



Enviro-T

In-Line Fluorometer

Version A

August 31, 2011

P/N 998-2810

TURNER DESIGNS

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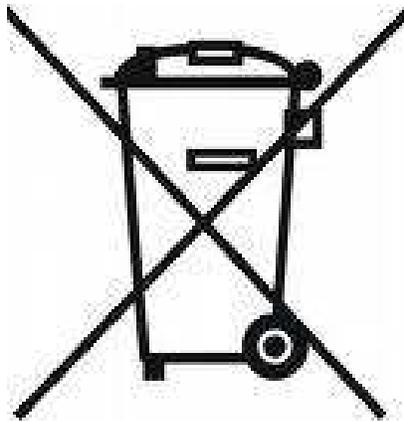
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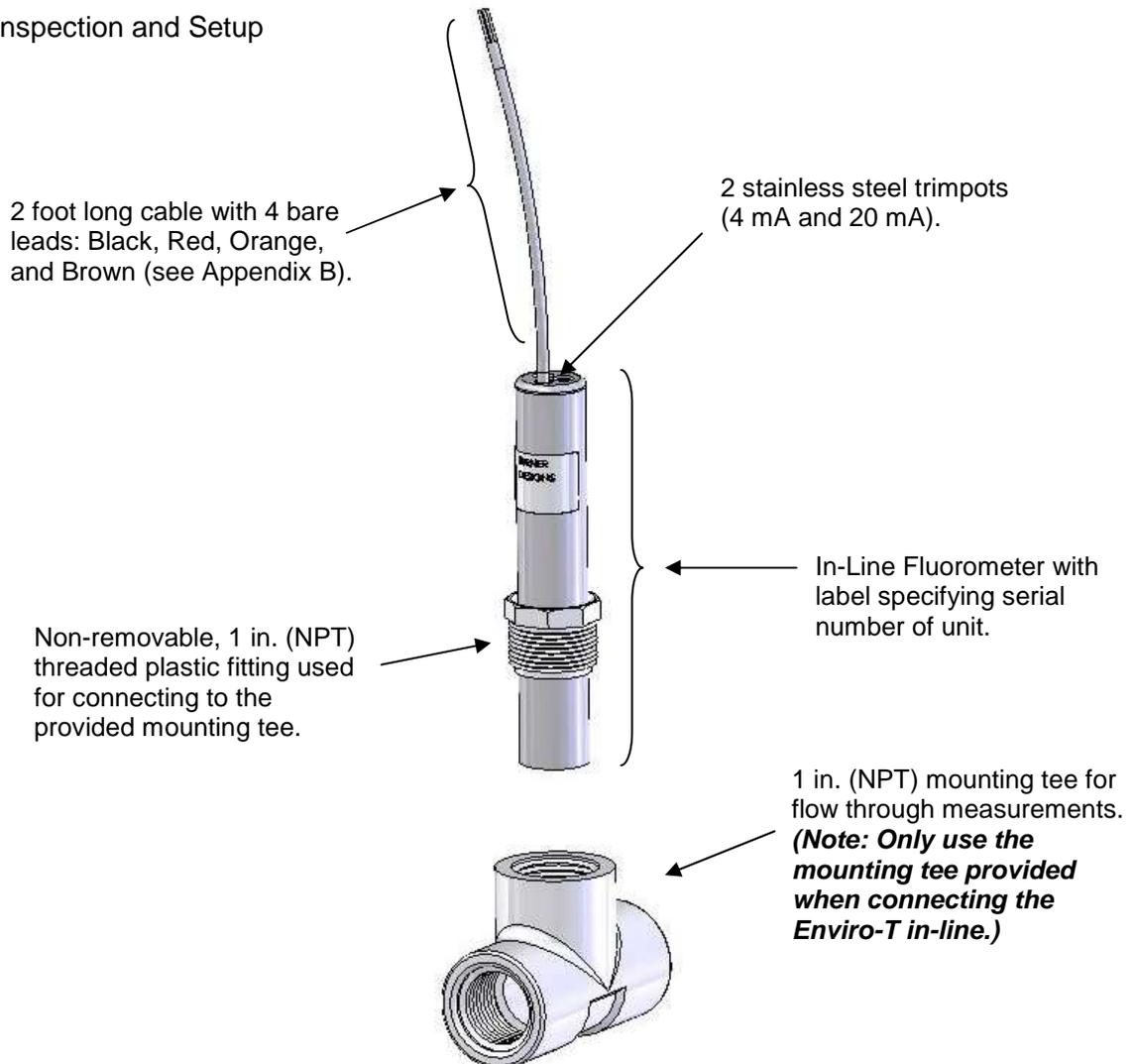
Equipment Specified as Electrical and Electronic Waste

1. Introduction

1.1 Description

Turner Designs' Enviro-T In-Line Fluorometer is an accurate, single-channel fluorometer designed to measure fluorescence from water samples. The Enviro-T In-Line Fluorometer provides a 4 - 20 mA output signal proportional to the fluorescence in the sample or source water. In a representative application, the Enviro-T In-Line Fluorometer can be used with a data collection system to monitor and control the level of algal biomass in industrial applications. The sample water's fluorescence intensity is measured by passing the sample water, with chlorophyll-containing organisms, past the Enviro-T In-Line Fluorometer's optical window. An excitation light source illuminates the solution and excites chlorophyll in the solution which emits light at a different wavelength. The intensity of the emitted light is proportional to the concentration of the algal biomass in the sample. Turner Designs' Enviro-T In-Line Fluorometer has a low maintenance design to provide trouble-free performance.

1.2 Inspection and Setup



2. Installation and Operation

2.1 Installation

Turner Designs' Enviro-T In-Line Fluorometer is rated for light industrial environments.

Do not install the Enviro-T In-Line Fluorometer:

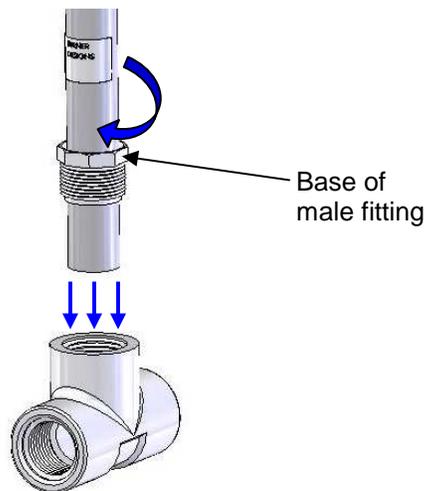
- In direct sunlight or near heat sources (operating temperature 0-50 °C)
- On vibrating walls or surfaces that affect the flow
- Near devices that produce a strong electromagnetic field such as large generators

It is recommended that the Enviro-T In-Line Fluorometer be installed in such a way that the flow is directed upward to expel any trapped air bubbles as air trapped on the optical window will influence signal and cause erratic readings (see section 4.0).

2.2 Tee Installation

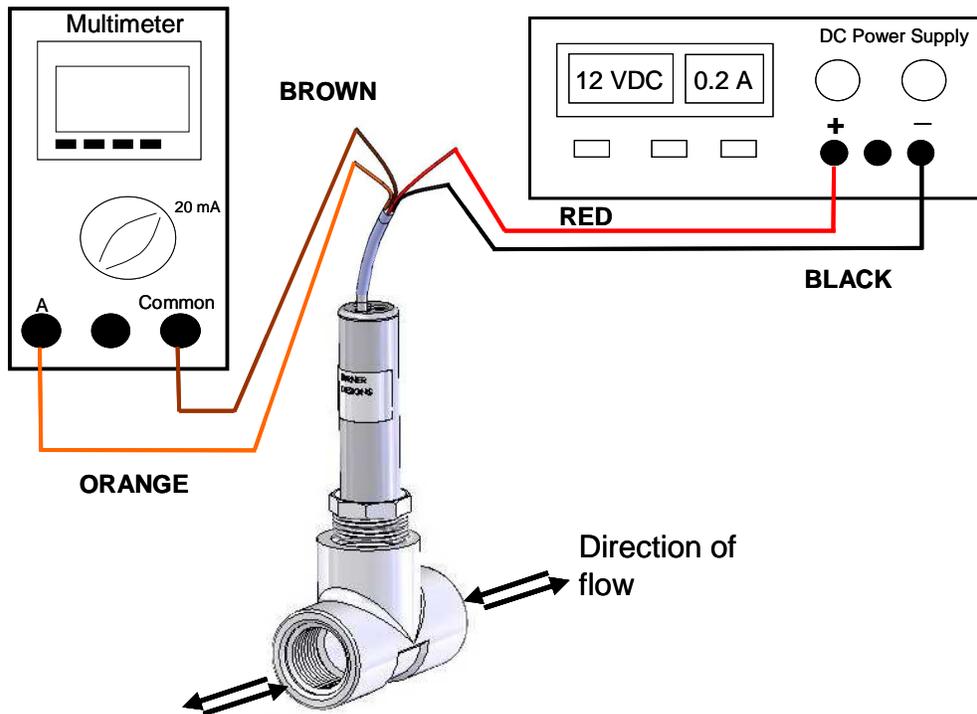
We recommend the following installation procedure for installing the Enviro-T In-Line Fluorometer onto the mounting tee provided for flow through applications:

- 1) Wrap Teflon tape around the threaded male fitting which is bonded to the fluorometer's housing. **Note: Turner Designs applies Teflon tape prior to shipping. For re-applications, do not wrap Teflon tape more than 3 – 4 full turns.**
- 2) Turning clockwise, fully hand-tighten the Enviro-T In-Line Fluorometer to the mounting tee provided.



Enviro-T In-Line Fluorometer

- 3) After the Enviro-T In-Line Fluorometer is fully hand tightened onto the mounting tee provided, use a wrench to make one more full clockwise turn.
- 4) Connect the mounting tee in line with your flow and start flowing water.
- 5) Inspect for leaks.
- 6) If a leak occurs, continue tightening $\frac{1}{4}$ inch at a time until the leaking stops.
Note: The base of the male fitting should not be flush with the mounting tee; the male fitting's threads should be visible after securing the connection using a wrench.
- 7) Connect the Enviro-T In-Line Fluorometer to the power supply and digital multimeter as shown below. **(Note: The power ground (Black Wire) and the 4-20 mA return (Brown Wire) are not common. These wires should not be connected to the same point.)**



2.3 Operation

Turner Designs' Enviro-T In-Line Fluorometer uses a Light Emitting Diode (LED) at a specific wavelength to excite the fluorophore of interest in samples or source water. Upon excitation, the fluorophore emits a different wavelength of light (fluorescence) that will be detected by the fluorometer's photodiode.

After power (8 - 30 VDC) is applied to the Enviro-T In-Line Fluorometer allow 5 seconds for the LED to stabilize. After 5 seconds measurements can be taken continuously as current output (4 – 20 mA).

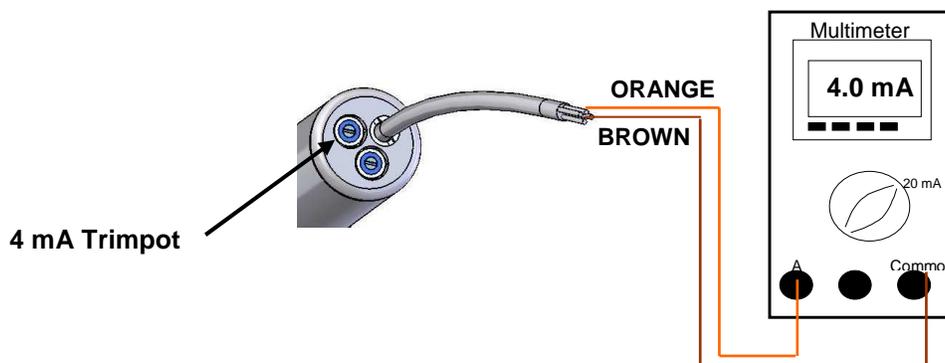
3. Calibration and Calculations

3.1 Calibration

- 1) Connect the Enviro-T In-Line Fluorometer to the mounting tee provided (see section 2.2, steps 1-6).
- 2) Connect the Enviro-T In-Line Fluorometer to the power supply and digital multimeter (see section 2.2, step 7).
- 3) Obtain a bucket with a known volume of the source water you will be measuring. **(Note: This water should represent your blank; this signal will be set as your zero so make sure that it does not contain any fluorophore.)**
- 4) Fully submerge the mounting tee into the bucket with water and allow water to fill the mounting tee.

(IMPORTANT NOTE: MAKE SURE TO REMOVE ALL BUBBLES FROM THE MOUNTING TEE BY TILTING THE ENVIRO-T IN-LINE FLUOROMETER AND GENTLY SHAKING WHILE FULLY SUBMERGED IN THE WATER AS AIR BUBBLES TRAPPED NEAR OR ON THE OPTICAL HEAD WILL INFLUENCE RESULTS.)

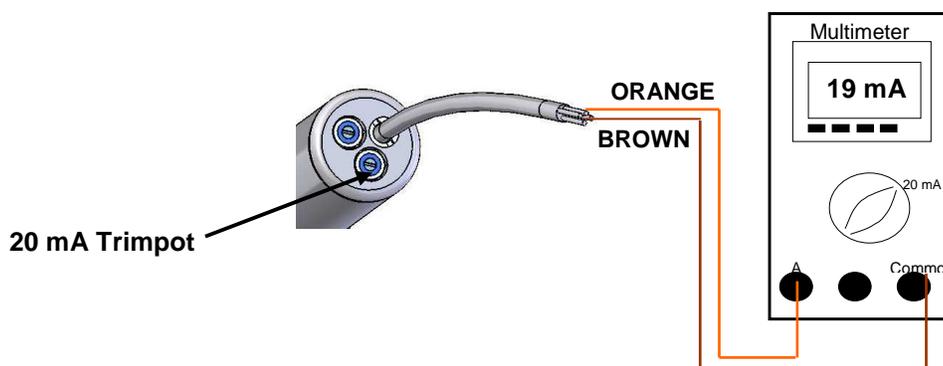
- 5) Once bubbles have been removed, allow the multimeter signal to stabilize and then use a flathead screwdriver to rotate the marked 4 mA trimpot so that the multimeter reads a minimum of 4 mA. **(Note: Allow the multimeter reading to stabilize before adjusting the trimpot between readings; do not adjust the trimpot more than 1 full turn at a time before allowing signal to stabilize.)**



- 6) Make sure to log the reading (see Table 1 for example).
- 7) Remove the Enviro-T In-Line Fluorometer from the bucket.
- 8) In the same bucket which contains a known volume of your source water, make a known concentration solution using your fluorophore of interest that represents the maximum concentration you intend to measure.
- 9) Ensure the solution is well mixed, submerge your mounting tee into the solution, and allow the solution to fill the mounting tee.

(IMPORTANT NOTE: MAKE SURE TO REMOVE ALL BUBBLES FROM THE MOUNTING TEE BY TILTING THE ENVIRO-T IN-LINE FLUOROMETER AND GENTLY SHAKING WHILE FULLY SUBMERGED IN THE SOLUTION AS AIR BUBBLES TRAPPED NEAR OR ON THE OPTICAL HEAD WILL INFLUENCE RESULTS)

- 10) Once bubbles have been removed, allow the multimeter signal to stabilize and then use a screwdriver to rotate the marked 20 mA trimpot so that the multimeter reads 19mA. **(Note: Allow the multimeter reading to stabilize before adjusting the trimpot between readings; do not adjust the trimpot more than 1 full turn at a time before allowing signal to stabilize.)**



- 11) Make sure to log the reading (see Table 1 for example).
- 12) You can now install the Enviro-T In-Line Fluorometer in line with the system you intend to monitor following installation instructions provided (see section 2.1).
- Data collected upon completing these calibration steps can be put into a table similar to the table below to track future calibrations.

Table 1: Example of data collected from calibration steps 1-10.

Solution Measured	Concentration	Multimeter current output
Blank Solution	C_b (0 ppb)	R_b (4 mA)
Sample Solution	C_s (30 ppb)	R_s (19 mA)

3.2 Calculating Calibration Coefficients

With the data collected you can find the coefficients required for calculating concentrations using the equation:

$$y = mx + c \quad \text{(Equation 1)}$$

Where:

y is the sample concentration,
 m is the slope of your equation,
 x is the sensor output in mA,
 c is the x intercept (offset) when y = 0.

1. Finding the slope of your equation using example data from Table 1 and slope from Equation 2:

$$m = (C_s - C_b) / (R_s - R_b) \quad \text{(Equation 2)}$$

$$m = (30 - 0) / (19 - 4) = 30/15 = 2$$

2. Finding the offset for your curve using example data from Table 1:

$$0 = (m * R_b) + C \quad \text{(Equation 3)}$$

$$0 = (2 * 4) + C$$

$$c = -8$$

3. Substitute m and c from Equation 1 with end values from Equations 2 and 3:

$$y = 2x - 8 \quad \text{(Equation 4)}$$

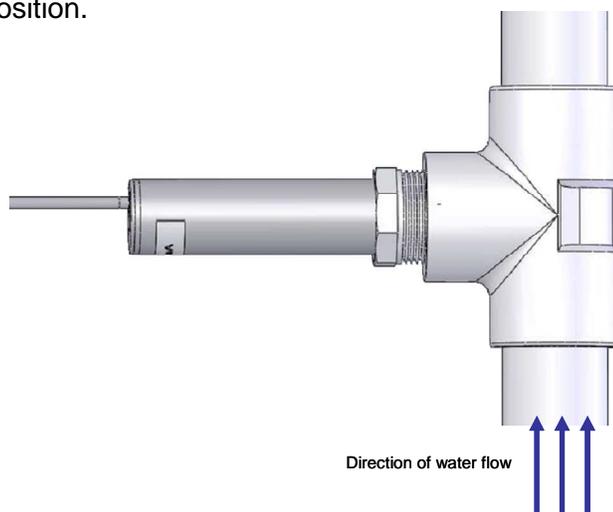
You can now calculate y (ppb) concentrations simply by substituting sensor output (mA) values for x in equation 4.

4. Recommended Measurement Practices

4.1 Minimizing Variations in Signal

Turner Designs' Enviro-T In-Line Fluorometer has a flat-surfaced optical window that might trap air bubbles when positioned vertically. For this reason we recommend:

- 1) Installing the Enviro-T In-Line Fluorometer horizontally so that the mounting tee is in a vertical position.



- 2) That the flow direction is upward through the mounting tee.

This will ensure that any trapped air bubbles will be released and will not interfere with sample measurement.

4.2 Temperature Considerations

Fluorescence is temperature dependant. The fluorescence signal from most fluorophores will decrease as sample temperature increases. However, fluorescence values can be corrected for temperature effects if the temperature correction coefficient of the fluorophore being measured is known. Table 2 lists known temperature correction coefficients. These coefficients (for additional information regarding chlorophyll see Appendix C) can be used with recorded temperatures in the following equation to correct temperature effects on fluorescence values:

$$F_r = F_s * e^{[n (T_s - T_r)]}$$

Where:

F_r is the calculated fluorescence at the reference temperature, T_r

T_r is the reference temperature

T_s is the sample temperature at time of reading F_s

F_s is the sample's fluorescence at the time the temperature of the sample is measured, T_s .

e is the base of natural log

n is a temperature coefficient for whatever dye is used (see Table 2)

Enviro-T In-Line Fluorometer

For greatest accuracy, if possible, determine the temperature correction coefficient of the dye or fluorophore being used, record the sample temperature, and correct the sensor output for changes in temperature. Additional information on how to apply these corrections is included in the Turner Designs Application Note: [A Practical Guide to Flow Measurements](#).

Table 2: Temperature correction coefficients:

<i>In vivo</i> Chlorophyll (See Appendix C)	1.4% / °C Linear
PTSA	-0.00126 / °C Exponential
Fluorescein	0.0036 / °C Exponential
Rhodamine WT	0.026 / °C Exponential

5. Maintenance and Warranty

The Enviro-T In-Line Fluorometer fluorometer is designed for light industrial monitoring applications that require continuous measurements. It provides maximum performance and solid state reliability with minimal maintenance.

A maintenance check should be made to ensure the optical window is free from any chemical or biological fouling. Frequency of maintenance checks are dependent on the fouling rate of the system being monitored. Systems that have a higher fouling rate might require more frequent maintenance checks.

5.1 Visual Inspection and Cleaning

To visually check if the optical window has been fouled:

- 1) Remove the Enviro-T In-Line Fluorometer from the mounting tee.
- 2) If there is any noticeable fouling, use a soft bristle brush or non-abrasive cloth material and soapy water to clean the optical window. Be sure to rinse thoroughly.
- 3) If the fouled window is unable to be cleaned with soapy water and the soft bristle brush, make a 10% HCL solution and use that solution, in place of the soapy water, with the soft bristle brush to clean the window. **(Note: Hydrochloric acid is a hazardous material and should only be handled by qualified personnel.)**
- 4) Once the optical window has been cleaned, re-install the mounting tee back onto the Enviro-T In-Line Fluorometer **(Note: See section 2.2 on how to properly install the mounting tee.)**

5.2 Maintenance Check Using Standard Solutions

You may also check if the unit is responding correctly simply by running standard solutions past the optical window.

- 1) Make a standard solution (solution of known concentration of the fluorophore being measured) that is less than the maximum concentration set for the Enviro-T In-Line Fluorometer.
- 2) Flow this solution past the optical window and record the mA reading.
- 3) Calculate the solution concentration using your equation determined via calibration from section 3.2 and compare to the actual solution concentration.
- 4) If the calculated concentration varies by more than 5% of the actual solution's concentration, see section 5.1 for visual inspection and cleaning

Maintenance checks are important and will ensure the Enviro-T In-Line Fluorometer is continuing to provide maximum performance and measurement reliability.

5.3 Warranty Terms

Turner Designs warrants the Enviro-T In-Line Fluorometer and accessories to be free from defects in materials and workmanship under normal use and service for a period of 12 months from the date of shipment from Turner Designs with the following restrictions:

Turner Designs is not responsible for replacing parts damaged by accident or neglect. Your instrument must be installed according to instructions in the User's Manual. Damage from corrosion is not covered. Damage caused by customer modification of the instrument is not covered.

This warranty covers only Turner Designs products and is not extended to equipment used with our products. We are not responsible for accidental or consequential damages, except in those states where this limitation is not allowed. This warranty gives you specific legal rights and you may have other rights which vary from state to state.

Damage incurred in shipping is not covered.

5.4 Warranty Service

To obtain service during the warranty period, the owner shall take the following steps:

1. Write, email or call the Turner Designs Technical Support department and describe as precisely as possible the nature of the problem.

Phone: 1 (877) 316-8049

Email: support@turnerdesigns.com

2. Carry out any adjustments or tests as suggested by the Technical Support Department.
3. If proper performance is not obtained you will be issued a Return Materials Authorization number (RMA) to reference. Package the unit, write the RMA number on the outside of the shipping carton, and ship the instrument, prepaid, to Turner Designs. If the failure is covered under the warranty terms, the instrument will be repaired and returned free of charge, for all customers in the contiguous continental United States.

For customers outside of the contiguous continental United States who purchased equipment from one of our authorized distributors, contact the distributor. If you purchased directly, contact us. We will repair the instrument at no charge. Customer pays for shipping duties and documentation to Turner Designs. Turner Designs pays for return shipment (custom duties, taxes and fees are the responsibility of the customer).

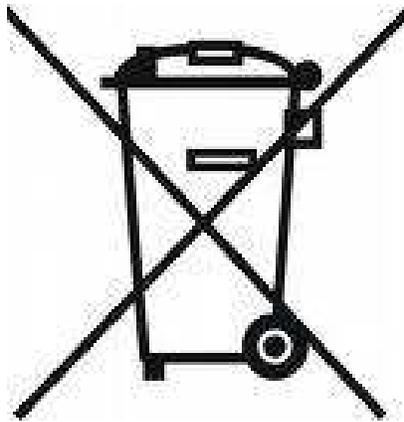
Enviro-T In-Line Fluorometer

5.5 Out of Warranty Service

Follow steps for Warranty Service as listed above. If our Technical Support department can assist you by phone or correspondence, we will be glad to, at no charge. Repair service will be billed on a fixed price basis, plus any applicable duties and/or taxes. Shipment to Turner Designs should be prepaid. Your bill will include return shipment freight charges.

Address for Shipment:

Turner Designs, Inc.
845 W. Maude Ave.
Sunnyvale, CA 94085



Equipment Specified as Electrical and Electronic Waste

Appendix A: Fluorometer and Mounting Tee Specifications

Parameter	Specification
Linearity (over dynamic range)	0.99 r ²
MDL for Chlorophyll	0.03 µg/L
Dynamic Range for Chlorophyll	0-100 µg/L
Power Draw	0.96 W @ 12 VDC (1.2 W max.)
Input Voltage	8 – 30 VDC
Signal Output	4 – 20 mA
Light Source	Light Emitting Diode
Detector	Photodiode
Warm up time	5 seconds
Dimensions	Length: 5.92 in. (15.04 cm) Diameter (housing): 1.05 in. (2.67 cm) Diameter (Max.): 1.54 in. (3.91 cm)
Weight	3.35 oz. (95 g)
Material	PVC – Type I, machined plastic

Mounting Tee Specifications

Parameter	Specification
Material	PVC – Type I, molded plastic
Threading	1 inch (NPT)
Length	3.44 in. (8.74 cm)
Dynamic Pressure Rating	100 PSI
Fitting	Schedule 80

Appendix B: Wiring Guide

Wire Color	Function	Connection
Red	Supply Voltage 8 – 30 VDC	PSU – Positive Connection
Black	Supply Ground 0 VDC	PSU – Ground Connection
Orange	Signal out to data logger, “A”, 4 – 20 mA DC	Multimeter “A” Connection
Brown	Signal out to data logger, “Common”, 4 – 20 mA DC	Multimeter “Common” Connection

Appendix C: *In Vivo* Chlorophyll Measurements

Turner Designs' Enviro-T In-Line Fluorometer can be configured with chlorophyll optics to determine the relative abundance of algae in water samples. The instrument provides a 4 - 20 mA output signal proportional to the fluorescence from the sample or source water being measured. This signal can be recorded using any data collection system with the capability to read current data (4-20 mA) output and can be used to estimate algal abundance.

In vivo chlorophyll measurements provide qualitative data. It is up to the user to convert these qualitative readings into quantitative data if actual concentration estimates are desired. Accuracy of concentration estimates is dependent on the calibration or correlation used to convert relative readings to concentrations.

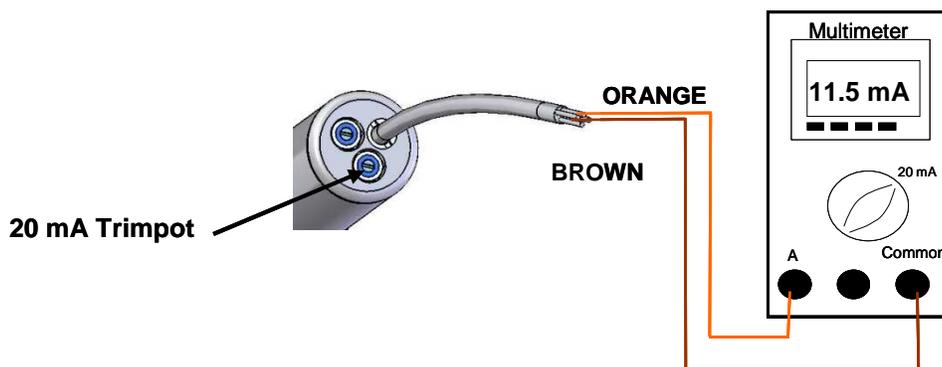
Calibrating the Enviro-T In-Line Chlorophyll Fluorometer

The following calibration will enable users to approximate algal concentrations that fall between 0-100 ug/L using relative fluorescence responses collected from the Enviro-T.

- 1) Follow steps 1-7 from section 3.1 of the manual
- 2) In the same bucket that contains your blank sample, make a concentration of 8 ppb Rhodamine WT, which represents approximately 50 $\mu\text{g/L}$ of algae (species *Duanlialla salina*).
- 3) Ensure the solution is well mixed, submerge your mounting tee into the solution, and allow the solution to fill the mounting tee.

(IMPORTANT NOTE: MAKE SURE TO REMOVE ALL BUBBLES FROM THE MOUNTING TEE BY TILTING THE ENVIRO-T IN-LINE FLUOROMETER AND GENTLY SHAKING WHILE FULLY SUBMERGED IN THE SOLUTION AS AIR BUBBLES TRAPPED NEAR OR ON THE OPTICAL HEAD WILL INFLUENCE RESULTS)

- 4) Once bubbles have been removed, allow the multimeter signal to stabilize and use a screwdriver to rotate the marked 20 mA trimpot so that the multimeter reads 11.5 mA. **(Note: Allow the multimeter reading to stabilize before adjusting the trimpot between readings; do not adjust the trimpot more than 1 full turn at a time.)**



- 5) Make sure to log the reading (see Table C1 for example).
- 6) Your Enviro-T has been adjusted to read relative algal concentration between 0-100 µg/L and you can now install the Enviro-T In-Line Fluorometer in line with the system you intend to use for signal monitoring or control, following installation instructions provided (see section 2.1 of manual).

Data collected upon completing these calibration steps can be put into a table similar to the table below. To calculate the relative concentration of algae in the sample water use Equation 5 determined from values found in Table C1:

$$\text{Chl } (\mu\text{g/L}) = [50 / (11.5 - 4)] * (\text{mA output} - 4) \quad (\text{Equation 5})$$

Table C1: Example of data collected from calibration steps 1-6.

Solution Measured	Rhodamine WT Solution	Equivalent Chl Concentration	Multimeter Current output
Blank Solution	RWT_b (0 ppb)	Chl_b (0 µg/L)	R_b (4 mA)
Sample Solution	RWT_s (8 ppb)	Chl_s (50 µg/L)	R_s (11.5 mA)

Calculating Calibration Coefficients

To create your own calibration coefficients using *in vivo* algal fluorescence correlated to an actual chlorophyll concentration estimate, determined via extraction protocol, you'll need to estimate the chlorophyll concentration of your sample using a chlorophyll extraction protocol and use that sample in place of the Rhodamine WT solution (follow calibration steps 1-6 in Appendix C). Use equation 6 below to determine your calibration coefficient,

$$\text{Chl } (\mu\text{g/L}) = [(Chl_s) / (R_s - R_b)] * (\text{mA output} - 4) \quad (\text{Equation 6})$$

This equation will allow you to calculate chlorophyll concentrations based on your calibration using an actual algal solution and the responses recorded.

(NOTE: See the Maintenance Checks section of Appendix C prior to enabling the Enviro-T In-Line Fluorometer for in-line measurements of your system's source water.)

Temperature Correction

Temperature Considerations

Fluorescence is temperature dependant. The fluorescence signal from most fluorophores will decrease as sample temperature increases. However, fluorescence values can be corrected for temperature effects if the temperature correction coefficient of the fluorophore being measured is known. Table 2 in section 4.2 lists the temperature correction coefficient for correcting temperature effects on chlorophyll fluorescence. The correction is linear so the following equation can be used to make the correction:

$$\text{Temperature Corrected Chlorophyll (ug/L)} = [(\text{Sample}_T - \text{Reference}_T) * (-0.014)] + (\text{Signal Measured})$$

Where,

Sample_T = Temperature of sample measured.

Reference_T = Reference Temperature. The temperature at the time of calibration.

Signal Measured = (mA output – 4)

Maintenance Check Using Standard Solutions

You may also check if the unit is responding correctly simply by running standard solutions past the optical window.

- 1) Make an 8 ppb Rhodamine WT standard solution using Deionized water.
- 2) Flow only this solution past the optical window and record the value before measuring your source water.
- 3) Put the fluorometer in line with your system and allow it to start making measurements on your source water.
- 4) Once a week, flow only the 8 ppb solution past the optical window and record the value.
- 5) If the readings vary by more than 5% of the initial value recorded for the 8 ppb Rhodamine Wt concentration, see section 5.1 for visual inspection and cleaning

Maintenance checks are important and will ensure the Enviro-T In-Line Fluorometer is continuing to provide maximum performance and measurement reliability.