Combination Fluorometer and Turbidity Sensor

ECO FLNTU

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.

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ECO Sensor Warranty

This unit is guaranteed against defects in materials and workmanship for a period of one year after the original date of purchase. WET Labs will supply all replacement parts and labor and pay for return via 3rd day air shipping in honoring this warranty. This warranty is considered void if the factory determines that the unit was subjected to abuse or neglect beyond the normal wear and tear of field deployment, or in the event the pressure cans have been opened by the customer (this does not apply to pressure cans on battery-supplied units). The customer should call for a Return Manufacturer's Authorization (RMA) before returning the instrument to the factory and is responsible for shipping costs to WET Labs. WET Labs is not responsible for shipping damage done during the return shipment. WET Labs assumes no liability for equipment damage, personal injury or loss of data resulting from use of this instrument, except for that stated in this warranty.

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.

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1. Specifications

Model	FL-NTU(RT)	FL-NTU	FL-NTUB	FL-NTUS	FL-NTUSB
Mechanical					
Diameter	2.5 in (6.3 cm)	2.5 in (6.3 cm)	2.5 in (6.3 cm)	2.5 in (6.3 cm)	2.5 in (6.3 cm)
Length	5.0 in (12.7 cm)	5.0 in (12.7 cm)	10.0 in (25.4 cm)	5.25 in (13.3 cm)	10.25 in (26.0 cm)
Weight in air	0.9 lbs (0.4 kg)	0.9 lbs (0.4 kg)	2.1 lbs (0.96 kg)	1.1 lbs (0.5 kg)	2.1 lbs (0.96 kg)
Weight in water	0.05 lbs (0.02 kg)	0.05 lbs (0.02 kg)	0.3 lbs (0.14 kg)	0.19 lbs (0.08 kg)	0.3 lbs (0.14 kg)
Material	ABS	ABS	ABS	ABS	ABS
Environmental					
Temperature range	0–30 deg C	0–30 deg C	0–30 deg C	0–30 deg C	0–30 deg C
Depth rating	600 m	600 m	600 m	300 m	300 m
Electrical					
Digital output resolution	12 bit	12 bit	12 bit	12 bit	12 bit
Analog output signals	0–5 V	0–5 V	0–5 V	0–5 V	0–5 V
Internal data logging	N	Y	Y	Y	Y
Internal batteries	N	N	Y	N	Y
Connector	Subconn MCBH6M	Subconn MCBH6M	Subconn MCBH6M	Subconn MCBH6M	Subconn MCBH6M
Input	7–15 VDC	7–15 VDC	7–15 VDC	7–15 VDC	7–15 VDC
Current, typical	80 mA	80 mA	80 mA	80 mA	80 mA
Current, sleep	--	85 µA	85 µA	85 µA	85 µA
Data memory	--	1 MB (65,000 samples)	1 MB (65,000 samples)	1 MB (65,000 samples)	1 MB (65,000 samples)
Sample rate	to 8 Hz	to 8 Hz	to 8 Hz	to 8 Hz	to 8 Hz
RS-232 output	19200 baud	19200 baud	19200 baud	19200 baud	19200 baud
Anti-fouling bio-wiper™	N	N	N	Y	Y
Bio-wiper™ cycle	--	--	--	100 mA	100 mA
Optical (Turbidity)					
Wavelength	700 nm	700 nm	700 nm	700 nm	700 nm
Sensitivity (min)	0.1 NTU	0.1 NTU	0.1 NTU	0.1 NTU	0.1 NTU
Range, typical	0–25 NTU	0–25 NTU	0–25 NTU	0–25 NTU	0–25 NTU
Optical (Fluorescence)					
Wavelength excitation	470 nm	470 nm	470 nm	470 nm	470 nm
Wavelength emission	685 nm	685 nm	685 nm	685 nm	685 nm
Sensitivity (per count)	0.02 µg/l	0.02 µg/l	0.02 µg/l	0.02 µg/l	0.02 µg/l
Range, typical	0.02 to 60 µg/l	0.02 to 60 µg/l	0.02 to 60 µg/l	0.02 to 60 µg/l	0.02 to 60 µg/l
Linearity (both signals)	99% R^2	99% R^2	99% R^2	99% R^2	99% R^2

FL-NTU(RT)—Provides analog or RS-232 serial output with 4,000-count range. This unit operates continuously when powered.

FL-NTU—Provides the capabilities of the FL-NTU(RT) with periodic sampling.

FL-NTUS—Provides the capabilities of the FL-NTU with an integrated anti-fouling *bio-wiper*™.

FL-NTUB—Provides the capabilities of the FL-NTU with internal batteries for autonomous operation.

FL-NTUSB—Provides the capabilities of the FL-NTUS with internal batteries for autonomous operation.

2. ECO Meter Components

The following subsections describe the bulkhead connectors, test cable, optional batteries and bio-wiper, and a list of items delivered with the ECO sensor.

2.1 Connectors

ECO-Series meters 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.

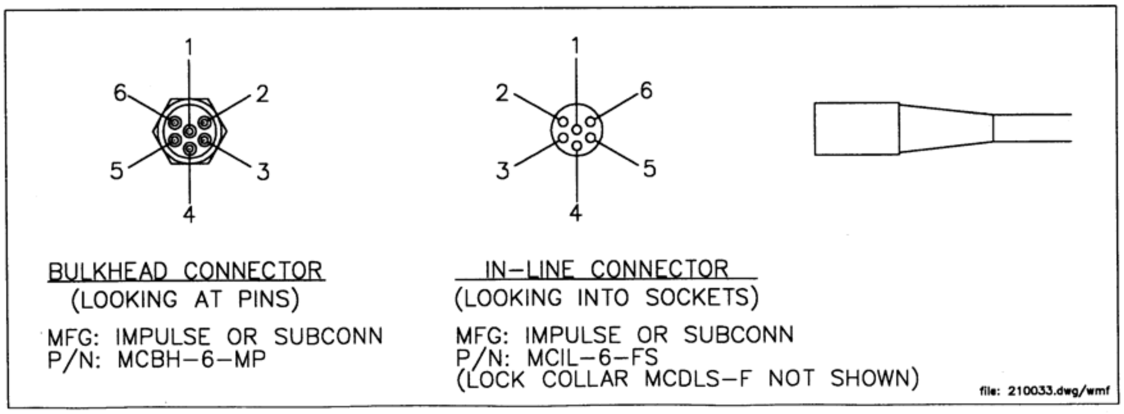


Figure 1. *ECO* Connector Schematic

Table 1. Pinout Summary for *ECO* Connectors

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

Input power of 7–15 VDC is applied to V in (pin 4). The power supply current returns through the common ground pin (pin 1). The input power signal has a bi-directional filter. This prevents external power supply noise from entering into *ECO*-FLNTU, and also prevents internally generated noise from coupling out on to the external power supply wire. Data is sent out the serial output pin.

2.1.1 *ECO* FL-NTUB, FL-NTUSB Connectors

FLNTUB and FLNTUSB (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.

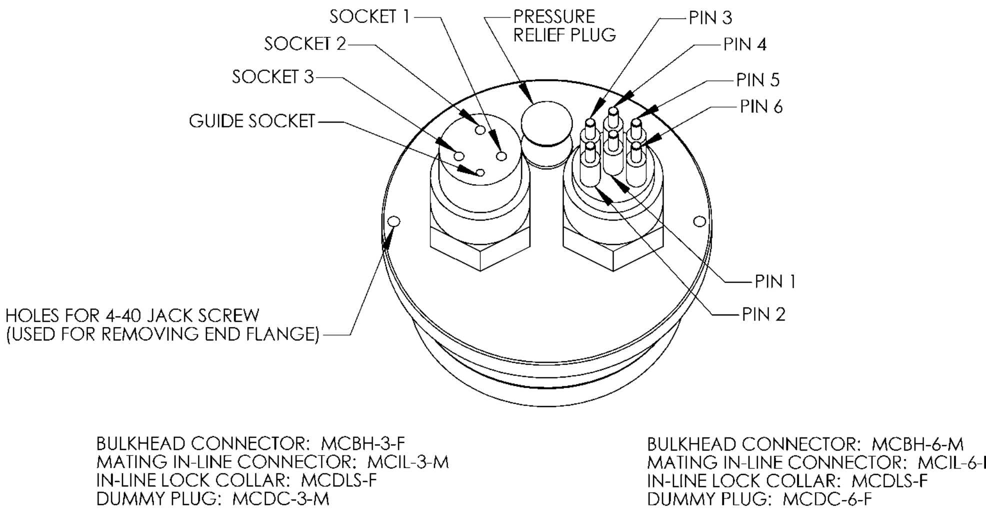


Figure 2. *ECO* FLNTUB and FLNTUSB connector schematic

Table 2. Pinout summary for *ECO* FLNTUB/FLNTUSB 3-socket connector

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

2.2 Test Cable

A test cable is supplied with each unit. This cable includes five legs:

1. A power interface module provides power to the instrument from the connected 9 V battery.
2. An auxiliary analog out connector.
3. A second auxiliary analog out connector for NTU only.
4. A DB-9 serial interface connector.
5. A six-socket in-line connector plugs into the sensor to provide power and obtain signal.

2.3 Delivered Items

FLNTUB and FLNTUSB (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.)

2.4 *Bio-wiper™*

The FLNTUS and FLNTUSB include an integrated non-contact anti-fouling *bio-wiper*™ for use in extended deployments. This shutter 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.

2.5 Batteries

The FLNTUB and FLNTUSB incorporate six 9-volt batteries as their internal power source. They can either use standard alkaline cells for a total capacity of approximately 1000 mA-hrs, or for longer deployments can use $LiMnO_2$ 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.

2.6 Delivered Items

The standard *ECO* delivery consists of the following:

- the instrument itself
- protective cover for optics
- dummy plug with lock collar
- test cable
- this user's guide
- ECOView user's guide
- ECOView host program and device file (on CD)
- instrument-specific characterization sheet
- FLNTU(RT), FLNTU, FLNTUS only: stainless steel mounting bracket and hardware (See Appendix A for details)
- One 0.50 hex key for shutter removal/replacement
- spare parts kit (battery units only):
  - ❑ Two end flange O-rings (size 224)
  - ❑ 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 (0.250 inches) of 0.094-inch diameter white nylon bar stock for replacing the white plastic dowel pin.

3. Theory of Operation

The *Environmental Characterization Optics* (*ECO)* combination fluorometer and turbidity sensor allows the user to measure chlorophyll fluorescence at 470 nm and turbidity at 700 nm within the same volume.

The fluorometer allows the user to monitor chlorophyll concentration by directly measuring the amount of chlorophyll-*a* fluorescence emission from a given sample volume of water. Chlorophyll, when excited by the presence of an external light source, absorbs light in certain regions of the visible spectrum and re-emits a small portion of this light as fluorescence at longer wavelengths. Two bright blue LEDs (centered at 455 nm and modulated at 1 kHz) provide the excitation source. A blue interference filter is used to reject the small amount of red light emitted by the LEDs. The blue light from the sources 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. A red interference filter is used to discriminate against the scattered blue excitation light. The red fluorescence emitted is synchronously detected by a silicon photodiode.

Turbidity is measured simultaneously by detecting the scattered light from a 700 nm LED at 140 degrees to the same detector used for fluorescence. The turbidity measurement is performed at the same 140 degree angle as the chlorophyll fluorescence.

4. Instrument Operation

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

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

4.1.1 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. Auxiliary "chl" is the fluorometer output. Auxiliary "NTU" is the NTU output. 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.

4.2 Operating the Sensor for Data Output

Note

ECO scattering 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. Place the flat of your hand in front of the sensor face and note that the signal will increase toward saturation (maximum value on characterization sheet) as your hand gets closer. 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 per second immediately upon applying 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.

4.3 Deployment

WARNING!
FLNTUS and FLNTUSB:
Always check vent seal plug for full insertion immediately prior to deployment.

Caution
The FLNTU should be mounted so that the infrared LED source will not "see" any part of a cage or deployment hardware. This will affect the sensor's output.

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.

4.4 Upkeep and Maintenance

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

The *ECO* FLNTU is compact device and its maintenance can be easily overlooked. However, it is a precision instrument and does require a minimum of routine upkeep.

After each cast or exposure of the instrument to natural water, flush the instrument 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. When not in use, make sure the protective cap is secured to the face. At the end of an experiment, the instrument should be rinsed thoroughly, air-dried and stored in a cool, dry place.

4.5 *Bio-wiper*™ Operation

The *ECO*-FLNTUS and -FLNTUSB are provided with an anti-fouling *bio-wiper*™. The *bio-wiper*™ extends 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.

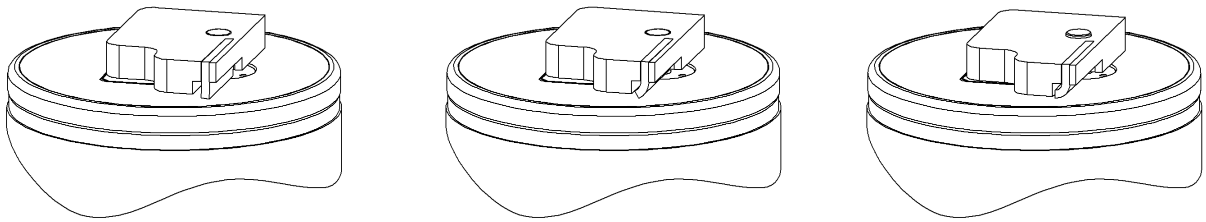
4.5.1 *Bio-wiper*™ Cleaning and Maintenance

When not in active sample mode, the *bio-wiper*™ can be removed by using the factory-supplied 0.050 hex key to loosen the set screw that attaches the shutter to the instrument. Take care to ensure no unnecessary torque is placed on the shaft.

To clean, wash in soapy water, rinse and dry thoroughly. Note the condition of the copper on the instrument side of the shutter. It is normal for the copper *bio-wiper*™ to corrode and turn green, especially after the instrument has been removed from the water. This corrosion will slightly reduce the shutter's antifouling ability the next time it is deployed. For maximum antifouling capability:

1. Remove *bio-wiper*™
2. Buff with a pad of green Scotch Brite® (or similar) until shiny
3. Re-install *bio-wiper*™

When re-installing the *bio-wiper*™ on the instrument, the wiper blade must be properly flexed. To achieve the proper flex of the wiper, set the gap between the copper *bio-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 (Figure 3).



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.

Figure 3. Adjusting *bio-wiper*™ for proper flex

To set this gap:

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

2. Make sure the *bio-wiper*™ is in the closed position. You may have to run the instrument.

3. If it is not already loosened, loosen the set screw holding the *bio-wiper*™ and put the paper gage between the instrument face and the bio-wiper.

4. Push down on the *bio-wiper*™ and rotate it counter-clockwise so that the shutter is in the closed position.

5. Without letting the wiper spring up, tighten the set screw.

6. Run the instrument to verify operation

5. FL-NTUB: 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-NTU and FL-NTUS units.

5.1 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).

5.2 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.

5.3 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 over-tighten truss screw.

Note

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

6. Data Analysis

Data from the *ECO* fluorometer and turbidity sensor represents raw output from the sensor. Applying linear scaling constants, this data can be expressed in meaningful forms of chlorophyll fluorescence and NTUs.

6.1 Scale Factor

The scale factor is calculated by obtaining a consistent output, then subtracting the meter's clean water offset.

Chlorophyll
Scale Factor = 25 ÷ (ECO Output – Clean Water Offset)
For example: 25 ÷ (3198 – 71) = 0.0080.

NTU
Scale Factor = *xx* ÷ (solution value, counts - CWO)
where *xx* is the value of a Formazin concentration. For example: 12.2 ÷ (2011 - 50) = 0.0062.

This information is on the characterization sheet unique to each instrument that is shipped with the meter.

6.2 Analog Response

The *ECO*-FLNTU response is linear over the measurement range provided. The instruments have a chlorophyll measurement range of approximately 0.02 to 50.0 μg/l and an NTU measurement range of approximately 0–25. Because of the varied environments in which each user will work, it is important to do calibrations using similar seawater as you expect to encounter *in situ.* Please 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 concentration and NTUs is straightforward using the equations:

Chlorophyll:

$$[\mathrm{Chl}]_{sample} = (V_{output} - V_{cwo}) * \text{Scale Factor}$$

where $[\mathrm{Chl}]_{sample}$ = concentration of a chlorophyll sample of interest (μg/l)
V_{output} = output when measuring a sample of interest (VDC)
V_{cwo} = measured signal for clean water offset (VDC)
Scale factor = multiplier in μg/l/volts

The scale factor is applied to the analog output signal to provide the direct conversion of the analog output voltage to chlorophyll concentration.

NTU:

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

where $[NTU]_{sample}$ = level of turbidity (NTU)
V_{output} = output when measuring a sample of interest (VDC)
V_{cwo} = measured signal for clean water blank (VDC)
Scale factor = multiplier in NTU/volts

The scale factor is applied to the analog output signal to provide the direct conversion of the analog output voltage to NTUs.

6.3 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 offset value and multiplying the difference by the instrument scaling factor.

Chlorophyll:

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

where $[Chl]_{sample}$ = concentration of a chlorophyll sample of interest (µg/l)
C_{output} = output when measuring a sample of interest (counts)
C_{cwo} = measured signal for clean water offset (counts)
Scale factor = multiplier in µg/l/counts.

NTU:

$$[NTU]_{sample} = (NTU_{output} - C_{cwo}) * \text{Scale Factor}$$

where $[NTU]_{sample}$ = concentration of NTU solution
NTU_{output} = output when measuring a sample of interest (counts)
C_{cwo} = measured signal of clean water offset in raw counts (counts)
Scale factor = multiplier in NTU/counts.

7. Characterization and Testing

ECO FLNTU is configured for a chlorophyll measurement range of 0.02–50 μg/l. The turbidity sensor's measurement range is 0–25 NTU. 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.

The tests below ensure the meter's performance

1. **Pure Water Blank**: Pure, de-ionized water is used to set the "zero" level of the meter. This zero level is set for 50 counts (+/-15) on all models.

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

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

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.

5. **Noise**: The noise value 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 characterization sheet. The calculated noise must be below 2 mV.

6. **Voltage and Current Range Verification**: To verify that the *ECO* operates over the entire specified voltage range (7–15 V), a voltage-sweep test is performed. *ECO* is operated over the entire voltage range, and the current and operation is observed. The current must remain constant at approximately 85 mA over the entire voltage range.

8. 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.

8.1 Interface Specifications

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

8.2 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.

9. ECOView Device Files

The ECOView 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.

9.1 Plot Header

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

9.2 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.

9.3 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 count: meter output in air with optics head taped
off = clean water offset, meter output in clean water
mw = wavelength measured by the sensor
dw = display wavelength – color to plot the BB data in
v = measured volts dc

Valid Column Descriptions are listed in the subsections below.

9.3.1 Fluorescence Measurements

CHL=	x	sc	off
IENGR=	x	sc	off
PHYCOCYANIN=	x	sc	off
PHYCOERYTHRIN=	x	sc	off
URANINE=	x	sc	off
RHODAMINE=	x	sc	off
CDOM=	x	sc	off

9.3.2 Miscellaneous

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

9.3.3 Turbidity Measurements

LSS=x	sc	off	Light Scattering Sensor Measurement
NTU=	sc	off	Turbidity Measurement

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 as a reference to the factory setting for the user when the user manually adjusts the scale and offsets that are used in the engineering unit calculations. The 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.

9.4 Sample Device File

Below is a sample device file for an ECO FLNTU.

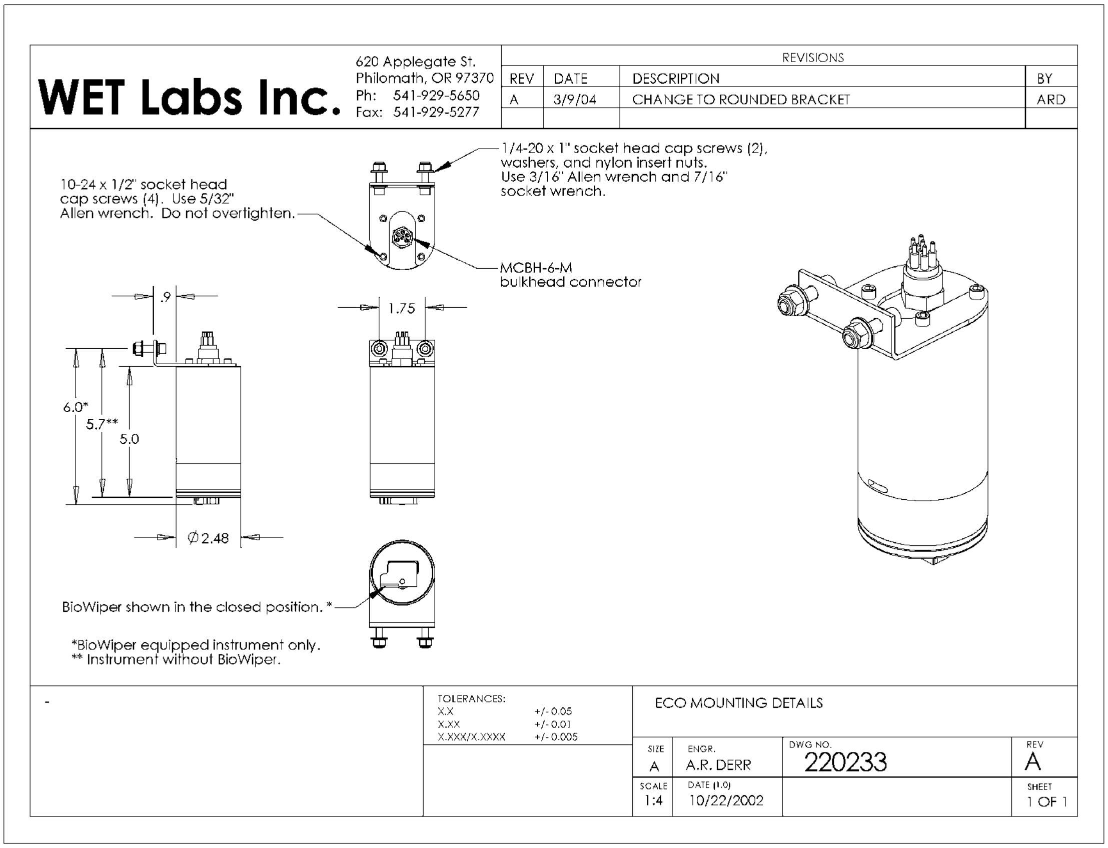
```
ECO FLNTUS-045
Created on: 07/03/03

COLUMNS=7
DATE=1
TIME=2
CHLREF=3
CHL=4   0.0128    62.0
NTUREF=5
NTU=6   0.0063 85.0
N/U=7
```

9.5 Sample Output File

Below is a sample output file for an FLNTU. From left to right, columns describe:

Date (MM/DD/YY)	Time (HH:MM:SS)	CHL Reference	CHL Signal	NTU Reference	NTU Signal	Thermistor
05/01/03	10:06:51	1817	49	1583	69	536
05/01/03	10:06:53	1818	48	1583	68	536
05/01/03	10:06:54	1818	49	1583	68	536
05/01/03	10:06:56	1818	49	1583	67	536
05/01/03	10:06:58	1818	47	1583	69	536
05/01/03	10:07:00	1819	48	1584	68	536
05/01/03	10:07:02	1819	50	1584	69	536
05/01/03	10:07:03	1819	48	1584	69	536

Appendix A: Mounting Bracket Drawing



Revision History

Revision	Date	Revision Description	Originator
A	7/24/03	New document (DCR 322)	H. Van Zee
B	9/22/03	Correct syntax in 8.3.2 (DCR 336)	H. Van Zee
C	10/2/03	Add Terminal Communications section (DCR 337)	H. Van Zee
D	11/24/03	Modify explanation for stop data collection command (DCR 342)	W. Strubhar
E	11/25/03	Update specfications (DCR 338)	I. Walsh
F	2/17/04	Update bio-wiper maintenance and column description for device files (DCR 367)	A. Derr, I. Walsh
G	3/10/04	Add new test cable description, operational description, mounting diagram (DCR 381)	A. Derr, D. Whiteman
H	5/10/04	Delete warning about pins 3 and 6 (DCR 390)	I. Walsh