TN480 Portable Turbidity Meter

Instruction Manual

CE RoHS compliant ISO 9001:2015 IP67 WATERPROOF

APERA INSTRUMENTS, LLC

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Table of Content

1 OVERVIEW

Thank you for purchasing Apera Instruments TN480 Portable Turbidity Meter (hereafter referred to as the instrument).

The instrument uses infrared light emitting diode (LED 860±30nm) as the light source and 90° scattering method, which is compliant with ISO7027 and DIN EN 27027 standards for the determination of the turbidity for water solutions. TN480 allows you to measure turbidity in a reliable and simple manner wherever you are.

Main features and functions

- Large TFT color screen, with on-screen instructions for easy operation.
- TruRead™ measurement mode automatically takes multiple consecutive readings, and calculate their average, minimum and maximum value, as well as displaying each set of data in a brief test report. TruRead™ is a much better way to determine the true turbidity of your samples, rather than relying on just one reading. It's especially suitable for sample solutions with rapid settling and continuous measurement changes.
- U.S. EPA certified, non-toxic, easy-to-use polymer standard calibration solutions
- Zero turbidity error reminder: the instrument has zero-point calibration and zero-point error reminder to ensure measurement accuracy for low turbidity solutions.
- 200 sets of data storage with USB data output to PC (Windows-based), unlimited data storage when connecting with PC.
- Multi-language operating system, including English, Spanish, and Chinese.
- Rugged design, suitable for use in harsh environments and field.
- Everything comes in a rugged carrying case, including accessories such as calibration solutions, sample cuvettes, software flashdrive, and more.

2 TECHNICAL SPECIFICATIONS

Measuring Method	ISO 7027 and DIN EN 27027 compliant nephelometric method (90°)
Light Source	Infrared light emitting diode (860±30nm)
Measuring Range	0 – 1000 NTU, automatic range selection: 0.01 – 19.99 NTU 20.0 – 99.9 NTU 100 – 1000 NTU
Accuracy	≤ ±2 % of reading + stray light
Repeatability	≤ ±1% of reading or 0.02 NTU (FTU), whichever is greater
Resolution	0.01 / 0.1 / 1 NTU (FNU)
Stray Light	≤0.02 NTU(FNU)
Calibration Standards	AMCO Polymer Solution or Formazin Solution: 0, 20, 100, 400 and 800 NTU (FNU)
Detector	Silicone photovoltaic
Measurement Mode	Normal measurement and TruRead™ measurement
Data Storage	200 sets
Data Output	USB to PC
Calibration Record	Calibration points, date, and time
Display	TFT color screen
Sample Cuvette	Φ25×60 mm, high borosilicate glass with lid
Sample Cuvette Volume	18 ml
Power Supply	4× AA Alkaline Batteries
Working Condition	Temperature: 0 to 50°C（32°F to 122°F）; Relative humidity： 0 to 90% at 30°C, 0 to 80% at 40°C, 0 to 70% at 50°C, no condensation
Storage Condition	Instrument: -40 to 60°C (-40 to 140°F) Calibration Solution: 5 to 30°C (41 to 86°F)
Instrument sealing grade	IP67
Certification	CE and RoHS
Limited Warranty	2 years
Dimension and Weight	Meter: (90×203×80) mm/385g Test Kit: (310×295×110) mm/1.5kg

3 INSTRUMENT DESCRIPTION

3.1 Instrument Overview

Diagram-1

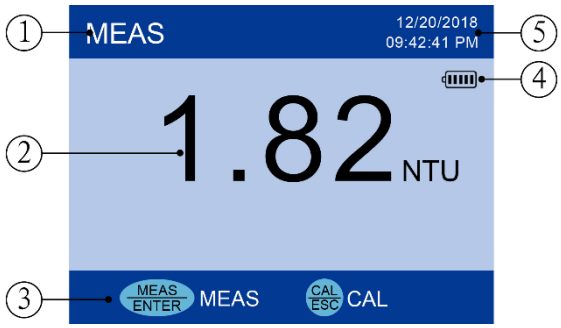
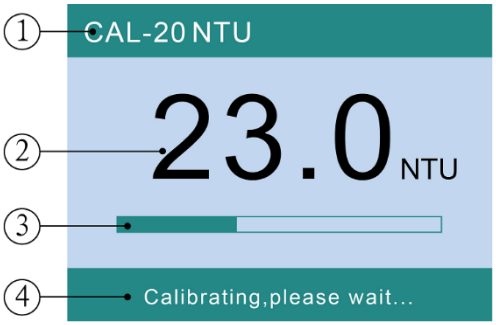
①	Flip cover of the sample cuvette holder (Close the cover when measuring)	⑥	Battery cover
②	Housing	⑦	Dust-proof plug (Take off the plug when measuring)
③	Display	⑧	Sample cuvette holder
④	Keypad	⑨	Calibration cuvettes or sample cuvettes
⑤	USB Port	⑩	Positioning mark (Align the mark with the mark on the calibration cuvette or sample cuvette)

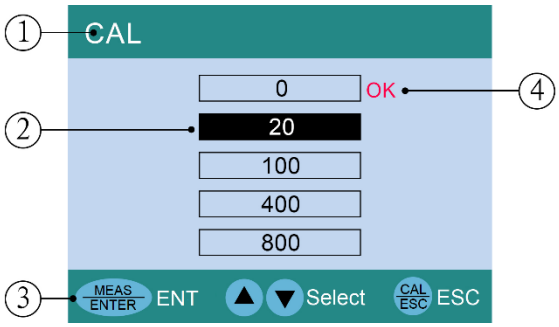
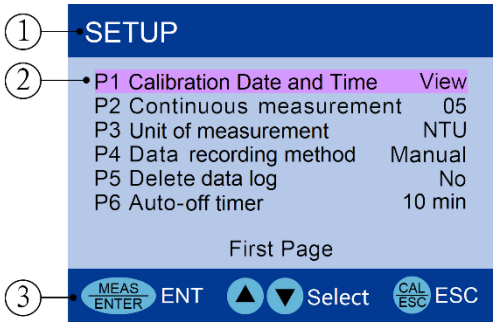
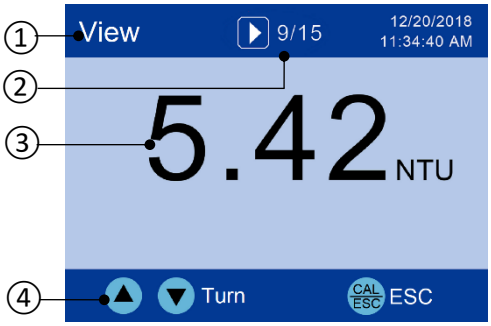
3.2 Configuration

Diagram-2

①	Calibration Solutions： 0.0, 20.0, 100, 400, 800 NTU
②	Carrying case
③	TN480 Turbidimeter
④	Microfiber cloth
⑤	Screwdriver (to remove battery cover)
⑥	Software flash drive
⑦	AA Alkaline battery×4
⑧	Silicone oil (10 ml)
⑨	Sample cuevette×6
⑩	USB Cable (under the meter)
⑪	User Manual

3.3 Display Mode

Measuring Mode		① Measurement mode ② Measurements and unit ③ Operation guide ④ Battery icon ⑤ Date and time
Calibration Mode		① Calibration solution ② Measurements and unit ③ Progress bar ④ Operation guide

Calibration Menu		① Calibration mode ② Standard values ③ Operation guide ④ Finished calibration indicator
Parameter Setup		① Parameter Setup ② Menu ③ Operation guide
Data Recall		① Data Recall ② Saved data numberings ③ Saved data ④ Operation guide

3.4 Keypad

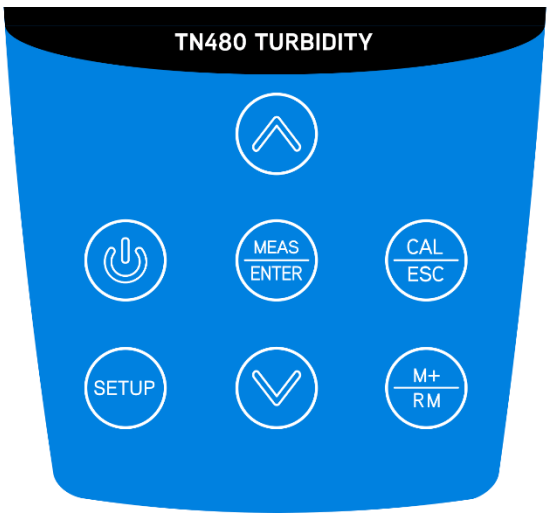
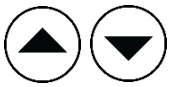


Diagram 3

Keypad	Functions
	● Power on/off
	● In measurement mode, press to enter or exit calibration mode ● In calibration mode, press to exit calibration mode ● In parameter setup and data recall mode, press to return to measurement mode
	● In measurement mode, short press to perform single measurement; long press (>3s) to perform continuous measurement. ● In calibration mode, press to confirm calibration. ● In parameter setup mode, press to confirm change.
	● In calibration mode, press to select which standard to calibrate. ● In parameter setup mode, press to scroll on the menu options. ● In recall mode, press to view store number
	● Press to enter parameter setup mode
	● Short press to save measured data; long press (>3s) to enter data recall mode

3.5 Power Supply

1. The instrument adopts 4 pieces of AA alkaline battery. Make sure not to mix new & old batteries or different models of batteries.
2. Battery capacity indication
   Battery capacity icon:  Please replace new batteries when icon displays to ensure measuring accuracy; when  icon displays, the battery must be replaced, otherwise the instrument can't work properly. To extend battery life, user can setup auto-power off time in Parameter Setup P6 according to usage requirements.
3. Use the screwdriver to remove the screws on the battery cover. Insert 4 pieces of AA alkaline battery. Please make sure the polarity is correct. Put on the battery cover and screw tightly.

3.6 Data Log, Recall, and Deletion

a) Manual data logging and Automatic data logging

In parameter setup P4, users can select manual or automatic data logging mode. In the manual mode, after measurement is finished, press  to save the data (also the measurement interface); In automatic mode, the data (also the measurement interface) will be automatically saved after each measurement. The instrument has two types of measurement mode: normal measurement (as in Diagram 4) and TruRead™ measurement (Diagram 5).  12 in Diagram 4 means that 12 sets of data has been saved. The storage number only indicates the number of measurement interfaces. In normal measurement mode, one serial number corresponds to one measurement data. In TruRead™

measurement mode, one serial number corresponds to multiple measurements (according to user's setting) in the measurement interface. The data, as shown in Diagram 5, has 10 measurements. Obviously, for one measurement interface, the memory storage of the normal measurement is different to that of TruRead™ measurement. The below table shows the amount of storage for each measurement mode.

Measurement Mode	Storage Capacity
Normal	200 sets
TruRead™ (5 times measurement)	100 sets
TruRead™ (10 times measurement)	61 sets
TruRead™ (15 times measurement)	44 sets
TruRead™ (20 times measurement)	34 sets

Therefore, when the instrument is stored in a mixture of measurement mode, the storage capacity of measurement interface is different, and it's between 34 to 200. If the stored value is full, FULL will flash to remind you and you need to clear the storage before saving new data.

b) Data Recall

In measurement mode, long press M+ RM (>3s), the instrument will display the saved data interface. As shown in Diagram 6, 9/15 means there are 15 saved data interfaces and it's currently showing the 9th one. Press ▲ or ▼ to check other data. Hold ▲ or ▼ to quickly check other data. Press CAL ESC to return to measurement mode.

Diagram 4

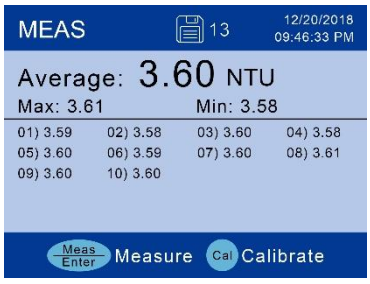


Diagram 5

Diagram 6

c) Data Deletion

Once the data storage is full, users need to delete the data in order to save new data. Select Yes in P5 in parameter setup and press MEAS ENTER to confirm the deletion (will delete all the saved data, irreversible).

3.7 Setup for first-time use

Check and adjust settings for the following items: date, time, system language, etc. See the detail in Section 6 Parameter settings.

4 CALIBRATION

4.1 Preparation for Calibration

a) Calibration point

The instrument has 5 calibration points: 0 NTU, 20 NTU, 100 NTU, 400 NTU, and 800 NTU. Among them, 0 NTU point uses AMCO 0.0 NTU calibration solution or laboratory distilled water, and the remaining 4 calibration points use AMCO polymer solutions. Note that the cap of the 0.0 NTU solution cuvette can be unscrewed. After the solution is invalidated, users can replace the 0.0 NTU calibration solution or use fresh laboratory distilled water. The AMCO 0.0 NTU calibration solution refill can be purchased from the supplier; For the remaining 4 calibration solutions, their cuvette caps cannot be opened. Simply dispose the solutions after they are expired and buy new ones from your supplier to replace. See the detail in Section 8 Replacement Parts.

b) Replace 0.0 NTU turbidity standard solution

- Open the 0.0 NTU cuvette cap, pour out the original solution, add 1/2 distilled water, screw on the cap and shake the cuvette to rinse it off and pour out the water. Repeat it 3 times. Shake off the distilled water in the cuvette. Pour in new AMCO 0.0 NTU calibration solution or fresh laboratory distilled water. Then close the cuvette cap.
- AMCO 0.0 NTU calibration solution has 6 to 12 months of shelf-life, distilled water is only valid for a couple of days.

AMCO 0.0 NTU solution is provided in the default kit. For purchase details, please refer to Section 8 Replacement Parts.

c) Clean cuvette surface

Apply a small drop of silicone oil on the surface of the cuvette and wipe it off with a lint-free cloth to evenly distribute the silicone oil on the surface in order to cover smudges and scratches, which helps light scattering. But please pay attention to the following points:

① The silicone oil applied should not be too much. After wiping with lint-free cloth, please wipe with filter paper or high-quality tissue paper to clean off. Excessive residual silicone oil on the cuvette surface will affect the measurement accuracy.

② It's not necessary to use silicone oil for each calibration and measurement. Apply silicone oil every several days or once a week. In between, just clean the surface with filter paper or high-quality tissue paper.

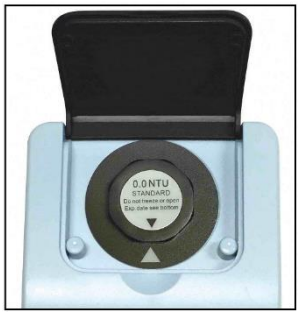
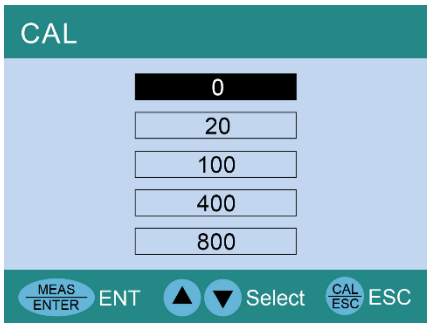
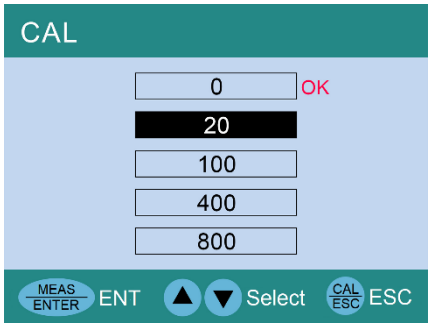
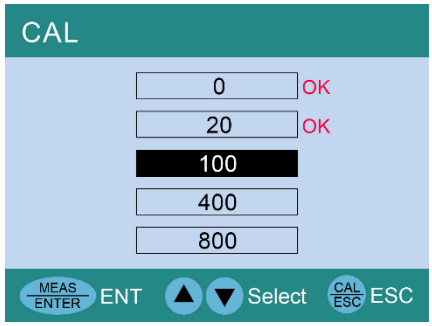
③ Clean the calibration cuvette and sample cuvette together and keep the steps and actions consistent to achieve same degree of cleanliness.

④ Stability of calibration solutions

The U.S EPA approved AMCO polymer standard calibration solution is very uniform and stable. It does not precipitate, drift or condense. Generally, it can be used directly without shaking or flipping the cuvette (to make the solution even). For AMCO polymer calibration solutions that have not been used for a long time, slowly flip the cuvette twice and let it stand for 2 minutes.

Be careful not to shake the solution vigorously, as this will create air bubbles which will destabilize the measurement; For 0.0 NTU calibration solution, do NOT shake or flip. If using Formazin calibration solution, as it tends to precipitate easily, each time users must flip and shake the cuvette to make the solution even. But sediment can still occur during tests and would make the measurement unstable. Users need to have rich experience handling Formazin calibration solutions.

4.2 Calibration Procedure (Take 0 NTU and 20 NTU as an example)

<table>
<tr><td colspan="2">1) Instrument warm up (only required for low-range or high-accuracy measurement): Power on the instrument, set parameter P2 (continuous measurement time) to 5 times. Long press MEAS ENTER to start continuous measurement (don't insert the cuvette), then wait for 3 to 5 minutes.</td></tr>
<tr><td>2) Open the flip cover and place the 0.0 NTU calibration cuvette. Align the arrow on the cuvette lid with the arrow on the sample cuvette holder and close the flip cover.</td><td>  </td></tr>
<tr><td>3) Press CAL ESC to enter the calibration menu, the cursor is at 0 NTU. Press MEAS ENTER to start calibration.</td><td>  </td></tr>
<tr><td>4) After calibration is done, press MEAS ENTER to confirm.
The instrument will return to the calibration menu (see Diagram on the right side). The OK sign indicates that 0 NTU has been calibrated and prompt to calibrate 20 NTU.</td><td>  </td></tr>
<tr><td>5) Place the 20.0 NTU calibration cuvette in the sample cuvette holder, press MEAS ENTER to start 20 NTU calibration. After calibration is done, press MEAS ENTER to confirm. The instrument will return to the calibration menu (see diagram on the right side). The OK sign indicates that 20 NTU has been calibrated.</td><td>  </td></tr>
</table>

6) If you want to continue to calibrate 100, 400 and 800 NTU, place the 100 NTU calibration cuvette in the sample cuvette holder and press MEAS ENTER to calibrate. After calibration is done, press MEAS ENTER to confirm; repeat the steps to calibrate 400 NTU and 800 NTU. After calibration is done, press CAL ESC to return to measurement mode.

7) Press CAL ESC to exit calibration mode, the instrument will return to measurement mode as shown in the right Diagram.

4.3 Notes for Calibration

a) **Calibration point verification:** The calibration point can be verified after the calibration is completed. If the calibration point has a large error, enter the calibration mode and repeat the calibration. For calibration point accuracy, users can refer to the following standards:

Calibration point	Accuracy for reference
0 NTU	≤0.05 NTU
20 NTU	≤±0.2 NTU
100 NTU	≤±2 NTU
400 NTU and 800 NTU	≤±5 NTU

b) **Calibration point selection:** The instrument has been calibrated at full range before leaving the factory. For subsequent use, you can select 2 or more points as needed, as long as the estimated measurement range is between the two calibration points. In calibration setup mode, press ▲ or ▼ to select the calibration point.

c) **Low turbidity calibration requirement**

- For low turbidity measurements (measurement less than 2 NTU), please test 0.0 NTU calibration solution. If the accuracy is not meeting requirements, calibrate the instrument at 0.0 NTU and 20.0 NTU before test; then use 1# or 2# sample cuvette for measurement.
- Using the same sample cuvette to calibrate and measure can eliminate the error caused by different cuvettes, thus reaching higher accuracy. For example, add laboratory distilled water to 1# cuvette for calibration and then add sample solution to 1# cuvette for measurement. Note that the cuvette should be rinsed off thoroughly when changing solutions.

d) **Zero Turbidity Error Reminder:** 0 NTU is the reference point for low-turbidity measurement. Due to the complexity of turbidity measurement, various inaccuracies resulting from instruments, solutions, cuvettes, and operations can cause large errors at the 0 NTU point, which has a great

impact on the measurement accuracy of low turbidity solutions. When the reading is displayed as 0.00 NTU, if a positive error occurs, a 0.0 NTU calibration solution can be used for verification test. If a negative error occurs, it cannot be verified. For this instrument, there is a Zero Turbidity Error Reminder function. If the negative error at the zero point exceeds the preset value, it will prompt users to recalibrate 0.0 NTU. At this time, please re-calibrate 0.0 NTU. If this prompt still comes up after re-calibration, it means your 0.0 NTU standard solution may not be valid anymore. Please replace the 0.0 NTU solution according to Section 4.1b and calibrate again. Please note that in comparison to other calibration solutions, 0.0 NTU is more prone to deterioration and error.

e) **High turbidity calibration requirement:** For turbidity measurement greater than 2 NTU, it is recommended to calibrate once a week, or to test a calibration solution close to the sample solution. If the error is large, the instrument needs to be recalibrated.

f) The instrument does not automatically recognize the calibration solution. If the wrong solution is selected for calibration, the measurement will be completely wrong. In this case, it can be restored by recalibrating all the points with the correct calibration solutions.

g) Place the instrument on a flat and level surface. Do not hold the instrument in hand while operating.

h) If using Formazin standards for calibration, please make sure to use the freshly made Formazin standard to ensure calibration accuracy.

5 TURBIDITY MEASUREMENT

5.1 Sample Cuvette Handling

a) 6 sample cuvettes are included in the test kit. The cap is marked with 1# to 6#, and the bottom of the cuvette also has the same number. The number of the cuvette and the cap should always be the same. *Pay attention that 1# and 2# cuvettes are only for low turbidity solution measurement. (< 2 NTU)

b) The cuvette has been rigorously cleaned and sterilized. They can be used directly for the first time. For subsequent uses, follow the steps below to perform a thorough cleaning.

- Clean the sample cuvette inside and outside with detergent → rinse with distilled water or deionized water multiple times → Rinse the cuvette twice with the sample solution → Pour the sample solution into the cuvette → Close the cap.

5.2 Measurement Preparation

a) Collect the sample solution with a clean container and add the solution to the 4/5 of the cuvette (about 18ml), see Diagram 7. Then close the lid.

b) Before the measurement, users can slowly flip the sample cuvette a few times and let it stand for 2 to 5 minutes to eliminate potential air bubbles (see Diagram 8).

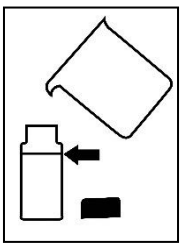


Diagram 7

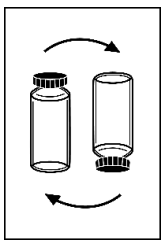


Diagram 8

c) Make sure the surface of the cuvette is dry, clean and free of stains. Apply a small drop of silicone oil on the surface of the cuvette and wipe it off with a micro-fiber cloth. Then wipe again with filter paper or high-quality tissue paper. See section 4.1(c) for details.

5.3 Measurement Mode

a) Normal Measurement Mode

Press MEAS ENTER, the screen will display the progress bar, and the measured value will be displayed in 10 seconds. To take the next measurement, press MEAS ENTER again.

b) TruRead™ Measurement Mode

Long press MEAS ENTER and release the key when you hear a beep (see Diagram 9.1), then enter TruRead™ mode. For example, if the number of continuous measurements is set to 20 times in parameter setting P2, a measured value will be displayed every 20 seconds. Diagram 9.2 is the third measurement. Diagram 9.3 is the display interface at the end of TruRead™ measurement. The average, maximum and minimum values will be displayed along with a list of 20 measured values. TruRead™ measurement mode can be used for observing the stabilizing process of turbidity, and can also be used for testing rapid-settling solutions.

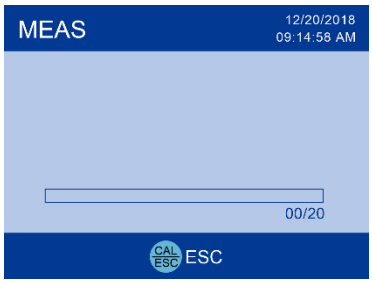


Diagram 9.1

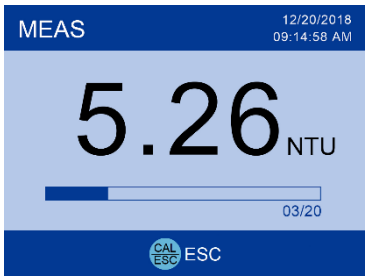


Diagram 9.2

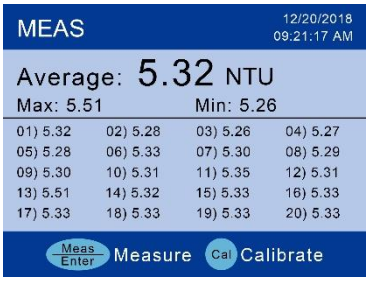


Diagram 9.3

c) We Recommend using TruRead™ Measurement Mode

Turbidity measurement is a complex analytical measurement. Its error and stability are related not only to the design of the instrument, but also many other factors such as solution uniformity and precipitation, stray light, air bubble interference, sample cuvette contamination, optical errors, and operation technique. Therefore, using normal measurement mode will obviously result in a larger error. For this reason, we recommend using TruRead™ measurement mode with 5 times continuous measurement for regular tests, that is, set the continuous measurement to 5 times in parameter setting P2 and read the average value each time to improve the measurement accuracy. Compare the maximum and minimum values at the same time. If the difference is too large, it means that the measured value is not reliable, the solution may be unstable or there might be other factors affecting the measurement. Users need to check the causes and measure again. For rapid-settling or continuously changing solutions, set continuous measurement for 10, 15 or 20 times.

5.4 Notes for Measurement

a) **Keep the sample stable**: After the cuvette is placed into the sample cell, it is recommended to wait for 1 to 2 minutes before calibration, as the solution will experience some shaking when the cuvette moves, which may result in inaccurate measurements.

b) **Sample Cuvette cleaning requirement**: Sample cuvette must be rigorously cleaned and free from smudges and scratches. When wiping, user should grip the cap and bottom to avoid leaving fingerprints on the surface of the cuvette. Its surface should be applied with a drop of silicone oil be wiped with a micro-fiber cloth. After that, please clean with filter paper or high-quality tissue paper. See section 4.1(c) for details.

c) **Mixing and Degassing**: Samples should not be vigorously shaken or vibrated. It is recommended that users gently shake the sample cuvette to make solution evenly distributed. Air bubbles in solution will cause big error to turbidity measurement. So, the cuvette should be left stand still for 2 to 5 minutes to eliminate potential air bubbles before measuring. But mixing and degassing simultaneously is a difficult process to handle, especially for solution with precipitates, which requires some operating experience or making some limits in test conditions, for example, limiting the mixing condition and waiting time for degassing to be the same before comparing measurements.

d) **Other Requirements**

- On the premise of ensuring evenly distributed samples, sample solution should be measured immediately to prevent temperature changing and precipitates from affecting measurements.
- Avoid sample dilution for measurement as much as possible.
- Avoid operating under direct sunlight.
- Do not pour solution into the cuvette holder. Sample cuvettes must be used for measurement.
- Please do not wash the cuvette holder as this may damage its optical structure.

6 PARAMETER SETUP

6.1 Operation

Press (SETUP) to enter parameter setup mode → press (▲) or (▼) to switch P1-P2-...P9 → press (MEAS ENTER) to enter each parameter → press (▲) or (▼) to make changes → press (MEAS ENTER) to confirm → press (CAL ESC) to return to measurement mode.

6.2 Parameter Setup Reference Table

Symbol	Parameter	Content
P1	Last calibration date and time	View
P2	Continuous measurement	5-10-15-20
P3	Measurement unit	NTU-FTU
P4	Data logging mode	manual-automatic
P5	Delete saved data	No-Yes
P6	Auto-power off timer	10-20-30-OFF
P7	Select language	English-Spanish-Chinese
P8	Date setting	/
P9	Time setting	/

6.3 Parameters Description

P1 ─ Calibration date and time: users can check the date and time of last calibration

P2 ─ Continuous measurement: users can select the number of times for continuous measurements (5, 10, 15 or 20 times).

P3 ─ Measurement Unit: users can select which unit to use: NTU or FTU

P4 ─ Data logging mode: users can select automatic data logging mode or manual data logging mode (see section 3.6 for details)

P5 ─ Delete saved data: select Yes to delete all the saved data (non-reversible)

P6 ─ Auto. close timer: users can select in how soon the instrument will turn off automatically if there is no operation: 10 minutes, 20 minutes, 30 minutes, or off; when selecting off, the instrument can only be turned off by pressing the power button.

P7 ─ select language: users can select English, Spanish, or Chinese as the system language.

P8 and P9 ─ set up date and time: in the setting process icon ◆▶ indicates to switch between date and time, icon ▲▼ indicates to change the digit of date and time.

7 DATA OUTPUT VIA USB PORT

7.1 Display Interface

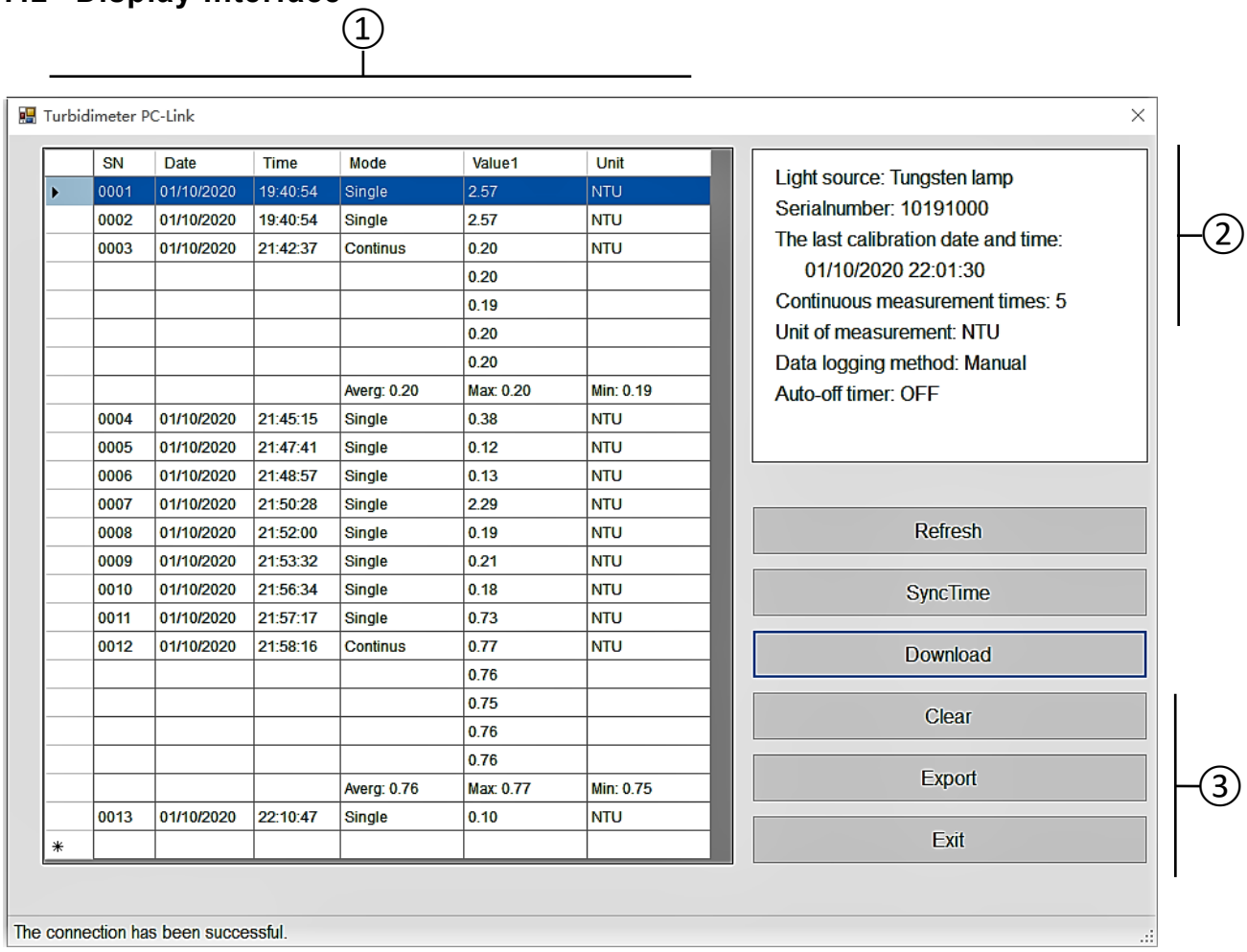


Diagram 10

①— Display area for saved data

To display numberings, date, time, measurement method (normal measurement or continuous measurement), measured values, and measurement unit. For continuous measurement, average, maximum, and minimum values will also be displayed.

②— Instrument serial number, last calibration information and parameter setting information.

③— Function buttons

7.2 Operation Key in Software Interface

Refresh — Port reset key. When the instrument and computer are not connected, click to connect.

SyncTime — Sync time key, click to sync computer time with instrument time.

Download — Download key, click to send data from instrument memory to computer.

Clear — Clear key, click to delete data saved in computer (data saved in instrument will not be deleted).

Export — Export key, click to export the saved data to computer in a Microsoft Excel document.

Exit — Exit key, press to exit PC-Link program.

7.3 Install Software

The instrument uses Turbidimeter PC-Link communication software. It is only compatible with Windows-based operating system. The communication port is USB. Copy and paste the program files from the USB drive to the computer. Connect USB cable to the instrument and computer, open Turbidimeter PC-Link.exe, the instrument will connect with computer automatically.  icon will be displayed at the top of LCD screen. If the instrument cannot connect with computer, please click "Refresh" key or install the relevant software driver included in the USB drive.

7.4 Run Software

Click Download key, all data in the instrument memory will be sent to the computer. When the program is running, all measurement information will be sent to the computer via USB. There is no data storage limit and the data will not be saved in the instrument. In Manual data logging mode, press 

key after measurement is completed to save data in the computer; in Auto. data logging mode, data will be automatically saved in the computer after each measurement is completed. For TruRead™ measurement mode, it will save all the measured values along with maximum, minimum and average values.

7.5 Data Processing

Click Export key to export saved data to a Microsoft Excel document. The data can be further analyzed and printed.

8 REPLACEMENT PARTS

Model	Name	Description	Quantity
T500-2	AMCO 0.0 NTU calibration solution	0.0 NTU/100mL	1 bottle
T200-1	20/100/400/800 NTU AMCO polymer solutions	Compatible with TN400&TN480	4 bottles
T500-3	Sample cuvettes with lid	Φ25×60mm，1# to 6#	6 pcs
TN400-S3	Silicone oil	10mL	1 bottle

9 WARRANTY

We warrant this instrument to be free from defects in material and workmanship and agree to repair or replace free of charge, at the option of APERA INSTRUMENTS, LLC, any malfunctioned or damaged product attributable to the responsibility of APERA INSTRUMENTS, LLC for a period of TWO YEARS for the instrument from the delivery.

This limited warranty does NOT cover any issues due to:

- Accidental damage
- Improper use
- Normal wear and tear
- Transportation
- Storage
- Failure to follow the product instructions
- Unauthorized maintenance, modifications, combination or use with any products, materials, processes, systems or other matter
- Unauthorized repair
- External causes and other actions or events beyond our reasonable control.

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