Digital output resolution	14 bit					
Analog output signal	0–5 V					
Internal data logging	No	No	Yes			
Internal batteries	No				Yes	
Connector	MCBH6M					
Input voltage	7–15 VDC					
Current, typical	80 mA					
Current, sleep	--		85 µA			
Data memory	--		65,000 samples			
Sample rate	to 8 Hz					
RS-232 output	19200 baud					
Optional Anti-fouling bio-wiper	N			Y	N	Y
Bio-wiper™ cycle	--			140 mA	--	140 mA

Optical Specifications for Fluorescence Meters

Ranges given below are typical. Other ranges are available on request.

Chlorophyll-*a* (CHL)
Ex/Em: 470/695 nm • Sensitivity: 0.01 µg/l • Linearity: 99% R^2 • Range: 0.01–125 µg/l

Colored Dissolved Organic Matter (CD)
Ex/Em: 370/460 nm • Sensitivity: 0.09 ppb • Linearity: 99% R^2 • Range: 0.09–500 ppb

Uranine (fluorescein) (UR)
Ex/Em: 470/530 nm • Sensitivity: 0.07 ppb • Linearity: 99% R^2 • Range: 0.07–1200 ppb

Rhodamine (Rh)
Ex/Em: 540/570 nm • Sensitivity: 0.01 ppb • Linearity: 99% R^2 • Range: 0.01–230 ppb

Phycoerythrin (PE)
Ex/Em: 540/570 nm • Sensitivity: 0.01 ppb • Linearity: 99% R^2 • Range: 0.01–230 ppb

1.2 Connectors

ECO-series digital fluorometers use a six-pin bulkhead connector. The pin functions for this connector are shown in Figure 1. Table 1 summarizes pin functions for the bulkhead connectors.

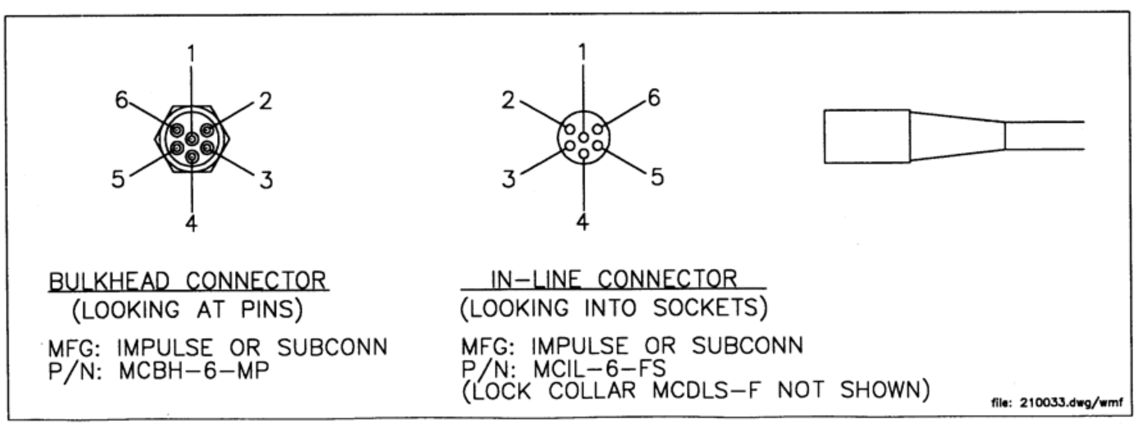


Figure 1. *ECO* FL connector schematic

Table 1. Pinout summary for *ECO* connectors

Pin (or Socket)	Function
1	Ground
2	RS-232 (RX)
3	Reserved
4	V in
5	RS-232 (TX)
6	Analog out

WARNING

If you are going to build or use a non-WET Labs-built cable, do not use the wire from pin 3 or the *ECO* meter will be damaged.

Input power of 7–15 VDC is applied to pin 4. The power supply current returns through the common ground pin. The input power signal has a bi-directional filter. This prevents external power supply noise from entering into *ECO* FL, and also prevents internally generated noise from coupling out on to the external power supply wire. Data is sent out the serial output pin.

1.2.1 ECO FLB, FLSB Connectors

ECO FLB and FLSB (units with internal batteries) have a second bulkhead connector that comes with a jumper plug to supply power to the unit. The pin functions for this connector are shown in Figure 2. Table 2 summarizes pin functions for the 3-socket bulkhead connector.

FLB and FLSB (internal battery units) are supplied with a jumper plug that provides power from the internal batteries for autonomous operation. (Power is supplied from pin 6 to pin 4.)

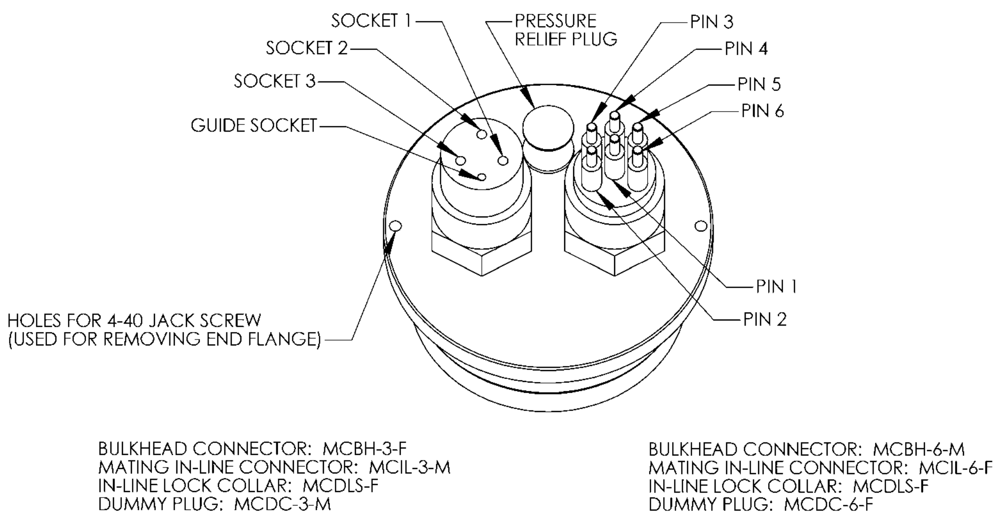


Figure 2. *ECO* FLB and FLSB connector schematic

Table 2. Pinout summary for *ECO* FLB/FLSB 3-socket connector

Pin (or Socket)	Function
1	V in
2	N/C
3	Battery out

1.3 Delivered Items

The standard ECO delivery consists of the following:

- the instrument itself
- dummy plug with lock collar
- protective cover for optics
- this user's guide
- ECOView user's guide
- ECOView host program and device files (on CD)
- instrument-specific calibration sheet
- FL(RT), FL, FLS only: stainless steel mounting bracket and hardware (See Appendix A for details)
- Internal battery units: six 9-V Lithium batteries (installed)

Spare Parts

- Fluorescent stick for bench testing
- One 3/32-in. hex key for *bio-wiper*™ removal (units with *bio-wiper*™ only)
- Three 4-40 x 3/8 in. 316 stainless steel replacement screws (units with bio-wiper™ only)
- Silicone oil (Dow Corning DC200) (pressure sensor-equipped units only)
  Additional spare parts for internal battery units
  - ❑ Two end flange O-rings (size 224) and two vent plug O-rings (size 010)
  - ❑ Two jacking screws for connector flange removal
  - ❑ One 3/32-in. hex key for jacking screws
  - ❑ Power plug for autonomous operation
  - ❑ Three pre-cut segments (7 inches) of 0.036-inch diameter monofilament for end flange
  - ❑ Three pre-cut segments (0.25 inches) of 0.094-inch diameter white nylon bar stock for replacing the white plastic dowel pin.

1.4 Optional Equipment

1.4.1 Test Cable

A test cable is optionally available with each unit. This cable includes three legs:

1. A connector for providing power to the instrument from a user-supplied 9V battery.
2. A DB-9 serial interface connector.
3. A six-socket in-line connector for providing power and signal to the instrument.

1.4.2 Copper Faceplate

ECO meters are optionally equipped with copper faceplates to improve the meter's resistance to biofouling. Refer to Section 3.5.1 for important details on maintenance and cleaning.

1.4.3 Bio-wiper™ and Copper Faceplate

The FLNTUS and FLNTUSB are equipped with an integrated non-contact anti-fouling *bio-wiper*™ and copper faceplate for use in extended deployments. This wiper can be manually controlled by a host controller package, or can perform autonomously as part of a pre-programmed sampling sequence upon instrument power-up. The rate of closure and opening is dependent upon both temperature and depth.

Refer to Section 3.5.1 for important details on the maintenance and cleaning of the *Bio-wiper*™ and copper faceplate.

WARNING!
Do **NOT** rotate the *Bio-wiper*™ manually. This can damage the wiper motor and will void the warranty.

1.4.4 Batteries

ECO units with internal batteries are supplied with six 9-volt Lithium batteries as their power source. They can use either standard alkaline cells for a total capacity of approximately 1000 mA-hrs, or for longer deployments, $LiMnO_2$ cells to achieve more than 2000 mA-hrs of operational capacity. Actual total usage time of the internal batteries is a function of several parameters. These include nominal water temperature, sequence timing, sample periods, and total deployment duration.

WARNING!
Pin 6 is always "hot." Be sure to keep the dummy plug on the FLB and FLSB when not in use.

For even greater deployment capability contact WET Labs for information on external battery packs.

1.4.5 External Thermistor

ECO meters are optionally equipped with an external thermistor. The thermistor is calibrated at WET Labs and the calibration coefficients are supplied on the instrument's calibration sheets. Thermistor output is in counts and can be converted into engineering units using the instrument's device file and ECOView software or the raw data can be converted in the user's software (e.g. MATLAB or Excel) using the calibration equation:

Temperature (deg C) = (Output * Slope) + Intercept

1.4.6 Pressure Sensor

ECO meters are optionally equipped with a strain gauge pressure sensor. The pressure sensor is calibrated at WET Labs and the calibration coefficients are supplied on the instrument's calibration sheets. Pressure sensor output is in counts and can be converted into engineering units using the instruments device file and ECOView software or the raw data can be converted in the user's software (e.g. MATLAB or Excel) using the calibration equation:

Relative Pressure (dbar) = (Output * Slope) + Intercept

Please note that strain gauge pressure sensors are susceptible to atmospheric pressure changes and should be "zeroed" on each deployment or profile. The calibration equation for pressure above should be used first to get the relative pressure and the cast offset should then be subtracted to get the absolute pressure:

Absolute Pressure (dbar) = Relative Pressure (dbar) - Relative Pressure at Atmospheric/Water interface (dbar)

WARNING!
Do not exceed the pressure sensor's depth rating (see calibration sheet).

Pressure Sensor Maintenance

A plastic fitting and capillary tube, both filled with silicone oil, provide a buffer between the pressure transducer and seawater. The transducer is both sensitive and delicate. Following the procedures below will ensure the best results and longest life from your pressure sensor.

Pressure is transmitted from the water to the stainless steel transducer diaphragm via a capillary tube filled with silicone oil. The inert silicone oil protects the pressure sensor from corrosion, which would occur after long exposure to salt water. The capillary tube will generally prevent the oil from escaping from the reservoir into the water. However, you may occasionally wish to ensure that oil remains in the reservoir on top of the transducer.

WARNINGS!
Never touch or push on the transducer.
Never attempt to fill the reservoir except by the procedure below.

Refilling procedure

1. Thoroughly clean the top of your instrument.
2. Completely remove the white nylon Swagelock fitting using a 9/16-in. wrench.
3. Add silicone oil (Dow Corning DC200) to within 1/16-in. of the top of the threaded cavity.
4. Wipe clean the o-ring at the base of the Swagelock fitting.
5. Hold a tissue over the end of the capillary tube.
6. Screw the Swagelock fitting into the end flange until finger tight.
7. Tighten it an additional 1/8 turn using a wrench only if necessary.
8. Wipe up any excess oil that may have squirted out of the capillary tube.

Hints

- If you can see drops of oil in the capillary tube, refilling is unnecessary.
- Rinsing the instrument with fresh water will help keep the tube end open.

2. Theory of Operation

The *Environmental Characterization Optics*, or *ECO* miniature fluorometer allows the user to measure relative chlorophyll, CDOM, uranine, phycocyanin, or phycoerythrin concentrations by directly measuring the amount of fluorescence emission in a sample volume of water. The *ECO* uses an LED to provide the excitation source. An interference filter is used to reject the small amount of out-of-band light emitted by the LED. The light from the source enters the water volume at an angle of approximately 55–60 degrees with respect to the end face of the unit. Fluoresced light is received by a detector positioned where the acceptance angle forms a 140-degree intersection with the source beam. An interference filter is used to discriminate against the scattered excitation light.

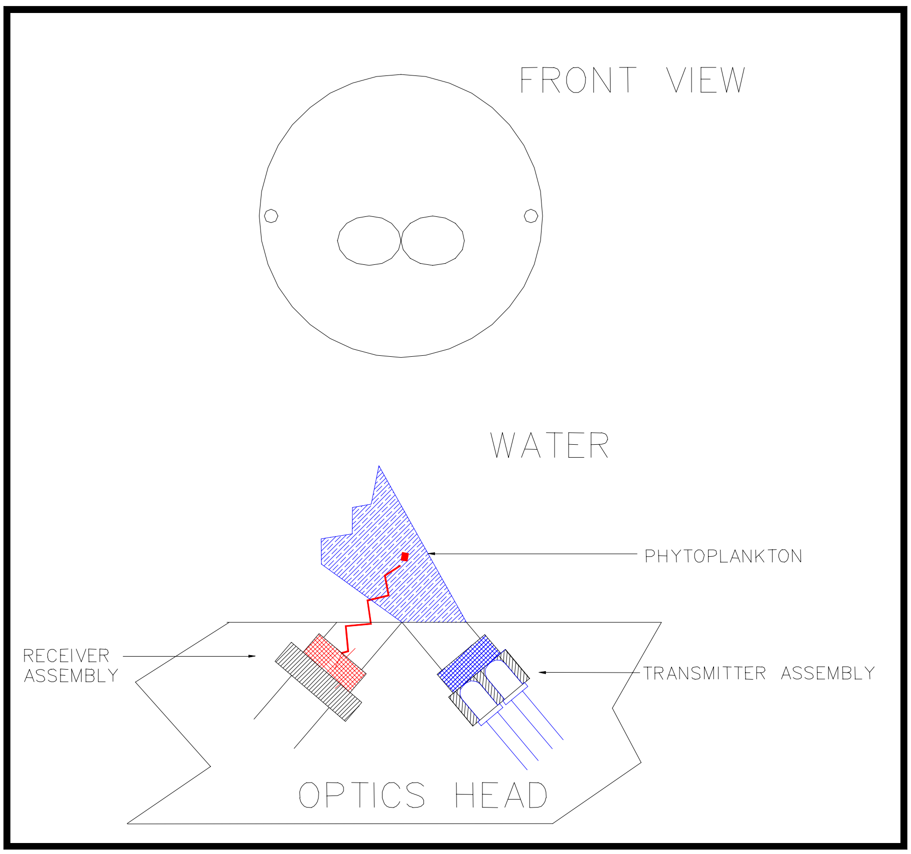


Figure 3. Optical configuration of *ECO* fluorometer

3. Instrument Operation

Please note that certain aspects of instrument operation are configuration-dependent. These are noted where applicable within the manual.

3.1 Initial Checkout

Supplied from the factory, *ECO*s are configured to begin continuously sampling upon power-on. Electrical checkout of *ECO* is straightforward.

Connect the 6-socket connector on the optional test cable to the instrument to provide power to the LEDs and electronics (see Section 1 for a diagram of the pinouts of *ECO* FL). Connect the battery leads on the test cable to the 9V battery supplied with the meter. Light should emanate from the meter.

3.1.1 Analog Option

Connect a digital multimeter (DMM) to the auxiliary leg of the test cable: the center of the RCA connector provides analog out signal and the outside provides ground. With the sensor face clean and dry the instrument should read approximately 0.050–0.095 VDC. The analog signal will saturate at 5 volts.

3.2 Operating the Sensor for Data Output

Note

ECO meters are sensitive to AC light. Before making measurement, turn AC lighting off.

1. Connect the 6-socket connector to the instrument to provide power to the LEDs and electronics. Connect the DB-9 connector to a computer with the ECOView host program installed on it.

WARNING!

Always use a regulated power supply to provide power to ECO sensors if not using the 9V battery provided with the test cable: power spikes may damage the meter.

2. Start ECOView. Select the appropriate COM Port and Device File. Supply power to the meter, then click on the Start Data button. Output will appear in the Raw Data window. Test the instrument's signal using the fluorescent stick. *ECO* is sensitive to room lighting; for best results, perform test in ambient light only (turn off AC lighting). Remove the protective cover. Hold the fluorescent stick 1–4 cm above the optical paths in an orientation that maximizes exposure of the stick. (Parallel with the beams, not intersecting them). The signal will increase toward saturation (maximum value on characterization sheet). When applying power to sensors with a *bio-wiper*™, it will open and, depending on the settings, operate until you select Stop Data in ECOView (or input `!!!!!` in a terminal program) The *bio-wiper*™ will close and the instrument will await the next command.

3. If the sensor completes the requested samples (this is common for meters set up in moored applications), it will go into sleep mode, and the meter will not light when power is cycled. To "wake" the meter, click Stop Data five times at the rate of two times a second immediately upon supplying power. This interrupts the sensor, returning it to a "ready" state, awaiting commands.

4. Check the settings for the ECO and change if necessary. ECOView factory settings for continuous operation:
   - Set Number of Samples = 0
   - Set Number of Cycles = 0.

5. If the meter does not light after performing step 3, check the battery. Replace if necessary, perform steps 2 and 3 to verify communication. If it still does not light, contact WET Labs.

Refer to the ECOView User's Guide for details about using the software.

3.3 *Bio-wiper*™ Operation

The *ECO*-FLS and -FLSB are provided with an anti-fouling *bio-wiper*™ and faceplate that extend the possible deployment duration by retarding biological growth on the instrument's optical surface. The *bio-wiper*™ covers the optical surface: 1) while the instrument is in "sleep" mode; 2) when it has completed the number of samples requested; and 3) when the user selects Stop Data in ECOView or types "!!!!!" in a terminal program. When the meter wakes up, the optical surface is exposed by the *bio-wiper's*™ counter-clockwise rotation.

If power is shut off in mid cycle, the *bio-wiper*™ will reinitialize to the beginning of the user-selected settings when power is applied again.

Caution

Do **NOT** manually rotate the *Bio-wiper*™. This will void the warranty.

3.4 Deployment

Once power is supplied to the ECO meter, the unit is ready for submersion and subsequent measurements. Some consideration should be given to the package orientation. Do not face the sensor directly into the sun or other bright lights. For best output signal integrity, locate the instrument away from significant EMI sources.

Other than these basic considerations, one only needs to make sure that the unit is securely mounted to whatever lowering frame is used and that the mounting brackets are not damaging the unit casing.

Note

FLB and FLSB: Always check vent seal plug for full insertion immediately prior to deployment.

3.5 Upkeep and Maintenance

We highly recommend that ECO meters be returned to the factory annually for cleaning, calibration and standard maintenance. Contact WET Labs or visit our website for details on returning meters and shipping.

After each cast or exposure of the instrument to natural water, flush with clean fresh water, paying careful attention to the sensor face. Use soapy water to cut any grease or oil accumulation. Gently wipe clean with a soft cloth. The sensor face is composed of ABS plastic and optical epoxy and can easily be damaged or scratched.

WARNING!
Do not use acetone or other solvents to clean the sensor.

3.5.1 Bio-wiper™ and Faceplate Cleaning and Maintenance

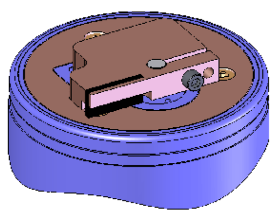
The *bio-wiper*™ and the copper faceplate need to be removed from the meter for thorough cleaning to maximize anti-fouling capability.

1. Be sure the meter is **NOT** powered or connected to a power source prior to uninstalling the *bio-wiper*™ and faceplate.

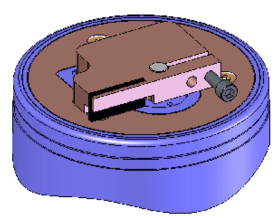
WARNING!
Manually turning the motor shaft can damage the wiper motor and will void the warranty.

Make sure the *bio-wiper*™ is loosened from the shaft before attempting to rotate the *bio-wiper*™.

2. Remove *bio-wiper*™: Use the factory-supplied 3/32-in. hex key to loosen the screw that secures the wiper to the shaft on the instrument. It may be necessary to remove the screw from the clamping hole and screw it into the releasing hole, tightening it just enough to free the *bio-wiper*™ from the shaft.



clamping screw hole



releasing screw hole

3. Remove faceplate: Use a small Phillips screwdriver to remove the screws that attach the plate to the optics head.

WARNING!
Be sure to retain and re-use the factory-installed screws as they are vented for pressure compensation.

4. Wash *bio-wiper*™ and/or copper faceplate with soapy water. Rinse and dry thoroughly. Note the condition of the copper on the instrument side of the wiper. It is normal for copper to corrode and turn green, especially after the instrument has been removed from the water. This corrosion will slightly reduce the shutter's anti-fouling ability the next time it is deployed.

5. Buff each with a pad of green Scotch Brite® (or similar) until shiny.

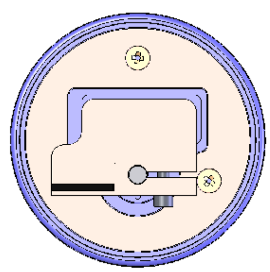
6. Clean the *bio-wiper*™ shaft and the shaft hole using an isopropyl alcohol-saturated cotton swab. Allow to dry.

7. Re-install faceplate.

8. Check the screw used to secure the bio-wiper to the shaft: a hex key must fit snugly into the screw socket. If the socket is in any way compromised, use a new screw (4-40 x 3/8 in. 316 stainless steel treated with anti-seize. These are shipped as part of the meter's spare parts kit.)

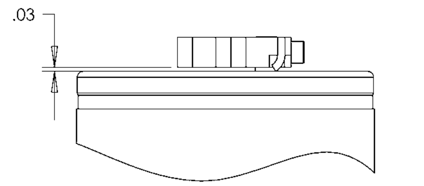
9. Slide the *bio-wiper*™ over the shaft. Be careful not to twist it on, thus rotating the shaft. If the wiper does not slide on easily, insert the screw into the expander hole, turning slowly until the b*io-wiper*™ slides easily onto the shaft.

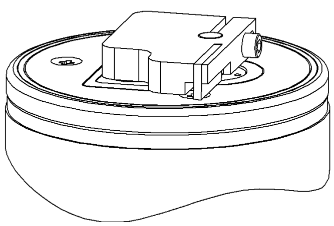
10. Rotate the *bio-wiper*™ into the closed position.



11. Set the gap between the b*io-wiper*™ and the instrument face to 0.03 in. (0.8 mm). An improperly set gap will either fail to clean the face or cause the motor to draw excessive current.

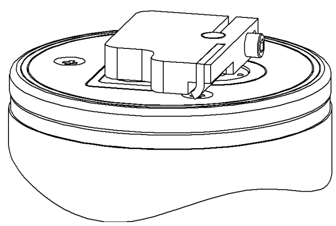
    To gauge 0.03 in., fold a piece of paper in half, then in half again, then fold a third time, creasing the edges. It's now 8 sheets and about 0.03 in. thick.





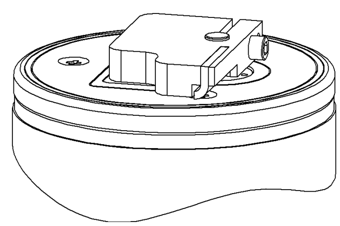
Not enough flex.

Wiper may not be effective.



Proper flex.

Wiper maintains contact with instrument face and optical window.



Too much flex.

Wiper may cause too much friction, using excessive power.

12. Use the 3/32-in. hex key to tighten the screw to "finger-tight," then snug an additional quarter-turn.

13. Run the instrument to verify operation. The *bio-wiper*™ must rotate 180 degrees to clear the optics before sampling, and 180 degrees to cover the optics after sampling.

14. If the wiper needs adjusting, loosen the screw, make any necessary adjustments, and repeat steps 9 through 13 to ensure the wiper is performing properly.

4. FLB and FLSB: Using Internal Batteries

ECO sensors powered with internal batteries can either run directly from the internal batteries or can operate from power supplied by an external DC power supply (7–15 volts). Internal-to-external source conversion is facilitated by a jumper plug that plugs into the unit's bulkhead connector. When inserted, the plug forms a connection from the battery to the electronics power supply. By removing the plug, the instrument can be powered and communicate via a test or deployment cable. Setup conditions, instrument checkout, real-time operation, and data downloading are thus all achieved identically to the methods prescribed for the FL and FLS units.

4.1 Removing End Flange and Batteries

WARNING!

Changing the batteries will require opening the pressure housing of the ECO sensor. Only people qualified to service underwater oceanographic instrumentation should perform this procedure. If this procedure is performed improperly, it could result in catastrophic instrument failure due to flooding or in personal injury or death due to abnormal internal pressure as a result of flooding.

WET Labs Inc. disclaims all product liability from the use or servicing of this equipment. WET Labs Inc. has no way of controlling the use of this equipment or of choosing qualified personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws that impose a duty to warn the user of any dangers involved with the operation and maintenance of this equipment. Therefore, acceptance of this equipment by the customer shall be conclusively deemed to include a covenant by the customer to defend and hold WET Labs Inc. harmless from all product liability claims arising from the use and servicing of this equipment. Flooded instruments will be covered by WET Labs Inc. warranties at the discretion of WET Labs, Inc.

1. Make sure the instrument is thoroughly dry.
2. Remove the dummy plugs.
3. With connector end flange pointed downwards away from face, release seal from vent plug.
4. Remove moisture from vent plug area.
5. Using needle nose pliers, remove filament from end flange.
6. Lift flange from pressure housing until seal is broken. The jacking screws can be used to "push" the flange from the pressure housing and then can be removed or left in the end flange.
7. Remove any excess moisture from flange–can seal area.
8. Work end flange out of pressure housing and remove any residual moisture. Remove the gray foam spacer and the neoprene insulator.
9. The battery pack is connected to the processor boards by a six-pin Molex connector: do NOT pull too hard or far on the battery pack or it will come unplugged and the unit returned to WET Labs.
10. Gently pull the white cord at the loop to remove the battery pack from the pressure housing.

11. Remove the black plastic protectors from the ends of the long screws securing the batteries.
12. Loosen and remove the screws (3/16-in slotted driver).

4.2 Replacing End Flange and Batteries

1. Replace the batteries.
2. Re-install the screws:
   - Align the groove in each of the plates so the six-wire extension bundle will fit in it along its length.
   - Be careful not to cross-thread into the bottom end plate nor to over-tighten the screws.
   - If they are too tight, the fiber washers that act as separators between the batteries will flex.
   - Make sure there are equal amounts of screw threads protruding from the bottom end plate when they are secure. This will ensure the pack is straight and will fit into the pressure housing with no difficulty.
3. Re-install the black plastic protective covers on the ends of the screws.
4. Remove and check the pressure housing O-ring for nicks or tears. Replace if necessary. Before re-installing, apply a light coat of vacuum grease on the O-ring.
5. Carefully replace the battery pack in the pressure housing. Place the neoprene insulator on the battery assembly and lay the white cord on the top.
6. Plug in the two-pin, then the six-pin Molex connectors. Sensor operation can now be tested if desired.
7. Align the hole in the end flange (NOT the jack screw holes) with the white dowel pin. While coiling the six wire bundle and making sure none are pinched between the end flange and the pressure housing, position the flange on the housing. Leave space to re-insert the gray foam spacer, making sure the cut-out accommodates the vent plug screw.
8. Push the end flange all the way on to the pressure housing, making sure no wires are pinched. Be sure the vent plug does not pop up. If it does, you'll need to re-position the foam spacer.
9. Re-insert the monofilament.

4.3 Checking Vent Plug

If there is fouling on the vent plug, it should be cleaned and the two 010 O-rings replaced. Otherwise, this mechanism should be maintenance-free.

WARNING!

The pressure housing is made of plastic material that scratches easily. Do not let the screwdriver slip and scratch the can when removing or replacing the vent plug. Use a toothpick (something softer than the plastic) to remove the O-rings from the vent plug.

1. Pull vent plug out about half way; hold plug while unscrewing the truss screw. When screw is removed, pull vent plug from end flange.
2. "Pinch" bottom O-ring around vent plug to form a small gap you can work a toothpick into. Use the toothpick to help roll the bottom O-ring off the plug.
3. Perform the same procedure with the top O-ring.
4. Clean the vent plug and vent plug hole using a dry lint-free tissue or cotton swab.
5. Lightly coat two undamaged or new O-rings with silicon grease. Install the top O-ring (nearest to large end of plug) first, then the bottom one.
6. Insert vent plug into its hole in the end flange and hold it while inserting the truss screw. Rotate the vent plug to begin tightening the screw. Finish tightening using a screwdriver, being careful not to overtighten truss screw.

Note

A portion of the truss screw head has been removed to allow for venting in case of pressure buildup.

5. Data Analysis

Raw data from the *ECO* meter is output in counts from the sensor, ranging from 0 to approximately 16000. The ECOView host program will automatically perform the necessary calculations for fluorescence data in the form of µg/l (chlorophyll), or ppb (other fluorescence measurements).

5.1 Scale Factor

The scale factor is factory-calculated by obtaining a consistent output of a solution with a known concentration, then subtracting the meter's dark counts. The scale factor, dark counts, and other characterization values are given on the instrument's characterization sheet.

For chlorophyll, WET Labs uses the chlorophyll equivalent concentration (CEC) as the signal output using a fluorescent proxy approximately equal to 25 µg/l of a *Thalassiosira weissflogii* phytoplankton culture.

Scale Factor = 25 µg/l ÷ (Chl Equivalent Concentration – dark counts)
For example: 25 ÷ (3198 – 71) = 0.0080.

For CDOM, uranine (fluorescein), and phycoerythrin, WET Labs uses a solution where *x* is the meter output in counts of the concentration of the solution used during instrument characterization.

Scale Factor = 308 ppb ÷ (meter output, counts – dark counts)
For example: 308 ÷ (4148 - 56) = 0.0753.

The scale factor is then applied to the output signal to provide the direct conversion of the output to chlorophyll concentration. WET Labs supplies a scale factor that can be found on the instrument-specific calibration sheet that ships with each meter. While this constant can be used to obtain approximate values, field calibration is highly recommended.

5.2 Analog Response

The *ECO* FL response is linear over the measurement range provided. Because of the varied environments in which each user will work, it is important to perform calibrations using similar seawater as you expect to encounter *in situ.* Refer to characterization section for further details. This will provide an accurate blank, equivalent phytoplankton types and similar physiological conditions for calculating the scale factor, thereby providing an accurate and meaningful calibration. Once a zero point has been determined and a scale factor established, the conversion of DC volts to chlorophyll, CDOM, uranine, or phycoerythrin concentration is straightforward using the equation:

$$[XX]_{sample} = (V_{output} - V_{dc}) * \text{Scale Factor}$$

where

$[XX]_{sample}$ = concentration of a sample of interest (μg/l or ppb)
V_{output} = voltage output when measuring a sample of interest
V_{dc} = dark counts, the measured signal output (in VDC) of meter in clean water with black tape over the detector
Scale factor = multiplier in μg/l/volts or ppb/volts

5.3 Digital Response

Digital data is processed in a similar fashion to analog data. Scaling is linear, and obtaining a "calibrated" output simply involves subtracting a digital dark counts value and multiplying the difference by the instrument scaling factor.

$$[XX]_{sample} = (C_{output} - C_{dc}) * \text{Scale Factor}$$

where

$[XX]_{sample}$ = concentration of a sample of interest (μg/l or ppb)
C_{output} = raw counts output when measuring a sample of interest
C_{dc} = dark counts, the measured signal output of meter in clean water with black tape over the detector
Scale factor = multiplier in μg/l/counts or ppb/counts

6. Characterization and Testing

Each meter is configured for a typical measurement range given in Section 1.1. Gain selection is done at WET Labs by setting several gain settings inside the instrument, and running a dilution series to determine the zero voltage offset and to ensure that the dynamic range covers the measurement range of interest. The dilution series also establishes the linearity of the instrument's response. As is the case with other fluorometers, a detailed characterization must be done by the user to determine the actual zero point and scale factor for his/her particular use.

6.1 Testing

When the instrument is completely assembled, it goes through the tests below to ensure performance.

6.1.1 Dark Counts

Pure, de-ionized water is used to set the "zero" level of the meter. This zero level is set for 125 counts (+/-75) on all models.

6.1.2 Pressure

To ensure the integrity of the housing and seals, ECOs are subjected to a wet hyperbaric test before final testing. The testing chamber applies a water pressure of at least 50 PSI.

6.1.3 Mechanical Stability

Before final testing, the *ECO*-FL meters are subjected to a mechanical stability test. This involves subjecting the unit to mild vibration and shock. Proper instrument functionality is verified afterwards.

6.1.4 Electronic Stability

This value is computed by collecting a sample once every 5 seconds for twelve hours or more. After the data is collected, the standard deviation of this set is calculated and divided by the number of hours the test ran. The stability value must be less than 2.0 mV/Hour.

6.1.5 Noise

Noise is computed from a standard deviation over 60 samples. These samples are collected at one-second intervals for one minute. A standard deviation is then performed on the 60 samples, and the result is the published noise on the calibration form. The calculated noise must be below 2 counts.

6.1.6 Voltage and Current Range Verification

To verify the *ECO* operates over the entire specified voltage range (7–15 V), a voltage test is performed at 7 and 15V, and the current draw and operation is observed. The current must remain constant at both 7 and 15V.

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7. Terminal Communications

As an alternative to the ECOView host software, *ECO* sensors can be controlled from a terminal emulator or customer-supplied interface software. This section outlines hardware requirements and low-level interface commands for this type of operation.

7.1 Interface Specifications

- baud rate: 19200
- data bits: 8
- parity: none
- stop bits: 1
- flow control: none

7.2 Command List

Command	Parameters passed	Description
!!!!!	none	Stops data collection; allows user to input setup parameters. Note that if the meter is in a sleep state, the power must be turned off for a minute, then powered on while the "!" key is held down for several seconds. If this does not "wake" the meter, refer to the ECOView user's guide Operation Tip to "wake" a meter in a low power sleep state to enable inputting setup parameters.
$asv	1, 2, or 4	Analog scaling value. Counts will be divided by this for analog output: a value of 4 will make the analog output cover the whole output range; 2 will cover half, and 1 will cover only the bottom fourth of the 14-bit count range (fluorometers only).
$ave	single number, 1 to 65535	Number of measurements for each reported value
$clk	24hr format time, hhmmss	Sets the time in the Real Time Clock
$dat	date, format ddmmyy	Sets the date in the Real Time Clock
$emc	none	Erases the Atmel memory chip, displays menu when done
$get	none	Reads data out of Atmel memory chip. Prints "etx" when completed.
$int	24hr format time, hhmmss	Time interval between packets in a set
$mnu	none	Prints the menu, including time and date
$pkt	single number, 0 to 65535	Number of individual measurements in each packet
$rec	1 (on) or 0 (off)	Enables or disables recording data to Atmel memory chip
$rls	none	Reloads settings from flash
$run	none	Executes the current settings
$set	single number, 0 to 65535	Number of packets in a set
$sto	none	Stores current settings to internal flash
$ugl	0 to 255	µg/l conversion value (calculates slope x 10,000). Fluorometer only.

8. Device and Output Files

Each meter is shipped with a CD containing the meter-specific device file, a sample output file, characterization information, ECOView host program, and the applicable user's guides.

The ECOView host program requires a device file to provide engineering unit outputs for any of its measurements. Except for the first line in the device file, all lines of information in the device file that do not conform to one of the descriptor headers will be ignored. Every ECOView device file has three required elements: Plot Header, Column Count Specification, and Column Description.

8.1 Plot Header

The first line in the device file is used as the plot header for the ECOView Plots.

8.2 Column Count Specification

The Column Count Specification identifies how many columns of data to expect. It follows the format "Column=n." The Column Count Specification must be present before any of the Column Descriptions are listed.

8.3 Column Description

Every column in the ECO meter's output must have a corresponding Column Description in the device file. The following notation is used in identifying the elements of each Column Description.

x = the column number, starting with 1 as the 1st column
sc = scale
dc = dark counts—meter output in clean water with optics head taped
mw = measurement wavelength—wavelength used by the sensor for its measurement
dw = display wavelength—wavelength/color range (380–780 nm)
v = measured volts dc

Valid Column Descriptions are listed in the subsections below.

8.3.1 Fluorescence Measurements

CHL=x sc dc
IENGR=x
PHYCOERYTHRIN=x sc dc
URANINE=x sc dc
RHODAMINE=x sc dc
CDOM=x sc dc

8.3.2 Miscellaneous

Date=x	MM/DD/YY
Time=x	HH:MM:SS
REF=x	Reference Counts—Currently not used by ECOView
N/U=x	The column is Not Used

Single sensor fluorometers have optional parameters that can be used to modify either the analog output or the internally calculated engineering units output. To vary the output range of a single sensor fluorometer, use the following parameters:

maxvoltage=v
ASV1=sc1
ASV2=sc2
ASV4=sc4

where v is the maximum output of the sensor, and scx is a engineering units per volt scale for each scale setting. Multiply v by scx to get the maximum output value for each Analog Scale Setting. These parameters will appear on the FL-Setup tab of ECOView.

The internally calculated fluorescence values, the engineering scale, offset, and output can be set by the user from the FL-Setup tab. They are listed below as a reference to the factory settings for the user when the user manually adjusts the scale and offsets that are used in the engineering unit calculations. Engineering units are displayed through ECOView where appropriate. The parameters for changing the internally calculated engineering units are:

iengrscale=sc
iengroffset=off
iengrunits=label   where label is any continuous character string.

8.4 Sample Device File

Below is a sample device file without engineering output for an ECO FL with an external thermistor.

```
ECO          FLSB-322
Created on:  6/23/2005

:   chl=ug/l
:     "iengrunits = µg/l for CHL. ppb for CDOM, uranine, PE."
:     column 5 = input scale factor and offset.

maxvoltage= 4.96
asv1=        6.4569
asv2=        12.9086
asv4=        25.8692
```

COLUMNS=5
N/U=1
N/U=2
N/U=3
Chl=4 0.0078 65
XTEMP=5 -0.0057 72.8832

Below is a sample device file **with** engineering output for an ECO FL with an external thermistor.

ECO FLSB-322
Created on: 06/23/05

iengrunits=µg/l
iengrscaleoffset=5

: chl=ug/l
: "iengrunits = µg/l for CHL, PC, PE. Ppb for CDOM and uranine."
: column 5 = input scale factor and offset.

maxvoltage= 4.96
asv1= 6.4569
asv2= 12.9086
asv4= 25.8692

: Has internal CHL in meter output

COLUMNS=6
N/U=1
N/U=2
IENGR=3
N/U=4
Chl=5 0.0078 65
XTEMP=6 -0.0057 72.8832

8.5 Sample Output File

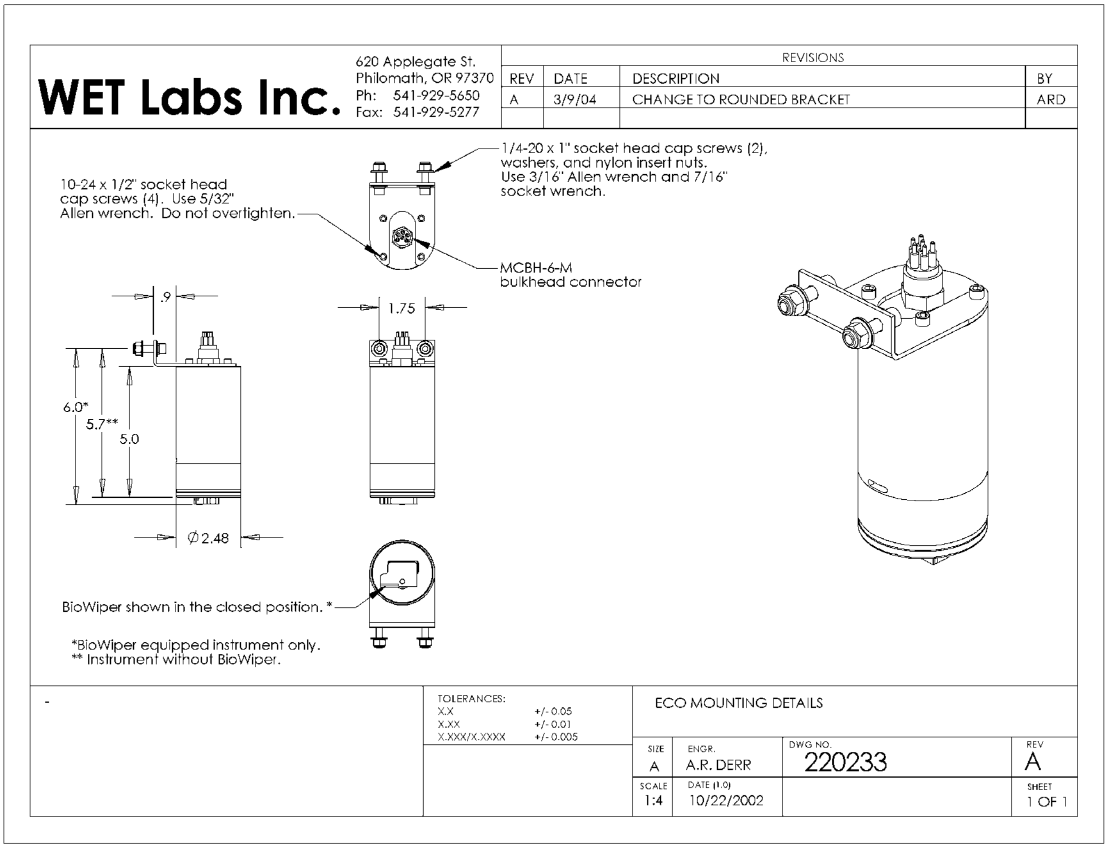
Below is a sample output file for an FL with an external thermistor.

Date	Time	Chl Ref	Chl Sig	Thermistor
6/14/2005	7:57:55	5194	75	16380
6/14/2005	7:57:56	5199	76	16380
6/14/2005	7:57:57	5201	75	16380
6/14/2005	7:57:58	5202	74	16380
6/14/2005	7:57:59	5203	74	16380
6/14/2005	7:58:00	5203	75	16380

Below is a sample output file with processed data (in µg/l) for an FL with no external thermistor.

Date	Time	Chl sig (µg/l)	Ref	Chl sig counts	Therm (N/U)
6/14/2005	7:57:55	26.99	5194	3535	544
6/14/2005	7:57:56	26.91	5199	3525	545
6/14/2005	7:57:57	27.06	5201	3544	545
6/14/2005	7:57:58	26.82	5202	3513	545

Appendix A: Mounting Bracket Drawing



Revision History

Revision	Date	Revision Description	Originator
A	10/16/02	New document (DCR 242)	W. Strubhar, D. Whiteman
B	10/23/02	Add mounting bracket description (DCR 251)	A. Derr
C	11/12/02	Add analog capability for (RT) models (DCR 254)	I. Walsh
D	2/10/03	Delete battery warning (DCR 272)	D. Whiteman
E	2/24/03	Change “shutter” to “bio-wiper™” (DCR 280)	H. Van Zee
F	3/03/03	Add Terminal Communications section (DCR 283)	I. Walsh
G	4/14/03	Add stop command to terminal communications (DCR 292)	W. Strubhar
H	5/29/03	Add analog signal option to section 3.1.1 (DCR 302)	I. Walsh
I	8/6/03	Add CDOM, Uranine, PC and PE; add deliverable items (DCR 320)	H. Van Zee
J	9/22/03	Correct paragraph in 8.3.2 (DCR 336)	H. Van Zee
K	10/27/03	Correct device file and date format (DCR 341)	D. Romanko
L	11/24/03	Modify explanation for stop data collection command (DCR 342)	W. Strubhar
M	11/25/03	Update specifications table (DCR 338)	I. Walsh
N	2/17/04	Update bio-wiper maintenance and column description for device files (DCR 367)	A. Derr, I. Walsh
O	3/10/04	Add new test cable description, operational description, mounting diagram (DCR 381)	A. Derr, D. Whiteman
P	5/11/04	Update optical specs, remove pin 6 from warning in section 1 (DCR 390)	I. Walsh
Q	6/29/04	Update specs (DCR 400)	I. Walsh
R	9/20/04	Correct sensitivity and excitation values (DCR 427)	I. Walsh
R1	9/27/04	Add draft text for optional thermistor and pressure sensor text	I. Walsh
S	9/28/04	Finalize draft (DCR 429)	I. Walsh
T	10/14/04	Add references to Lithium batteries for applicable models (DCR 433)	I. Walsh
U	7/26/05	Replace Clean Water Offset with Dark Counts (DCR 468)	M. Johnson
V	12/7/05	Clarify Section 5, fluorescent stick description, separate spare parts (DCR 477)	H. Van Zee, R. Watte, C. Wetzel
W	1/13/06	Clarify warranty statement (DCR 481)	A. Gellatly, S. Proctor
X	3/3/06	Add copper faceplate (DCR 490, ECN 217)	H. Van Zee, I. Walsh
Y	5/31/06	Correct reference to cleaning section, add annual maintenance recommendation (DCR 498)	S. Proctor
Z	6/28/06	Cleaning and maintenance of modified bio-wiper (ECN 230, DCR 502)	A. Derr, H. Van Zee
AA	7/27/06	Change length of securing screw on bio-wiper (ECN # not assigned; DCR 504)	J. da Cunha, H. Van Zee
AB	9/28/06	Update specifications (DCR 507)	M. Johnson
AC	11/1/06	Correct pressure sensor and thermistor output equations (DCR 509)	M. Johnson