Thermo Orion Turbidimeter Model AQ4500

INSTRUCTION MANUAL

Analyze • Detect • Measure • Control™

Thermo
ELECTRON CORPORATION

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Chapter I

Introduction

The Thermo Orion AQUAfast® IV Turbidimeter Model AQ4500 is the most advanced portable microprocessor based, LED, Turbidimeter on the market today. The AQ4500 Turbidimeter operates on the nephelometric and ratiometric principles of turbidity measurement. The Turbidimeter allows turbidity measurement based on EPA 180.1 and ISO 7027 as well as an infrared ratio (IR ratio) mode which give results in accordance with EPA GLI method 2. The Model AQ4500 also allows the user to make measurements based on percent transmittance (%T), American Society of Brewing Chemists (ASBC) units or European Brewing Chemists (EBC) units.

The AQUAfast IV Turbidimeter is the only completely waterproof turbidimeter with a rating of IP67. The AQ4500 can log 100 data points that can later be downloaded to a printer or computer.

Principle of Operation

Nephelometric turbidity is measured by determining the sideward-scattered light intensity. A light beam is passed through the flow cell and the scattered light produced by the solid particles (turbidity) is detected at a specific angle. This measurement method ignores the light that passes straight through the cell.

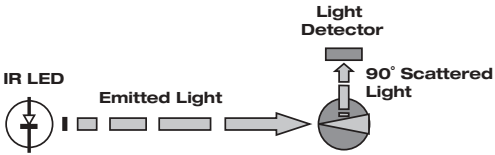

Figure 1: Pure nephelometric turbidity measurement without color compensation

If the medium contains absorbent substances (such as colored constituents), these can easily attenuate the light beam by factors ranging from 2 to 10 and thus falsify the results. So it is absolutely necessary to eliminate the effect of the medium's absorption in such cases. This is achieved by using two light beams: a measurement beam and a reference beam. The turbidity is thus determined from their ratio.

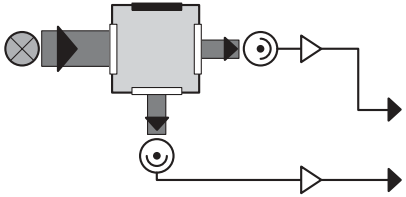

Figure 2: Color compensation in the dual-beam system with two photo detectors.

Display

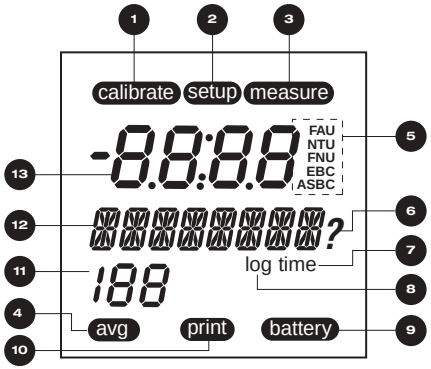

Figure 3: Model AQ4500 Display

Item	Number	Description
1	Calibrate	Icon lit while AQ4500 is in calibration mode
2	Setup	Icon lit while AQ4500 is in setup mode
3	Measure	Icon lit during measurement
4	Avg	Icon lit while AQ4500 performs zero
5	Units	Icons for units of measurement
6	?	Icon lit when AQ4500 prompts a question
7	Time	Icon lit while timer is active
8	Log	Icon lit if data is in AQ4500 log
9	Battery	Icon lit when battery in AQ4500 is low
10	Print	Icon lit during print function
11	188	Not used
12	8888	Alphanumeric display
13	8888	Numeric display

Keypad

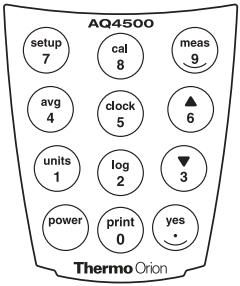

Figure 4: Model AQ4500 Keypad

Key	Description
power	Turns the AQ4500 on or off
print 0	Initiates print mode or inputs number 0
yes .	Confirms an answer or input of decimal point
units 1	Allows selection of measurement units or inputs number 1
log 2	Initiates log mode or inputs number 2
▼ 3	Scroll down, answer “No”, or input number 3
avg 4	Initiates Average mode or number 4
clock 5	Displays Time/Date and Stopwatch or number 5
▲ 6	Scroll up, answer “No”, or input number 6
setup 7	Initiates Setup function or number 7
cal 8	Initiates a calibration or number 8
meas 9	Initiates a measurement or number 9

Chapter II

Instrument Setup

Battery Installation

The model AQ4500 Turbidimeter requires 4 AA alkaline or lithium batteries. With 4 alkaline batteries, the expected life is 2,500 hours. With lithium batteries the expected life is 10,000 hours.

To install batteries, carefully loosen the two captive screws on the bottom of the battery cover. Remove the cover and insert batteries as shown in Figure 5.

Replace battery cover and tighten captive screws.

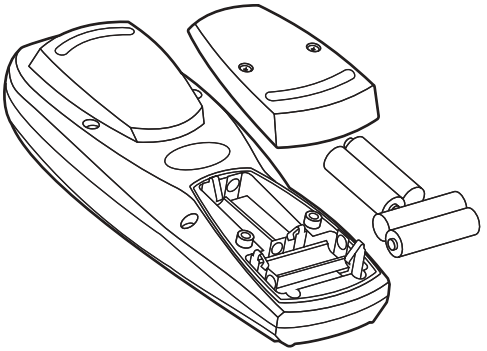

Figure 5: Battery Installation

The AQ4500 has an Auto-shutoff feature to conserve battery life. The auto-shutoff will turn the turbidimeter off if no keys have been pressed for approximately 20 minutes.

When the battery gets low “Battery” will be displayed. Also at power-up an indication of battery life is displayed.

Vial Cover

The vial cover serves two functions; first, it keeps the optical well covered so water, dirt and dust do not enter the well. Second, it covers the vial during measurement to prevent stray light from affecting the measurement. When the vial cover is installed and screwed down the AQ4500 is waterproof to IP67 standards.

The vial cover can be used in two ways. First for measurement when the waterproof integrity of the meter is important, place the vial cover over the vial and screw down as shown in Figure 6. To remove, unscrew and lift up.

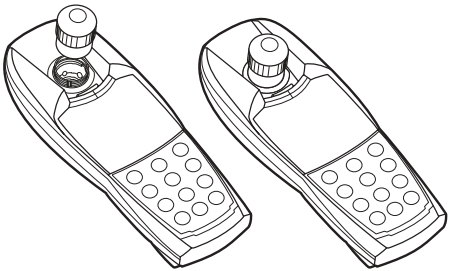

Figure 6

If using Turbidimeter in a lab where waterproof integrity is not a factor, the cover can just be placed down over the vial. To remove vial cover, lift cover straight up as shown in Figure 7.

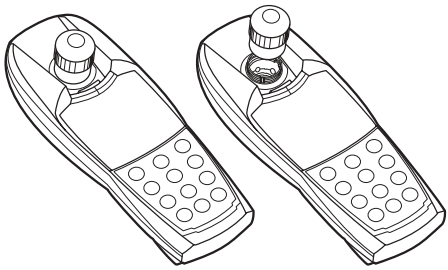

Figure 7

During measurement it is important to place the vial into the AQ4500 aligning the white triangle on the vial with the tab on the turbidimeter. See Figure 8 aligning vial with tab on Turbidimeter.

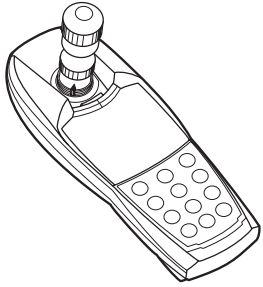

Figure 8

RS232 Connection

The AQ4500 has a bi-directional RS232 port located on the underside of the Turbidimeter. See Figure 7. To connect the AQ4500 to a printer or computer, use RS232 cable AQ4CBL. Also see the Use with Printers and Computers section.

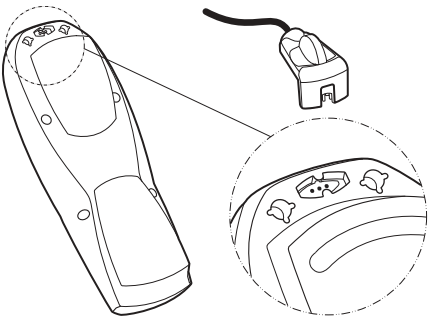

Figure 9: Model AQ4500 Connection

Chapter III

Setup Menu

The Setup key allows the user to access all the user selectable functions in the AQ4500 Turbidimeter.

Setup Functions

Cal Chek	Allows the user to confirm the time and date of the last calibration for the measurement mode selected.
Clock	Allows the user to set the date and time.
Set Baud	Allows the user to set the baud rate for the instrument when using it with a printer or computer.
Print	Allows the user to set the print out format.
Auto Print	Allows the user to set the Turbidimeter to automatically print each measurement.
Digits	Allows the user to select the number of significant digits to be displayed.
Battery	Allows the user to view remaining battery life.
Self-test	Allows the user to initiate a self-test to verify instrument operation.

Cal Chek

Allows the user to confirm the last calibration for the selected measurement mode.

1. Press setup 7 key.
2. Press the ▲ 6 or ▼ 3 keys until “CAL CHEK” is displayed.
3. Press yes key to accept.
4. The last calibration date and time will be displayed.
5. Press ▲ 6 or ▼ 3 keys to return to the Setup mode or meas 9 key to return to measurement mode

Clock

Allows the user to set the time and date.

1. Press setup 7 key.
2. Press the ▲ 6 or ▼ 3 keys until “CLOCK” is displayed.
3. Press yes key to accept.
4. “20_ _ will be displayed. Enter the year.
5. “_ _Month” will be displayed. Enter the month.
6. “_ _Day” will be displayed. Enter the day.
7. “_ _:_ _ (24) hour” will be displayed. Enter the time.
8. AQ4500 will proceed to next set up mode.

Set Baud

The default baud rate is 1200. The user may select another rate 1200 · 2400 · 4800 · 9600.

1. Press setup key.
2. Press the ▲ or ▼ keys until “SET BAUD” is displayed.
3. Press yes key to accept. 1200 or last baud rate selected is displayed.
4. Press ▲ or ▼ keys until the desired baud rate is selected.
5. Press yes key to accept.

Print

Allows the user to select the printout format. The user can select between a standard printout or a comma delimited format for importing data into a spreadsheet.

1. Press setup key.
2. Press the ▲ or ▼ keys until “PRINT” is displayed.
3. Press yes key to accept. “STND PRN?” is displayed.
4. Press the ▲ or ▼ keys to toggle between “STND PRN?” and “CMA DELM?”.
5. Press yes key to accept.

Auto Print

Auto print “ON” will automatically send readings to the printer.

1. Press setup 7 key.
2. Press the ▲ 6 or ▼ 3 keys until “AUTO PRT” is displayed.
3. Press yes . key to accept. “AUTO OFF?” or “AUTO ON?” is displayed.
4. Press the ▲ 6 or ▼ 3 keys to toggle between “AUTO OFF?” and “AUTO ON?”.
5. Press yes . key to accept.

Digits

The digit selection allows the user to select the resolution of the reading, from 0.000 -> 0.00 -> 0.0 -> 0 or Auto resolution. (Default is auto resolution).

1. Press setup 7 key.
2. Press the ▲ 6 or ▼ 3 keys until “DIGITS” is displayed.
3. Press yes . key to accept.
4. Press ▲ 6 or ▼ 3 keys until the desired resolution is selected.
5. Press yes . key to accept.

Battery

1. Press setup 7 key.
2. Press the ▲ 6 or ▼ 3 keys until “BATTERY” is displayed.
3. Press yes key to see remaining battery life.

Self-test

Puts the Turbidimeter into a self-diagnostic mode.

See Troubleshooting.

Chapter IV

Calibration

WARNING: *Never pour liquid directly into the sample well of the instrument. Only use Thermo Orion supplied vials Cat. No. AC2CTB.*

NOTE: *Always use clean dry vials for calibration and measurement. See measuring hints.*

The AQ4500 Turbidimeter must be calibrated before initial use. For best accuracy and regulatory compliance, perform an initial calibration with primary formazin standards every six months, or whenever a calibration check standard exceeds ± 10% of the expected value. The EPA 180.1,

ISO-NEPH, and IR Ratio modes may be calibrated in this manner. The EBC mode is automatically calibrated when the ISO-NEPH mode is calibrated. The ASBC mode is automatically calibrated when the EPA 180.1 mode is calibrated. The ISO-ABSB, White %T, and the IR %T modes require calibration with low-turbidity water only.

For EPA 180, ISO-NEPH, and IR Ratio modes, instrument performance checks should be performed on a daily basis using the secondary sealed standards in the AQ45CK calibration kit and low-turbidity water. See below for details.

For ISO-ABSB, White %T, and the IR %T modes, the instrument should be calibrated daily using low-turbidity water.

Preparation of Primary Calibration Standards for EPA 180.1, ISO-NEPH, and IR Ratio modes:

Thermo Orion provides a primary formazin stock standard at 4000 NTU as catalog number AQ45FZ. This formazin stock standard can be used to prepare primary calibration standards for the EPA 180.1, ISO-NEPH, and IR Ratio modes, as noted in the Table 1.

For initial calibration, prepare the following primary calibration standards by dilution of the 4000 NTU formazin stock standard with low-turbidity water. Preparing standards at these concentrations yields the best accuracy.

NOTE: *When using the 4000 NTU formazin stock and preparing primary calibration standards, it is important to keep the solutions well mixed when handling.*

Table 1
Primary Calibration Standards

EPA 180.1	ISO-NEPH	IR Ratio
1000 NTU	100 NTU	1000 NTU
100 NTU	10 NTU	100 NTU
10 NTU	1 NTU	10 NTU
1 NTU	Low-turbidity Water	1 NTU
Low-turbidity Water		Low-turbidity Water

If desired, the meter may be calibrated at concentrations other than those listed in Table 1.

NOTE: *Preparing standards and calibrating at these concentrations may yield reduced accuracy.*

Table 2
Calibration Ranges

Cal Standard Level	**EPA 180.1**	**ISO-NEPH**	**IR Radio**
1	0.90 to 1.1 NTU	0.86 to 1.1 FNU	0.86 to 1.1 NTU
10	9.0 to 11 NTU	9.0 to 11.6 FNU	9.0 to 11.3 NTU
100	90 to 110 NTU	90 to 157 FNU	90 to 119 NTU
1000	900 to 1100 NTU	N/A	654 to 1100 NTU

Preparation of Low-Turbidity Water

To obtain low-turbidity water for dilutions, nominal value 0.02 NTU, pass laboratory reagent-grade water through a 0.1 micron (mm) filter. Rinse the collecting flask at least twice with filtered water and discard the next 200 mL. Alternately, use laboratory reagent-grade water without filtering, if turbidity values are similar to or lower than filtered water.

Initial Calibration for EPA 180.1, ISO-NEPH or IR Ratio Modes

1. Select the measurement mode, EPA 180, ISO- NEPH or IR Ratio by scrolling up or down until the desired mode is displayed.
2. Press cal 8 key. “H2O INSERT” will be displayed.
3. Insert vial containing pure water and press yes key.
4. “H2O WAIT” will be displayed. Then 1.00 Yes?
5. If standard is 1.00, insert standard vial and press yes key. If standard is another value, press ▲ 6 or ▼ 3, “CHANGE?” will be displayed. Press yes key. “STD VAL?” will be displayed. Enter value of standard using numeric keypad. Press yes key to accept.
6. Repeat step 5 for each standard.
7. When the calibration is complete the AQ4500 will proceed to the measure mode.

After performing the initial calibration with the primary calibration standards, perform an instrument performance check by taking measurements of the secondary sealed standards and a blank (turbidity-free water). The performance is good when the blank reads less than 0.1 NTU and the secondary sealed standards read within ± 10% of the expected values. If results are not within limits, reanalyze the secondary sealed standards and blank. If the reanalysis confirms that calibration is outside of limits, discontinue analysis and determine the cause of error before proceeding.

Notes for Handling AQ45CK Kit standards

- DO not freeze kits
- DO not shake or agitate the sample
- remove fingerprints and smudges with a soft wiper cloth

Daily Calibration check for EPA 180.1, ISO-NEPH and IR Ratio modes

Check instrument performance on a daily basis by analyzing the secondary sealed standards and a blank before and after sample analysis. The performance is good when the blank reads less than 0.1 NTU and the secondary sealed standards read within ± 10% of the expected values. If results are not within limits, reanalyze the secondary sealed standards and blank. If the reanalysis confirms that calibration is outside of limits, discontinue analysis and determine the cause of error before proceeding. A new initial calibration may be required.

Calibration of ISO-ABSB mode

1. Select the measurement mode, ISO-ABSB by using the ▲ 6 or ▼ 3 key.
2. Press cal 8 key. "H2O INSERT" will be displayed.
3. Insert vial containing turbidity-free water and press yes key.
4. "H2O WAIT" will be displayed.
5. When the calibration is complete the AQ4500 will proceed to the measure mode.

After successful calibration, the low-turbidity water should read "0" FAU.

Calibration of White %T mode:

1. Select the measurement mode, White %T mode by using the ▲ 6 or ▼ 3 key.
2. Press cal 8 key. "W→100?" will be displayed.
3. Insert vial containing low-turbidity water and press yes key.
4. "WAIT" will be displayed.
5. When the calibration is complete the AQ4500 will proceed to the measure mode.

After successful calibration, the low-turbidity water should read "CAL DONE".

Calibration of IR %T mode:

1. Select the measurement mode, IR %T mode by using the ▲ 6 or ▼ 3 key.
2. Press cal 8 key. "IR→100?" will be displayed.
3. Insert vial containing turbidity-free water and press yes key.
4. "WAIT" will be displayed.
5. When the calibration is complete the AQ4500 will proceed to the measure mode.

After successful calibration, the low-turbidity water should read "CAL DONE".

Chapter V

Measurement

WARNING: *Never pour liquid directly into the sample well of the instrument. Only use Thermo Orion supplied vials Cat. No. AC2CTB.*

Below are general instructions for using Turbidity measurement. For best results, always cover vial with vial cover whenever measuring a sample.

Turbidity Sample Measurement

1. Allow sample to come to room temperature.
2. Mix thoroughly to disperse solids.
3. Wait until visible air bubbles disappear (a few minutes at most).
4. Select measurement mode.
5. Pour sample into a clean dry turbidity vial. (If sample has settled, mix gently to resuspend the solids before pouring into the sample vial.)
6. Cap vial securely.
7. Wipe vial free of liquid and fingerprints with a soft lint-free wipe or cloth.
8. Place into AQ4500 sample chamber and cover with vial cover.
9. Press 

key.
10. The AQ4500 will display the result. Record value or log data. Proceed with next sample.

Measurement of Low Level Turbidity Samples (< 1 NTU)

Observe the following precautions to improve accuracy of low-level turbidity sample measurements:

1. Prepare the calibration samples with low-turbidity water that has been filtered through a 0.1 mm membrane filter or water that has been demonstrated to be equivalent. Use care to avoid introduction of dust and particulates into the water, calibration standards, and samples.
2. Use scrupulously clean vials that are free from scratches and other imperfections.
3. Index the vials with the low-turbidity water to find the orientation that produces the lowest background blank value. Mark the orientation on the vials, above the marked line (so the orientation mark does not interfere with the meter light path).
4. Apply a light coating of silicon oil to mask minor imperfections in the glass vials. Spread the oil uniformly and remove excess oil by polishing with a soft, lint-free cloth. (Silicone oil and cloth kit, AC45S1.)
5. Do not handle vials where the light path of the meter strikes them. Hold vials above the marked line or by the cap, once the cap is on the vial.
6. Use the same indexed vial for the 1 NTU calibration point and for measurement of the low-level turbidity sample or samples. Clean the vial carefully between the calibration and the sample measurement. Fill with low-turbidity water and obtain a blank reading to ascertain that there has been no significant carryover, before using for sample measurements.

7. Rinse the vial a few times with the sample before filling.
8. Degas the sample before measurement, even if no bubbles are visible. Degas by immersing the sample cell in an ultrasonic bath for 1 to 2 seconds only or applying a partial vacuum.

Proceed with measurement steps.

Measurement Tips:

- Keep turbidity vials scrupulously clean both inside and out.
- Discard vials if they become scratched or etched.
- Do not handle vials in the light path area.
- Wash vials well with laboratory detergent, rinse repeatedly with DI water and allow to air dry.
- If condensation forms on the outside of the vial, warm sample to room temperature, wipe off excess moisture and remix sample before analysis.

Chapter VI

Functions

Log Function

The AQ4500 Turbidimeter allows the user to store up to 100 points in the log.

To Log Data:

Once measurement is complete, press log key to log point prior to next measurement.

To Display Log:

1. Press and hold log key for approximately 3 sec.
2. "DISPLAY" will be displayed and last point in log will be displayed.
3. Use ▲ or ▼ keys to scroll through log points.
4. Press meas key to escape log display mode.

To Clear Log:

1. Go into setup mode by pressing setup key.
2. Press ▲ or ▼ keys; "DEL LOG" will be displayed.
3. Press yes key; "CLR LOG?" will be displayed.
4. Press meas key to abort log clear.
5. Press yes key to clear log. "DELETED" will be displayed and AQ4500 will return to measure mode.

NOTE: It is recommended to print or download log prior to clearing.

To Print or Download Log:

1. Plug serial cable AQ4CBL into AQ4500.
2. Connect AQ4CBL cable to printer or computer.

See Chapter III, Print Setup.

3. Go to log display mode and press print 0 key.

Average Function

The average “AVG” function enables the instrument to take into account larger particles that may be floating through the sample during analysis. This situation is often encountered while testing environmental waters from rivers and lakes. As these particles may not always be present in the measuring path, observing the sample for a longer period of time may yield more accurate and reproducible readings. When AVG is turned on the meter takes a large number of consecutive readings, and then displays the averaged result. The measurement will take slightly longer (approximately 15 seconds). The result is a “better” or truer reading of the turbidity.

It is important to note that even if the meter’s AVG function is off, the instrument will perform a certain amount of signal averaging. This “smart” averaging is most prominent when measuring samples of very low turbidity (<1.5 NTU approximately), and is not noticeable at higher turbidities (above approximately 5 NTU).

To Activate Average Function

1. Press avg 4 key in measure mode, showing icon on.
2. Press meas 9 key.

To Deactivate Average Function

1. Press avg 4 key in measure mode, showing icon off.
2. Press meas 9 key.

Chapter VII

Use with Printers and Computers

The Model AQ4500 allows communication to a printer or communication with a computer. When connecting to a printer or a computer, use Thermo Orion Cat. No. AQ4CBL. This cable has a special 3-pin connector on one end for the AQ4500. When used to connect to a computer, a serial adapter may be required (a 25 pin to 9 pin adapter is included with AQ4CBL).

Data Transmission Settings

Baud Rate (selectable)	1200 (default), 2400, 4800, 9600
Parity	None
Data bits	8
Start bit	1
Stop bit	1

Chapter VIII

Troubleshooting

Turbidimeter Self-test

1. To initiate self-test, press setup 7 key.
2. Press ▲ 6 or ▼ 3 key until display reads "SELFTEST".
3. Press yes key to initiate self-test.
4. When "Press 7" is displayed, press the setup 7 key and follow the directions through the test.
5. When complete, unit should display "UNIT OK".
6. Press any key to confirm display operation.
7. Press any key to exit the self-test.
8. Press meas 9 key to return to measurement mode or press ▲ 6 or ▼ 3 key proceed through setup menu.

Maintenance

Turbidimeter

- Wipe the outside of the Turbidimeter with a damp cloth.
- Use a lens tissue, a soft cloth, or clean compressed air can to remove dust and dirt from the sample compartment.

Vials

- Always wipe moisture off any vial before inserting into the AQ4500.
- Always wipe fingerprints off any vial before inserting into the AQ4500.
- To clean vials, wash vials well with laboratory detergent, rinse repeatedly with DI water and allow to air dry

WARNING: *Opening the instrument enclosure (excluding the battery compartment) will void the warranty.*

Operator Assistance Codes

Operator Assistance Codes are used to inform a user of a problem during operation. See Table 3 for these codes. Contact Thermo Orion's Technical Service Department at 1-800-225-1480 for assistance.

Table 3:

Error Code	Error Code Type
E1	Keyboard Error
E2	Bad EEProm Error
E4	RTC not Detected
E8	RTC not Running
E16	RTC not generating interrupts
E32	RTC interrupt pulse out of specification or missing
E64	Bad ADC or battery reading out of specification
E128	White LED, transmission detector or monitor failure
E256	IR LED, transmission detector or monitor failure
E512	Scatter detector reading out of specification
E1024	No signal scatter or transmission readings out of specification
E2048	No signal monitor readings out of specification
E4096	White ZDI scatter too high
E8192	IR DI scatter too high
OVERRANGE	Measurement exceeded operation range

Chapter IX

Warranty

The Thermo Orion warranty covers failures due to manufacturer's workmanship or material defects from the date of purchase by the user. User should return the warranty card to Thermo Orion and retain proof of purchase. Warranty is void if product has been abused, misused, or repairs attempted by unauthorized persons.

Warranties herein are for product sold/installed by Thermo Orion or its authorized dealers.

Any product sold by a U.S. or Canadian distributor must be returned to Thermo Orion for any warranty work. Please contact our Technical Service department for further information. A Return Authorization Number must be obtained from Thermo Orion Technical Service before returning any product for in-warranty repair or replacement.

In the event of failure within the warranty period, Thermo Orion will at Thermo Orion's option, repair or replace product not conforming to this warranty. There may be additional charges, including freight, for warranty service performed in some countries. For service, call Thermo Orion (or its authorized dealer outside the United States and Canada). Thermo Orion reserves the right to ask for proof of purchase, such as the original invoice or packing slip.

Field Service is available on BOD AutoEZ™, EZ Flash® GC Accessory and TEA Analyzer®. Contact our Field Service department for details on quotations, service, other field service-related activities.

The following products are warranted to be free from defects in material and workmanship in the period listed below from the date of purchase from the user or from the date of shipment from Thermo Orion, whichever is earlier, provided use is in accordance with the operating limitations and maintenance procedures in the instruction manual and when not having been subjected to accident, alteration, misuse, abuse or breakage of electrodes:

Thirty-six months from date of purchase by the user (or forty-two months from date of shipment from Thermo Orion)

- Waterproof Meters (Models 630, 635, 830A, 835A, 260A, 261S, 265A, 266S, 130A, 131S, 135A, 136S, 1230, 142 and 842), Conductivity Meters (Models 105Aplus™, 115Aplus™, 125Aplus™, 145Aplus™, 150Aplus™ and 162A), PerpHect® pH/ISE Meters (Models 310, 320, 330, 350, 370) pH/ISE Meters (Models 210Aplus™, 230Aplus™, 250Aplus™, 290Aplus™, 410Aplus™, 420Aplus™, 520Aplus™, 525Aplus™, 710Aplus™, 720Aplus™ and 920Aplus™), pHuture MMS™ Meters (Models 535A and 555A), pH/Conductivity Meter (Model 550A), Dissolved Oxygen Meters (Models 805Aplus™, 810Aplus™, 850Aplus™ and 862A).

Twenty-four months from date of purchase by the user (or thirty-six months from date of shipment from Thermo Orion)

- Ross Ultra™ Electrodes, AQUAfast® IV Colorimeters, AQUAfast® IV Turbidimeter, Model 925 Flash Titrator™, Series 100 DuraProbe™ Conductivity Cells and Series 800 Dissolved Oxygen Probes.

Twelve months from date of purchase by the user (or eighteen months from date of shipment from Thermo Orion)

- Laboratory pH Meters, (Models 301, 611 and 940), SensorLink®, pHuture™ pH Meters (Models 610 and 620), Smart Chek™ meters, Sage® Pumps, Cahn® Balances, 930 Ionalyzer®, 950 ROSS™ FAST QC™ Titrator, 960 Titrator PLUS®, Karl Fischer Titrators, Autosamplers, Liquid Handling Devices, Liquid Handling Automation Workstations (Models AS2000, AS2500 and AS4000), Pumps (Models SP201, SP201-HR, SP201-S, Peristaltic and Rinse), pHuture® Conversion Box, Wine Master®, 607 Switchbox, rf link™, AQUAfast® II Colorimeters, Vacuum Degasser and Flowmeter.
- Thermo Orion EZ Flash® GC Accessory, TEA Analyzer® Models 610 and 510 excluding consumable items carry s twelve months warranty only.

- Ion Selective Electrodes, ionplus® Electrodes, ROSS™ Electrodes, Sure-Flow® Electrodes, PerpHecT® Electrodes, AquaPro Professional Electrodes, No Cal™ pH electrodes, Standard Line pH Electrodes, Tris pH Electrodes, KNIpHE® electrode, ORP Triode™ (Cat. No. 9180BN), pHuture™ pH Probes (Cat. No. 616500) and pHuture MMS™ Quatrode™ and Triode™ (Cat Nos. 616600 and 617900), Model 97-08 DO Probe, Series 100 Conventional Conductivity Cells, temperature probes and compensators (except those models noted).
- 93 and 97 ionplus Series sensing modules are warranted to give six months of operation if placed in service before the date indicated on the package, except 93-07 and 97-07 Nitrate modules are warranted to give ninety days of operation if placed in service before the date indicated on the package.

Six months from date of purchase by the user (or twelve months from date of shipment from Thermo Orion)

- Thermo Orion Flash Titration™ Probe (Cat. No. 092518), pHuture™ Electrode (Cat. No. 615700), pHuture MMS™ Pentrode™ (Cat. No. 617500), Quatrode™ (Cat. No. 617800) and Triode™ (Cat. No. 615800), Low Maintenance Triode™ (Cat. No. 9107BN), ORP Low Maintenance Triode™ (Cat. No. 9179BN), and PerpHecT® Low Maintenance Triode™ (Cat. No. 9207BN), Waterproof Triode™ (Cat. Nos. 9107WP, 9107WL, 9109WL and 9109WP), QuiKcheK® Meters and Micro Electrodes.

Three months from date of purchase by the user (or six months from date of shipment from Thermo Orion)

- Economy Line Electrodes, Models 91-05, 91-06, 91-15, 91-16, 91-25, 91-26, 91-35, 91-36, 92-06. Warranty also includes failure for any reason (excluding breakage), except abuse, provided the electrode is not used in solutions containing silver, sulfide, perchlorate, or hydrofluoric acid; or in solutions more than one (1) Molar in strong acid or base at temperatures above 50 °C.

"Out-of-Box" Warranty - Should any of the following products fail to work when first used, contact Thermo Orion immediately for replacement.

- Thermo Orion Solutions, Standards, Reagents, Cables, Ferrules, Tubing, Line adapters, Printers, Software, Cases, Stands, Probe Membranes, AQUAfast® Test Strips, EZ Flash® columns, Liquid Handling Probes, Adapter Plates and Racks and general accessories.

For products in the catalog not listed in this warranty statement, please visit our website at: www.thermoorion.com

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REPRESENTATION AND WARRANTIES MADE BY ANY PERSON, INCLUDING ITS AUTHORIZED DEALERS, REPRESENTATIVES AND EMPLOYEES OF THERMO ORION WHICH ALTER OR ARE IN ADDITION TO THE TERMS OF THIS WARRANTY SHALL NOT BE BINDING UPON THERMO ORION UNLESS IN WRITING AND SIGNED BY ONE OF ITS OFFICERS.

Chapter X

Declaration of Conformity

Manufacturer:

Thermo Orion
500 Cummings Center
Beverly, MA 01915 U.S.A

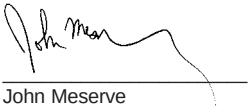
hereby declares that the Turbidity meter Model AQ4500 product conforms with the following standards and documents

Safety	EC Directive 72/23/EEC Low Voltage Directive	
EMC	EC 89/336/EEC Electromagnetic Compatibility EN/IEC 61326:1997 + A1: 1998, Annex C	
Emissions:	EN 55011 (Class A) Emissions FCC Part 15 Class A Canadian Emissions (EMCAB-3 ISSUE 2)	
Immunity:	DIN EN 50082-1 1994 IEC 61000-4-2 1999 IEC 61000-4-3 1998	Generic Immunity ESD Susceptibility Radiated Immunity

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

These products have been manufactured in compliance with the provisions of the relevant Thermo Orion manufacturing and test documents and processes. Further, these documents and processes are recognized as complying with ISO 9001: 1994(E) by QMI, listed as File # 001911.



Place and date of issue:
Beverly, MA. USA
September 26, 2002

John Meserve
Quality Assurance Manager

Chapter XI

Specifications

	AQ4500
Measurement Method	Range
EPA 180.1	0 – 4000 NTU
ISO-NEPH (7027)	0 – 150 FNU
ISO-ABSB	40 – 4000 FAU
IR-RATIO	0 – 4000 NTU
EBC	0 – 24.5 EBC
ASBC	0 – 236 ASBC
WHITE %T	0 – 100 %T
IR %T	0 – 100 %T
Resolution	0.01 NTU (0 - 9.99) 0.1 NTU (10 – 99.9) 1 NTU (100 – 1000)
Wavelength Selection	Automatic
Repeatability	± 1% of reading or 0.01 NTU
Accuracy	± 2 % of reading plus 0.01 NTU (0 - 500 NTU) ± 3 % of reading (500 - 1000 NTU) ± 5 % of reading (1000 - 2000 NTU)
Source Lamp	Light Emitting Diode (LED)
Detector	Silicon Photodiode
Sample Size	Approx 12 mL

	AQ4500
Environmental Conditions	
Temperature Operating Range	- 40.0 to 60.0 ˚C
Humidity	90% RH at 30.0 ˚C max
Waterproof	IP67
Inputs	
Keypad back	12 dual – function keys with tactile feed
RS232	Yes
Sample Chamber	24 mm
Display	Custom LCD
Units	FNU, NTU, FAU, ASBC, EBC
Low Battery Indicator	Yes
Software Features	
Datalogging	100 points
Built-in Clock with time and date display	
Auto Shut-off	Yes
Electrical Features	
Power	4 AA Batteries
Battery Life	2,500 hours (Alkaline) 10,000 hours (Lithium)
Non-volatile Memory	Yes

Appendix A.

Ordering Information

Cat. No.	Description
AQ4500	AQIV Advanced Turbidimeter, with field kit and instruction manual
AC2CTB	Turbidity measurement replacement vials, pack of 4
AQ4CBL	AQIV Cable RS232
AC45CK	AQ4500 Calibration kit with 4 standards: 1 NTU, 10 NTU, 100 NTU, 1000 NTU
AC45FZ	4000 NTU Formazin Standard Stock solution, 475 mL
AC45S1	Silicone oil (15 mL) and cloth kit

Appendix B.

Tungsten vs. LED Discussion

Traditionally, tungsten lamps have been used as light sources in turbidity measuring instrumentation. As such, they have been accepted by USEPA, and widely used in all “white light” turbidity measuring instrumentation. The primary characteristic, which made their use necessary, is the required broadband spectral distribution. Tungsten bulbs have a measurable output ranging from blue light all the way into infrared wavelengths.

At the time there had been no suitable alternatives to consider, so tungsten bulbs were accepted despite the operating problems they presented. Although LEDs were widely available for a very long time, they were characterized by a relatively narrow spectral emission, unsuitable for USEPA 180.1 method.

As of recently, high-powered “white” LEDs have become available. In essence, these are blue (450nm) LEDs with a phosphorus coating on the die. This construction gives off a broadband light from deep blue into deep red wavelengths.

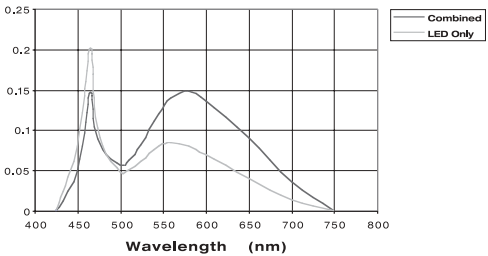
Thermo Orion has developed an instrument using this new solid-state light source. Following are some important considerations which characterize and compare this approach to that of a traditional tungsten light source.

Spectral Distribution

EPA 180.1 method describes a polychromatic measurement system. It is based on a tungsten light source and a detector system with spectral characteristics between 400 and 600nm.

In order to substitute a white LED light source, it is important to consider the spectral emission and transmission characteristics of the combined electro-optical system.

Detector-LED Combined Responsivity



As can be seen from the graph, the white LED – Si photo detector system described here is quite broadband. Its appearance is very similar to that of a tungsten bulb and a cadmium sulfide photo detector combination. It also contains a narrow secondary peak at 460nm. As the blue output is very limited in tungsten bulbs, this peak can aid in better detection of very small particles. However, as the peak area is very small compared to that of a main body, this enhancement is not very pronounced.

Stability

As follows from the theory of operation, and has been observed in practice, white LED instruments exhibit high level of stability over a wide range of operating conditions. The instruments have been observed to hold calibration over a period of weeks of intensive use. In contrast, tungsten bulb based instrumentation requires relatively frequent calibrations.

Ambient Light and Electronic Bias Rejection

Unlike tungsten bulbs, LED light sources readily lend themselves to rapidly pulsed operation. This enables the use of synchronous detection, a technique by which the ambient light as well as other electronic induced errors are effectively cancelled out. In doing so it is possible to reduce the ambient light leakage errors when making very low turbidity measurements.

Longevity

LEDs have a very long operating life: typically 100,000 hours or more. Thus, it is not necessary to include provisions for their replacement.

Voltage and Temperature Dependency

It is well known that the spectral output (color temperature) of tungsten bulbs is very dependent on the operating voltage. Although, this voltage can be easily regulated, the meter-to-meter reproducibility for certain samples can vary, as the typical voltage accuracy is on the order of 1%. This has a very significant effect on the color temperature, particularly in view of the fact that the bulbs themselves are not as reproducible as the LED sources.

The operating voltage and ambient temperature have a very minimal effect on LEDs, and are most pronounced on the intensity, not the spectral output. As any minor intensity variations are easily corrected by the instrument electronics, for all practical purposes, these errors are non-existent.

Warm-up

As the light sources are powered up, they all experience intensity and spectral characteristic shifts until the operating equilibrium is reached. This is commonly referred as the warm-up time. This parameter is a very important consideration when measuring the turbidity. It is important to have a spectrally and intensity stable light source. Although it is possible to correct for intensity variations, it is not possible to do so for color temperature effects.

Tungsten bulbs suffer from pronounced warm-up problems: both in intensity and color temperature. White LEDs also do have a warm-up period. However, this is much shorter (1 second or so), and the only parameter that significantly varies is the LED intensity.

Aging

Another well-known fact about the tungsten bulbs is that they change their properties through their life (aging). There are number of mechanisms which contribute to this, and presently it is not possible to eliminate these effects. This has number of consequences on the turbidity measurements, the most significant being the need for very frequent calibrations. In contrast, white LEDs do not exhibit any significant aging signs.

Shock Resistance

Unlike tungsten bulbs, all LEDs have very high shock resistance. This is particularly important for field instrumentation.

Bulb Replacement

As mentioned earlier, the LED based instrumentation does not need any provisions for bulb replacement. This not only results in cheaper instrumentation, but since the light source focusing and positioning has been pre-adjusted at the factory, it will be correct for the entire instrument operating life.

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