

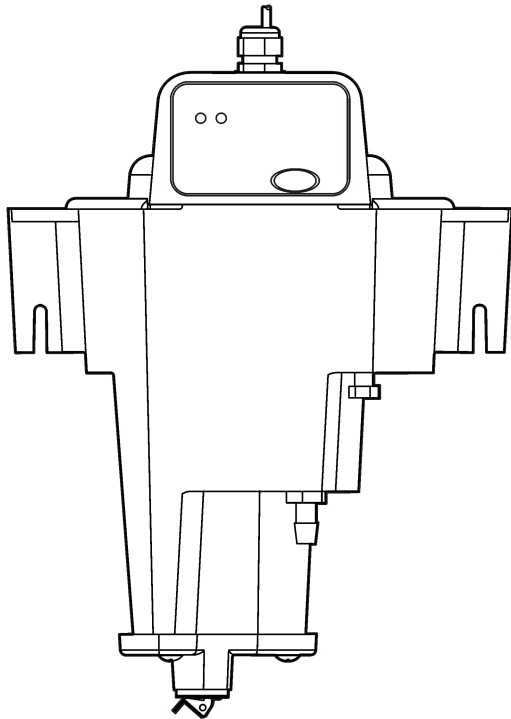


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FT660 sc

01/2012, Edition 2

User Manual



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Specifications

Specifications are subject to change without notice.

Specification	Details
Range	0.000–5000 milli-Nephelometric Turbidity Units (mNTU) (0–5.0 NTU with +10% over-range limit)
Measurement units	mNTU, mFTU, NTU, FTU, mg/L, Degree
Over-range limit*	+10%
Method compliance	USEPA Approved for drinking water applications by Method 10133
Lowest expected reading	7 mNTU
Accuracy	±3% of reading or ±5 mNTU (whichever is greater)
Repeatability	±0.42% at 50 mNTU ±0.3% at 800 mNTU
Resolution	0.001 mNTU on lowest range 0.1 mNTU on highest range
Calibration	Single point at 800 mNTU ±50 mNTU
Calibration frequency	Every 3 months (or as per regulations)
Calibration (wet) verification method	Pass/fail criteria or tolerance (standards less than 1000 mNTU): 25–50 mNTU Pass/fail criteria or tolerance (standards greater than 1000 mNTU): 5%
Calibration (dry) verification method	Verification level: 20–50 mNTU Performance default: ±5 mNTU of the identified baseline value Method precision: less than or equal to 5% relative standard deviation (RSD)
Signal averaging	No averaging, 6, 30, 60 or 90 seconds

Specification	Details
Sample light source	Class 1 Laser Product with embedded 7.5 mW, 670 nm, Class 3B Laser Source Complies with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007. FDA Laser Accession No. 9911570
Power requirement	10.5 to 13.2 VDC at 1.5 VA
Operating conditions	0 to 40 °C (32 to 100 °F), 5–95% non-condensing
Storage conditions	–20 to 60 °C (–4 to 140 °F)
Sample requirements	Temperature: 0 to 50 °C (32 to 121 °F) Flow: 100–750 mL/minute (1.6–11.9 gal/hour)
Recorder output	0–20 mA or 4–20 mA The output span is programmable over any portion of the 0.000–1000 mNTU range.
Sample inlet fitting	¼-in. NPT female, ¼-in. compression fitting
Drain fitting	½-in. NPT female, ½-in. hose barb
Tubing requirements	Sample inlet: ¼-inch OD rigid or semi-rigid tubing Drain: ½-inch ID flexible plastic tubing
Dimensions (W x D x H)	25.4 x 30.5 x 40.6 cm (10 x 12 x 16 in.)
Mounting options	Wall mounted or floor stand
Shipping weight	Turbidimeter and controller—16.31 kg (13.5 lb) Turbidimeter only—4.71 kg (10 lb)
ASTM conformance	D6698 Standard test method for online measurement of turbidity below 5 NTU
Limit of detection (LOD)	0.296 mNTU (ISO 15839)
Protection class	III
Pollution degree	2/II

* The instrument range is from 0 to 5000 mNTU. The instrument is guaranteed to meet specifications relative to accuracy, repeatability and linearity up to 5000 mNTU. The instrument will still show a value above 5000 mNTU to the level of 5500 mNTU, but above 5000 mNTU, measurement performance is not guaranteed. Between 5000 and 5500 mNTU, the warning alarm will flash to tell the operator that the operating range has been exceeded. An over-range event is also logged. All alarm setpoints are calculated based on the maximum value shown (5500 mNTU).

General information

In no event will the manufacturer be liable for direct, indirect, special, incidental or consequential damages resulting from any defect or omission in this manual. The manufacturer reserves the right to make changes in this manual and the products it describes at any time, without notice or obligation. Revised editions are found on the manufacturer's website.

Safety information

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

Use of hazard information

▲ DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

▲ WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

▲ CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.




NOTICE

Indicates a situation which, if not avoided, may cause damage to the instrument. Information that requires special emphasis.

Precautionary labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed. A symbol, if noted on the instrument, will be included with a danger or caution statement in the manual.

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	Electrical equipment marked with this symbol may not be disposed of in European public disposal systems after 12 August of 2005. In conformity with European local and national regulations (EU Directive 2002/98/EC), European electrical equipment users must now return old or end-of-life equipment to the Producer for disposal at no charge to the user. <i>Note: For return for recycling, please contact the equipment producer or supplier for instructions on how to return end-of-life equipment, producer-supplied electrical accessories, and all auxiliary items for proper disposal.</i>
	This symbol indicates that a risk of electrical shock and/or electrocution exists.
	This symbol indicates the need for protective eye wear.

	This symbol indicates a laser device is used in the equipment.
	This symbol, when noted on the product, identifies the location of a fuse or current limiting device.
	This symbol indicates that the marked item requires a protective earth connection. If not provided with a plug on a cord, connect positive earth to this terminal (U.S. cord set provides ground).

Certification

Canadian Radio Interference-Causing Equipment Regulation, IECIS-003, Class A:

Supporting test records reside with the manufacturer.

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

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

FCC Part 15, Class "A" Limits

Supporting test records reside with the manufacturer. The device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions:


1. The equipment may not cause harmful interference.
2. The equipment must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can

radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at their expense. The following techniques can be used to reduce interference problems:

1. Disconnect the equipment from its power source to verify that it is or is not the source of the interference.
2. If the equipment is connected to the same outlet as the device experiencing interference, connect the equipment to a different outlet.
3. Move the equipment away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

Product overview

⚠ DANGER	
	Chemical or biological hazards. If this instrument is used to monitor a treatment process and/or chemical feed system for which there are regulatory limits and monitoring requirements related to public health, public safety, food or beverage manufacture or processing, it is the responsibility of the user of this instrument to know and abide by any applicable regulation and to have sufficient and appropriate mechanisms in place for compliance with applicable regulations in the event of malfunction of the instrument.

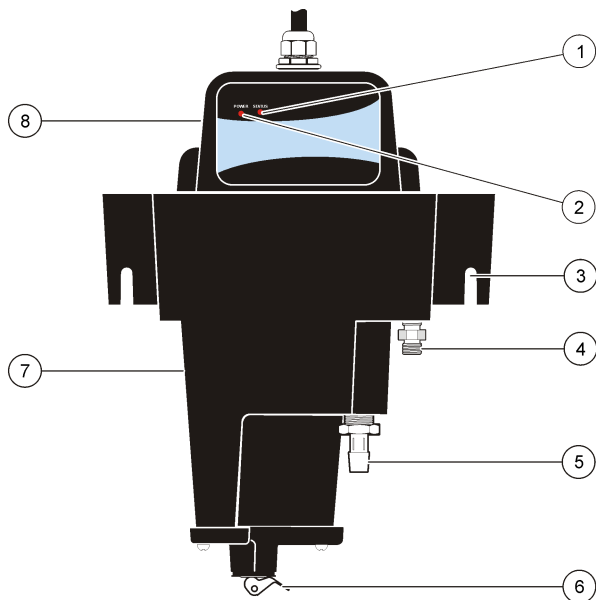
⚠ DANGER	
Although the sc controller is certified for Class 1, Division 2 Hazardous Locations, it is only certified when installed with sensors listed in Control Drawings 5860078. The sc controller and FT660 sc are NOT suitable for use in Class 1, Division 2 Hazardous Locations.	

The FT660 sc is a continuous-reading instrument for filter management (Figure 1). The FT660 sc is appropriate for ultra pure and all processes that include clean water monitoring.

The status light on the head assembly is illuminated when an error occurs and flashes when a warning occurs or the head assembly is not installed correctly.

The back of the head assembly has a molded "lip" that may be used to hang the head on the edge of the body of the instrument during maintenance.

Figure 1 Instrument overview

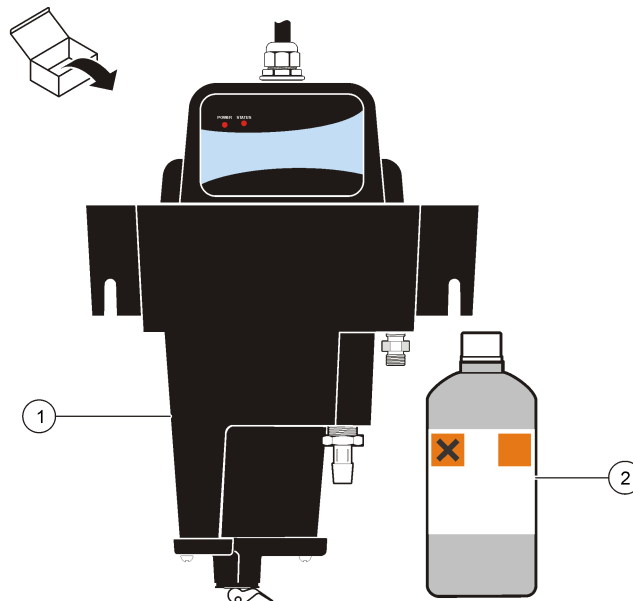


1 Status light	5 Drain fitting
2 Power light	6 Drain plug
3 Mounting bracket	7 Body of the instrument
4 Sample inlet fitting	8 Head assembly

Product components

Make sure that all components have been received (Figure 2). If any items are missing or damaged, contact the manufacturer or a sales representative immediately.

Figure 2 Instrument components



1 FT660 sc turbidimeter	2 800 mNTU StabiCal® Certified Standard
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Installation

⚠ DANGER



Multiple hazards. Only qualified personnel must conduct the tasks described in this section of the document.

Installation guidelines

NOTICE

High internal temperatures will damage the instrument components.

- Do not operate the instrument in direct sunlight or next to a heat source.
- Install the instrument indoors in a clean environment with minimum vibration.
Note: *Particulate contamination from the surrounding area is a major cause of error.*
- Install the instrument level.
- Keep the flow rate and operating temperature as constant as possible for best performance.

Mechanical installation

Instrument mounting

Install this instrument on a flat, vertical surface. Refer to the illustrated steps in [Figure 3](#). Mounting hardware (two ¼-20 bolts) is supplied by the customer.

Install the instrument as near to the sampling point as possible to minimize lag time of the sample flow.

Refer to [Figure 4](#) for instrument dimensions and clearance specifications.

Note: *As an alternative, this instrument can be installed on the optional floor stand.*

Figure 3 Instrument mounting

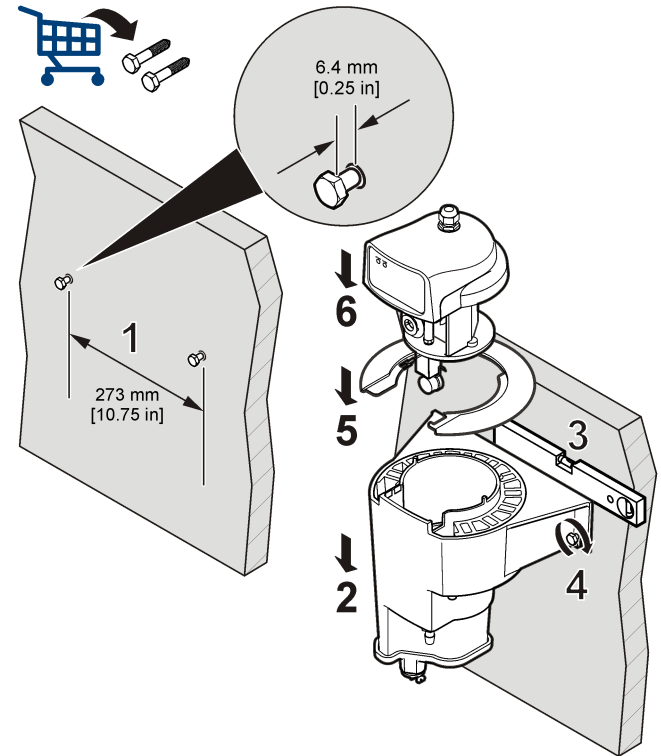
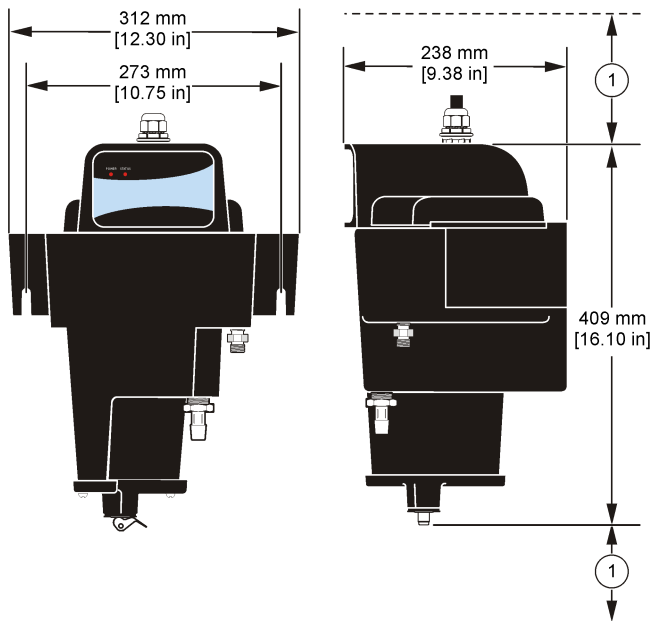


Figure 4 Instrument dimensions



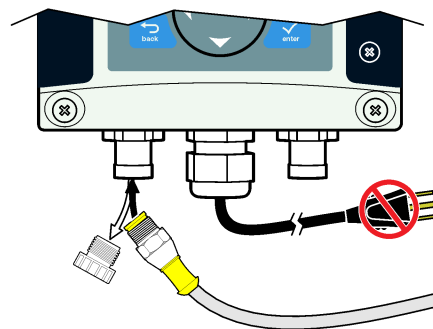
1 22 cm (10 in.) minimum clearance

Electrical installation

Connect an sc controller using Quick-connect fitting

The instrument can be connected to an sc controller using the keyed quick-connect fitting (Figure 5). Extension cables are available. Retain the connector cap to seal the connector opening in case the instrument must be removed. Refer to the sc controller manual for more information.

Figure 5 Quick-connect fitting



Plumbing

Sample line considerations

Select a good, representative sampling point for optimum instrument performance. The sample analyzed must be representative of the condition of the entire system.

To minimize erratic readings:

- Draw samples from locations that are sufficiently distant from points of chemical additions to the process stream
- Make sure samples are sufficiently mixed
- Make sure all chemical reactions are complete

Connect the sample stream

Connect sample inlet and drain lines to the fittings on the body of the instrument (Figure 1 on page 6). Sample inlet and drain tubing are supplied by the customer. Refer to [Specifications](#) on page 3 for tubing requirements.

Install the sample line(s) into a larger process pipe to minimize interference from air bubbles or pipeline bottom sediment. A sample line going into the center of a process pipe is best.

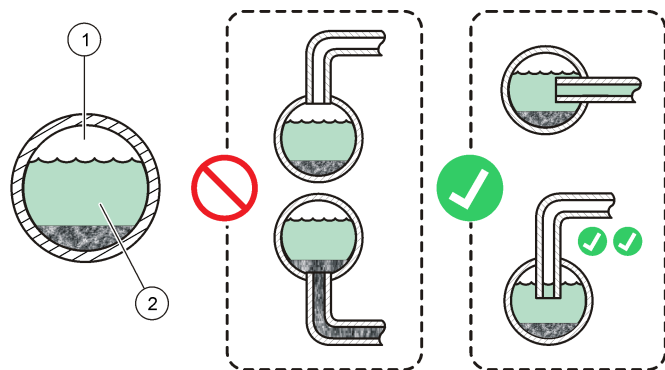
Figure 6 shows examples of good and bad methods of installing a sample line into a process pipe.

Notes:

- Keep the sample inlet and drain tubing as short as possible to minimize lag time of the sample flow.
- Control the flow rate into the instrument with a flow restriction device on the sample line. Refer to [Specifications](#) on page 3 for flow rate specifications.

Note: Flow rates greater than 750 mL/minute will cause the instrument to overflow into the drain, decrease the performance of the bubble trap and cause incorrect readings.

Figure 6 Sampling methods



1 Air

2 Sample flow

Operation

Using the sc controller

Before using the instrument with an sc controller become familiar with the operating mode of the sc controller. Refer to the sc controller user manual and learn how to use and navigate the menu functions.

Configure the instrument

Use the Configure menu to enter identification information and display options for the instrument and to change options for instrument settings, data handling and storage.

1. From the Main menu, select Sensor Setup, [Select Sensor], Configure.
2. Use the arrow keys to select an option and confirm. To enter numbers, characters or punctuation, push and hold the **UP** or **DOWN** arrow keys. Push the **RIGHT** arrow key to advance to the next space.

Option	Description
BUBBLE REJECT	Enable or disable bubble reject—Yes (default) or No Bubble reject is an averaging algorithm that compensates for higher readings caused by entrained air coming out of the solution in the sample chamber.
SIGNAL AVG	Select no signal averaging or the amount of time for signal averaging—no averaging, 6, 30, 60 or 90 (default) seconds.
MEAS UNITS	Select the measurement units to show on the display—mNTU (default), mFTU, NTU, FTU, mg/L or Degree.
EDIT NAME	Change the name to show on the display for the instrument. The instrument name can be a maximum of 12-digits in any combination of symbols and alpha or numeric characters. Note: The serial number of the instrument is the default name.
SET RESOLUTION	Set the number of significant digits to show on the display (default=3).

Option	Description
DATALOG INTRVL	Select the interval between saving data points to the data log—30 seconds or 1, 5, 10 or 15 (default) minutes.
OFFSET	<p>Sets an offset of the value of the standard used for calibration (-50 to +50 mNTU, default=0). The offset value is subtracted from the calibration standard value shown on the sc controller.</p> <p>The offset can be entered after a calibration is complete and is based on independent turbidity measurement of the calibration standard.</p> <p>Note: <i>The offset will not result in a calibration standard value of less than zero on the sc controller.</i></p>

Data logging

The sc controller provides one data log and one event log for each instrument. The data log stores the measurement data at selected intervals. The event log stores different types of events that occur on the devices (i.e., configuration changes, alarms and warning conditions).

The data log and the event log can be saved in CSV format. Refer to the sc controller user manual for instructions.

Calibration

Calibration is done in the body of the instrument or using the optional calibration kit.

Calibration is done using 1 L of 800 ± 50 mNTU StablCal Stabilized Formazin Certified Standard. Do not use other types or values of standards. Do not use user-prepared formazin.

The performance specifications given in this manual are based on and guaranteed only when calibration is done with StablCal Stabilized Formazin Certified Standard for this instrument. The manufacturer cannot guarantee the performance of the instrument if calibrated with copolymer styrenedivinylbenzene beads or other suspensions.

Prepare the StablCal® Standard

- Before opening a StablCal Standard bottle, clean the exterior surface of the bottle with clean water to remove dust or other debris.

- Gently invert the bottle for 1 minute (about 50 inversions). Do not shake.

Note: *The suspension is stable for 30–60 minutes after mixing.*

The StablCal Certified Standard is stabilized formazin with a value that is identified to within ± 1 mNTU. The value, specific to that particular lot of product, is printed on the label. Lot-to-lot variation will be ± 50 mNTU from the standard value, with a standard deviation of less than $\pm 5\%$ within a single lot.

Calibration notes

- Calibrate the instrument before initial use.
- Calibrate the instrument every three months (or as set by regulatory agencies).
- Calibrate the instrument after any significant maintenance or repair is done on the instrument.
- Always clean the instrument immediately before calibration. Refer to [Clean the instrument](#) on page 17.
- Operate the instrument at least 10 hours before calibration.
- For the best calibration, calibrate the instrument when it is at the same temperature as the operating conditions.
- The Hold Outputs feature is automatically enabled during the zero electronics and calibration procedure. The Hold Output feature holds attached outputs at the before-calibration settings.

Calibration procedure

1. From the Main menu, select Sensor Setup, [Select Sensor], Calibrate, StablCal Cal.
2. Select the available Output Mode (Active, Hold or Transfer) from the list box and confirm.
3. Remove the head assembly and bubble trap cover from the body of the instrument. Refer to [Figure 7](#).
4. Make sure that the body of the instrument is drained completely.
5. Enter the turbidity value that is on the label of the StablCal Standard bottle and confirm.

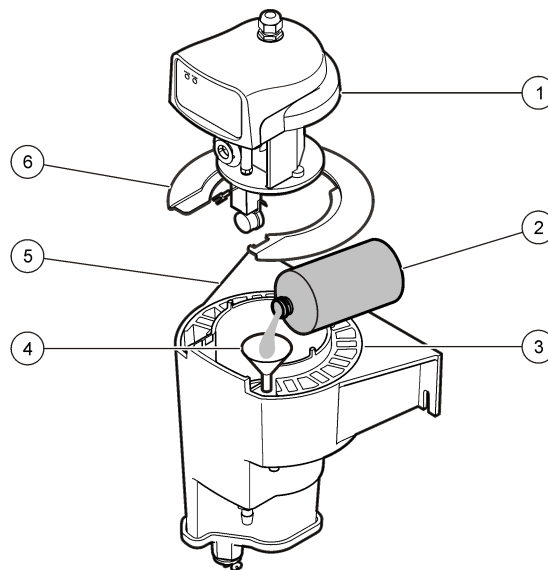
6. Put a funnel at the end of the bubble trap and slowly put 800 mNTU StablCal Standard in the funnel to fill the body. Refer to [Figure 7](#).
7. Put the bubble trap cover and head assembly on the body of the instrument.

Note: If the head assembly is not correctly installed, the laser will not turn on and the reading on the display will be near 0.000 mNTU or a negative value. The red status light on the instrument will also flash one time per second.

8. When the turbidity reading is stable (and after greater than 5 minutes), confirm to accept the reading.
9. When the display shows "GOOD CAL! GAIN: X.XX ENTER TO CONT.", confirm to save the turbidity value.

Note: If the display shows "BAD CAL!", confirm to do the calibration again or exit.
10. When the display shows "VERIFY CAL?", confirm to do a calibration verification or exit without verification.
11. Do a calibration verification or enter the operator initials to complete the calibration.
12. When the display shows "RETURN SENSOR TO MEASURE MODE", confirm.

Figure 7 Calibrate the instrument



1 Head assembly	4 Funnel
2 800 mNTU StablCal® Certified Standard	5 Body of the instrument
3 Bubble trap	6 Bubble trap cover

Calibration verification

Do a calibration verification immediately after every calibration. Subsequent verifications are referenced to the initial verification.

Do a calibration verification monthly between calibrations.

A calibration verification is a check that is done to make sure that the instrument is working correctly and calibrated.

Types of verifications

Wet or dry standards can be used to do calibration verifications.

To do a wet standard verification, refer to [Verification procedure with a wet standard](#) on page 12.

To do a dry standard verification, refer to [Prerequisites for dry standard use](#) on page 12 and then either:

- [Verification with a dry standard and software](#) on page 13—Applies to instruments with dry standard software.
- [Verification with a dry standard without software](#) on page 15—Applies to instruments that do not have dry standard software.

Verification procedure with a wet standard

Wet standard verification is done using 1 L of StablCal Stabilized Formazin Certified Standard (0–5500 mNTU) for this instrument. Do not use other standards. Do not use user-prepared formazin.

Note: For the best verification results, clean the instrument before doing a wet standard verification. Refer to [Clean the instrument](#) on page 17.

Note: On the sc controller, there is no option to set the pass or fail criteria (PFC) for a wet verification. The default PFC is ± 50 mNTU (0.050 NTU) or 5% of the reading, whichever is greater.

1. From the Main menu, select Sensor Setup, [Select Sensor], Calibrate, Verification, Perform Ver.
2. Select the available Output Mode (Active, Hold or Transfer) from the list box and confirm.
3. Select WET for the verification type and confirm.
4. Enter the turbidity value that is on the label of the StablCal Standard bottle and confirm.
5. When the display shows "DRAIN AND CLEAN BODY. ENTER TO CONT.", fully flush the body of the instrument with water that is less than 50 mNTU (0.05 NTU).
 - a. Remove the head assembly and bubble trap cover from the body of the instrument. Refer to [Figure 7](#) on page 11.
 - b. Put an empty container under the instrument.
 - c. Remove the drain plug from the bottom of the body of the instrument. Refer to [Figure 1](#) on page 6.

Note: There is no risk of laser exposure with the drain plug removed. The laser is disabled when the head assembly is removed.

- d. Fully flush the body of the instrument with water that is less than 50 mNTU (0.05 NTU).
 - e. Install the drain plug in the instrument.
6. Prepare the StablCal standard. Refer to [Prepare the StablCal® Standard](#) on page 10.
 7. Put a funnel at the end of the bubble trap and slowly put the StablCal Standard in the funnel to fill the body. Confirm. Refer to [Figure 7](#) on page 11.
 8. Put the bubble trap cover and head assembly on the body of the instrument.
 9. When the turbidity reading is stable (and after greater than 5 minutes), confirm to accept the reading.
 10. If "GOOD VER" (good verification) is shown:
 - a. Select ENTER INITIALS and confirm.
 - b. Enter operator initials and confirm.
 - c. Select RETURN SENSOR TO MEASURE MODE and confirm.
 11. If "BAD VER" (bad verification) is shown:
 - a. To do the calibration verification again, confirm.

Note: If the verification fails two times, "Please Recalibrate" is shown, then the display returns to the Calibrate Menu. Verification cannot be done until the instrument is recalibrated.

- b. To exit, push **BACK**.

Note: The bad verification is saved in the verification history.

Prerequisites for dry standard use

In order to use the dry standard, the instrument must have a special aperture plate. Refer to [Figure 8](#) on page 14. The instrument can also have a software upgrade to install dry standard software.

Instruments made before April 2008 do not have the special aperture plate. Customers can order and install the special aperture plate. Installation instructions are provided with the aperture plate.

Instruments made before April 2008 do not have dry standard software installed. Software upgrades must be done by the manufacturer.

Starting in April of 2008, the aperture plate and dry standard software will be installed on instruments at the time of manufacture.

Verification with a dry standard and software

This procedure includes instructions on how to:

- Enable the dry standard software and set the pass or fail criteria for verification
- Find and save a baseline value for the dry standard using the dry standard software
- Do a dry standard verification using the dry standard software

Find and save the baseline value for the dry standard immediately after the instrument is calibrated and after every subsequent calibration. Refer to [Assign a baseline value to the dry standard](#) on page 13.

The baseline value is referenced for subsequent calibration verifications until the next calibration.

Note: When not in use, keep the dry standard in the protective case.

Enable the dry standard software

1. From the Main menu, select Sensor Setup, [Select Sensor], Calibrate, Verification, CVM Select, Enable.
2. To set the pass or fail criteria to a value other than the recommended default (± 5 mNTU):
 - a. Select Verification, P/F Criteria.

Note: The P/F Criteria menu option is available only if CVM is set to ENABLE in step 1.
 - b. Use the arrow keys to change the PFC (pass or fail criteria) value and confirm.

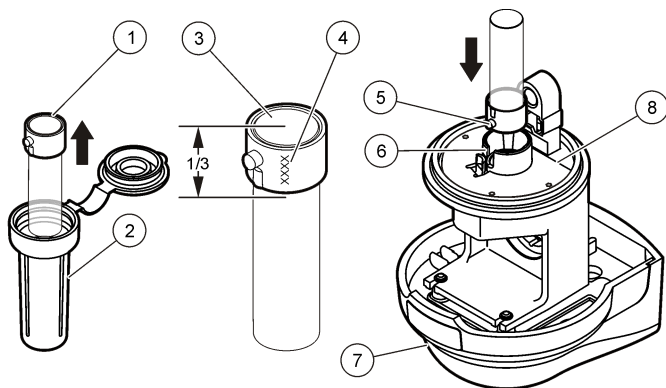
The PFC range is 5–250 mNTU.

Assign a baseline value to the dry standard

1. After the instrument is calibrated and the operator initials have been entered, the display shows "VERIFY CAL?". Confirm to start the verification process.
2. Select DRY for the verification type and confirm.
3. Remove the head assembly from the body of the instrument.
4. Remove the dry standard from the protective case. Refer to [Figure 8](#).
5. Record the serial number of the dry standard. Refer to [Figure 8](#).
6. Clean, dry and inspect the dry standard.
 - a. Use the disposable wipes provided to clean the dry standard.
 - b. Use a dry cloth to dry the top $1/3$ of the dry standard. Refer to [Figure 8](#).
 - c. Make sure that the glass of the dry standard is free of chips and scratches.
7. Install the dry standard.
 - a. Put the dry standard in the aperture plate. Make sure that the locking pin goes in the notch in the aperture plate. Refer to [Figure 8](#).
 - b. Turn the dry standard $1/8$ of a turn clockwise until the dry standard locks in position.
 - c. Use a dry cloth to remove any fingerprints and oils from the glass of the dry standard.
8. Put the head assembly on the body of the instrument.
9. Enter the serial number of the dry standard, then confirm.
10. When the instrument reading is stable, confirm to accept the reading as the baseline value.
11. Remove the dry standard from the instrument.
 - a. Remove the head assembly from the body of the instrument.
 - b. Turn the dry standard $1/8$ of a turn counter-clockwise, then remove the dry standard from the aperture plate.
 - c. Put the head assembly on the body of the instrument.
12. Confirm to go to Measurement Mode.

13. Push **HOME** to show the online measurements.
14. Put the dry standard in the protective case.

Figure 8 Install the dry standard



1 Dry standard	5 Locking pin
2 Protective case	6 Notch in the aperture plate
3 Top of the dry standard	7 Head assembly
4 Serial number	8 Aperture plate

Verification procedure with dry standard and software

1. From the Main menu, select Sensor Setup, [Select Sensor], Calibrate, Verification, Perform Ver.
2. Select the available Output Mode (Active, Hold or Transfer) from the list box and confirm.
3. Select DRY for the verification type and confirm.
4. Remove the dry standard from the protective case. Refer to [Figure 8](#) on page 14.

5. Make sure that the serial number on the display is the same as the serial number on the dry standard, then confirm. Refer to [Figure 8](#) on page 14.
6. Remove the head assembly from the body of the instrument.
7. Clean, dry and inspect the dry standard.
 - a. Use the disposable wipes provided to clean the dry standard.
 - b. Use a dry cloth to dry the top $\frac{1}{3}$ of the dry standard. Refer to [Figure 8](#) on page 14.
 - c. Make sure that the glass of the dry standard is free of chips and scratches.
8. Install the dry standard.
 - a. Put the dry standard in the aperture plate. Make sure that the locking pin goes in the notch in the aperture plate. Refer to [Figure 8](#) on page 14.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn clockwise until the dry standard locks in position.
 - c. Use a dry cloth to remove any fingerprints and oils from the glass of the dry standard.
9. Put the head assembly on the body of the instrument.
10. When the instrument reading is stable, confirm.

"GOOD VER" (good verification) or "BAD VER" (bad verification) is shown. If "BAD VER" is shown, the instrument did not to meet the PFC (pass or fail criteria), or the instrument was not able to get a stable reading. Use [Table 1](#) to identify the result and what action should be done.
11. Remove the dry standard from the instrument.
 - a. Remove the head assembly from the body of the instrument.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn counter-clockwise, then remove the dry standard from the aperture plate.
 - c. Put the head assembly on the body of the instrument.
12. Confirm to go to Measurement Mode.
13. Push **HOME** to show the online measurements.
14. Put the dry standard in the protective case.

Table 1 Interpretation of verification values

Verification values	Result identified	Suggested action
± 5 mNTU of the baseline ²	The instrument is calibrated.	None
- 5 mNTU (or less) of the baseline ^{2**}	The instrument is not calibrated.	<ol style="list-style-type: none"> 1. Clean the instrument. 2. Do the verification again. 3. Recalibrate the instrument if necessary. 4. If recalibrated, assign a new baseline value.
+ 5 mNTU (or greater) of the baseline	The instrument body may be contaminated. There may be fluid on the optical surface of the dry standard.	<ol style="list-style-type: none"> 1. Clean the body of the instrument, bubble trap, detector and dry standard. 2. Recalibrate the instrument. 3. Assign a new baseline value.

* If the instrument consistently does not meet the PFC, contact the manufacturer.

** A significantly low value is 25% or less of the expected value. A significantly low value may occur because the light source or detector is not working correctly. If the verification value is consistently significantly low, send the instrument to the manufacturer for service.

Verification with a dry standard without software

This procedure includes instructions on how to:

- Assign an initial baseline value to the dry standard without dry standard software
- Do a dry standard verification without dry standard software

Find and store the baseline value for the dry standard immediately after the instrument is calibrated and after every subsequent calibration. Refer to [Assign a baseline value to the dry standard](#) on page 15.

The baseline value is referenced for subsequent calibration verifications until the next calibration.

Note: This procedure can be done on instruments that use the AquaTrend® controller by manually recording the baseline value for the dry standard, pass or fail criteria (PFC) for verification and verification value.

Note: When not in use, keep the dry standard in the protective case.

Assign a baseline value to the dry standard

1. Remove the head assembly from the body of the instrument.
2. Remove the dry standard from the protective case. Refer to [Figure 8](#) on page 14.
3. Clean, dry and inspect the dry standard.
 - a. Use the disposable wipes provided to clean the dry standard.
 - b. Use a dry cloth to dry the top $\frac{1}{3}$ of the dry standard. Refer to [Figure 8](#) on page 14.
 - c. Make sure that the glass of the dry standard is free of chips and scratches.
4. Install the dry standard.
 - a. Put the dry standard in the aperture plate. Make sure that the locking pin goes in the notch in the aperture plate. Refer to [Figure 8](#) on page 14.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn clockwise until the dry standard locks in position.
 - c. Use a dry cloth to remove any fingerprints and oils from the glass of the dry standard.
5. Put the head assembly on the body of the instrument.
6. When the instrument reading is stable, record the value.

This value is one of three values that will be used to calculate an average value. The average value will be the final baseline value.
7. Prepare the dry standard to be measured again.
 - a. Remove the head assembly from the body of the instrument.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn counter-clockwise, then remove the dry standard from the aperture plate.
 - c. Do steps 3–5.
8. When the instrument reading is stable, record the value.

9. Do step 7 again.
10. When the instrument reading is stable, record the value.
11. Calculate and record the average of the three recorded values. The average value is the final baseline value for the dry standard for this specific instrument.
12. Near the final baseline value, record the serial number of the instrument and the serial number of the dry standard. Refer to [Figure 8](#) on page 14.
Note: The final baseline value for the dry standard is applicable only for the combination of the dry standard and the instrument used to measure the dry standard.
13. Remove the dry standard from the instrument.
 - a. Remove the head assembly from the body of the instrument.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn counter-clockwise, then remove the dry standard from the aperture plate.
 - c. Put the head assembly on the body of the instrument.
14. Put the dry standard in the protective case.

Verification procedure with dry standard without software

1. Do steps 1–5 of [Assign a baseline value to the dry standard](#) on page 15.
2. When the instrument reading is stable, record the value.
3. Use [Table 1](#) on page 15 to identify the result and what action should be done.
Note: Table 1 on page 15 assumes a PFC (pass or fail criteria) of ± 5 mNTU.
4. Remove the dry standard from the instrument.
 - a. Remove the head assembly from the body of the instrument.
 - b. Turn the dry standard $\frac{1}{8}$ of a turn counter-clockwise, then remove the dry standard from the aperture plate.
 - c. Put the head assembly on the body of the instrument.
5. Put the dry standard in the protective case.

Calibration and verification history

The calibration and verification history logs contain information on the last 12 calibrations and the last 12 verifications.

To access the calibration history logs, select Sensor Setup, [Select Sensor], Calibrate, Cal History.

To access the verification history logs, select Sensor Setup, [Select Sensor], Calibrate, Verification.

Push confirm to move through a history log. After all 12 entries are shown, the display goes back to the menu. Push **BACK** to go back to the menu.

A verification history entry shows the:

- Value of the certification standard used
- Turbidity reading at verification
- Operator initials
- Date and time


A calibration history entry shows the:

- Gain value
- Operator initials
- Date and time

Notes:

- History data is saved as first in, first out. When a history log is full, the newest entry is saved and the oldest entry in the log is deleted.
- When the instrument is received from the factory, default values or blank spaces are shown for the history information. Those values are replaced with real data as the history log is filled.

Maintenance

⚠ DANGER	
	Multiple hazards. Only qualified personnel must conduct the tasks described in this section of the document.

Maintenance schedule

NOTICE

The laser module and detector system are not user-servicable items. Contact Technical Support for replacement.

Clean the instrument at least once a month. The instrument may need to be cleaned more frequently depending on water quality.

Clean the instrument

▲ WARNING



Do not remove the bottom plate of the instrument or drain plug when the head assembly is installed and the instrument is in operation. Risk of exposure to Class 3B Radiation will result.

▲ WARNING

Personal injury hazard. Never remove covers from the instrument. This is a laser-based instrument and the user risks injury if exposed to the laser.

Sediment of the size that passes through with filter effluent is difficult to see. Reading accuracy may be affected if the instrument is not cleaned at regular intervals. Noise (fluctuation) in the reading may indicate the need to clean the instrument.

Refer to the illustrated steps to clean the instrument.

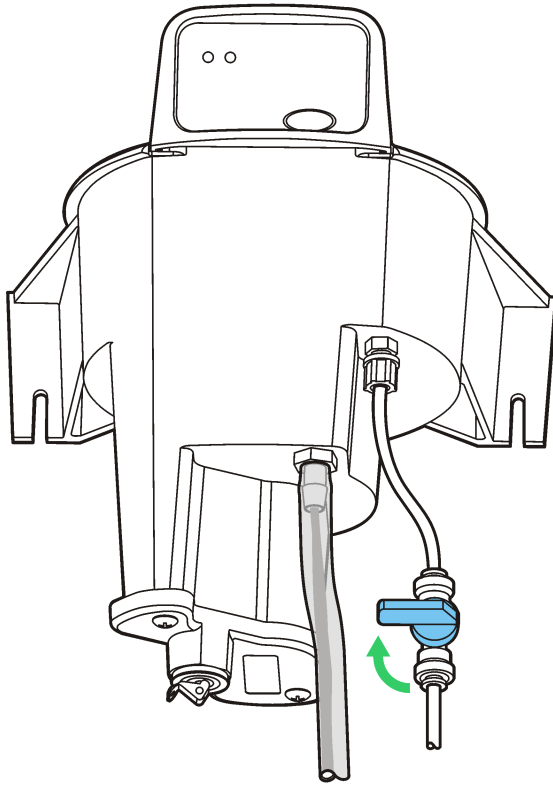
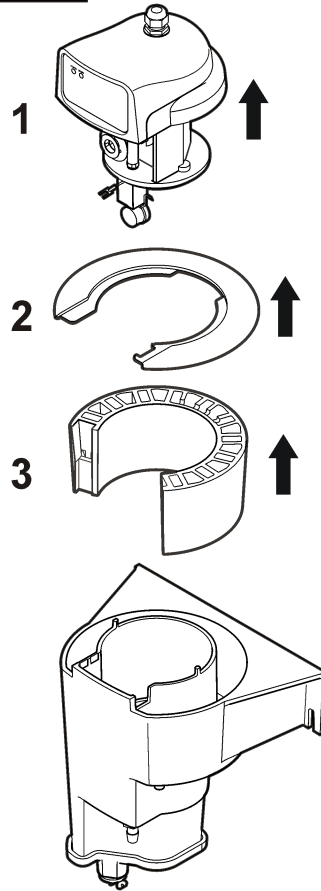
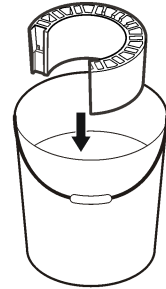
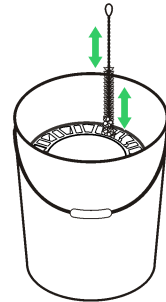
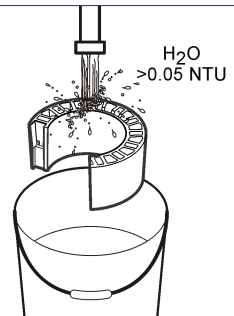
Make sure to remove debris from internal corners and other internal areas that are difficult to access.

Do a calibration verification after this procedure is complete if a calibration will not be done immediately.

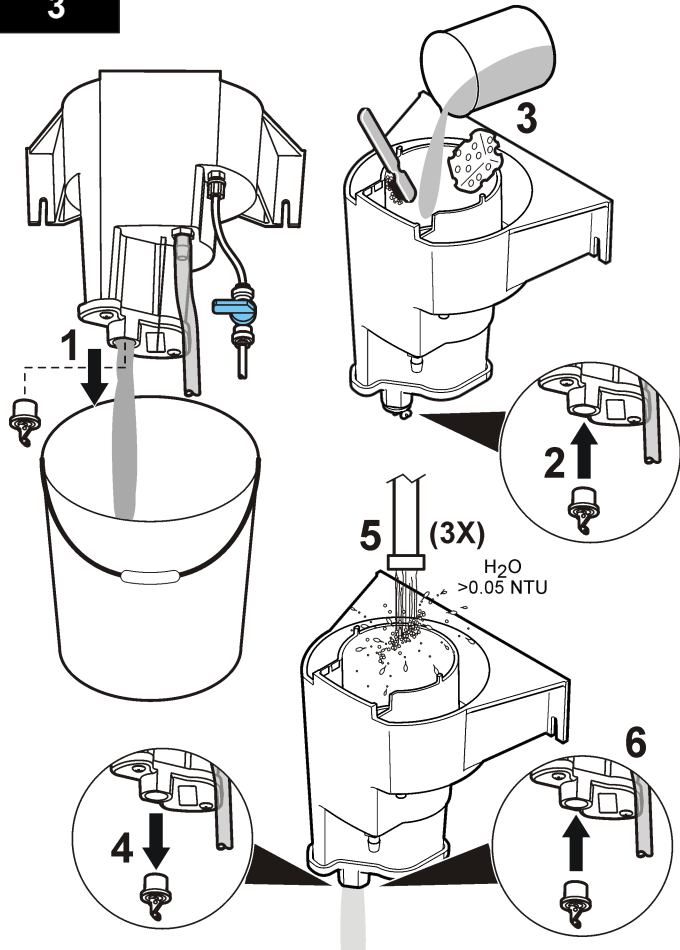
Required tools and materials:

- Soft brush
- Test tube brush
- Cleaning solution (25 mL of household bleach in 3.78 L of water or 1 mL laboratory detergent (i.e., Liqui-nox) in 1L of water)
- Water that is less than 50 mNTU (0.05 NTU)

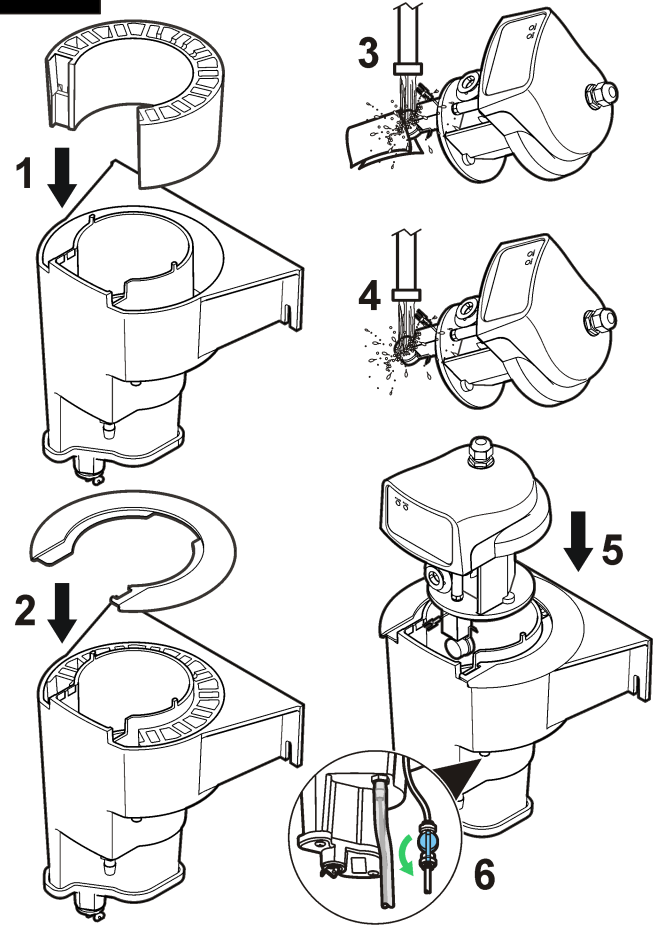
Note: Put the cleaning solution in a container that can hold all of the bubble trap.

1**2****4****5****6**


3



4



How to clean spills

⚠ CAUTION	
	Chemical exposure hazard. Dispose of chemicals and wastes in accordance with local, regional and national regulations.

1. Obey all facility safety protocols for spill control.
2. Discard the waste according to applicable regulations.

Troubleshooting

Problem	Possible cause	Resolution
Low (< 1) or negative readings	Head assembly is not correctly installed on the body of the instrument	Correctly install the head assembly on the body of the instrument. If not, the red status light will flash.
	Laser failure	Contact Technical Support.
	PMT/Electronics failure	

Errors

When an error occurs:

- The reading on the measurement screen flashes.
- All outputs are held.
- The red status light on the instrument turns on.

To access the current instrument errors, select Diagnostics, [Select Sensor], Error List.

Select an error and confirm to identify the cause of the error. Refer to [Table 2](#).

Table 2 Error list

Error	Possible cause	Resolution
A/D FAILURE	A/D conversion failure	Contact Technical Support.
LASER FAILURE	Laser did not work correctly and is turned off	
FLASH FAILURE	Data log and event log not working	
LOW SIGNAL ERROR	Signal is too low (less than 3.0 mNTU)	Make sure that the head assembly is installed correctly. If not, the red status light will flash. Contact Technical Support.

Warnings

When a warning occurs:

- A warning icon flashes and a message is shown on the bottom of the measurement screen.
- The red status light on the instrument starts flashing.

Warnings do not affect the operation of menus, relays and outputs.

To access the current instrument warnings, select Diagnostics, [Select Sensor], Warning List.

Select a warning and confirm to identify the cause of the warning. Refer to [Table 3](#).

Note: A warning can be used to trigger a relay. The sc controller can be used to set warning levels to identify the severity of the warning. Refer to the sc controller user manual.

Table 3 Warning list

Warning	Definition	Resolution
DARK READING	Dark reading identifies too much light (greater than 50 mNTU).	<ol style="list-style-type: none"> 1. Make sure that the head assembly is correctly installed on the body of the instrument. 2. From the Main menu, select Sensor Setup, [Select Sensor], Calibrate, 0 Electronics.
TEMPERATURE	The internal temperature of the head assembly is greater than 50 °C (122 °F).	<p>Make sure that the operating environment is within the specifications. Refer to Specifications on page 3.</p> <p>If the operating environment is within specifications, contact Technical Support.</p>
5 VOLT	The monitored voltage is outside the range 4.5–5.5 V.	Contact Technical Support.
VOLTAGE IN	The monitored voltage is outside the range of 9.08–14.3 V.	
LASER V	The laser voltage is out of the operating range of 4.55–5.5 V.	
LASER I	The laser current is out of operating range of 25–75 mA.	

Table 3 Warning list (continued)

Warning	Definition	Resolution
DATA LOG FULL	Only 30 minutes of storage space is available in the data log.	Download the log from the sc controller to prevent loss of data.
EVENT LOG FULL	Only 30 minutes of storage space is available in the event log.	
OUTPUT MODE NOT NORMAL	The instrument is being calibrated.	Complete calibration and/or calibration verification.
PMT VOLTAGE	The PMT voltage is out of operating range of 11.77–15.94 V.	Contact Technical Support.
REFERENCE VOLTAGE	The reference voltage is out of operating range of 2.41–2.59 V.	

Diagnostics and Test menu

The diagnostic and test menu shows current information about the instrument. Refer to [Table 4](#). To access the diagnostic and test menu, select Sensor Setup, [Select Sensor], Diag/Test.

Table 4 DIAG/TEST menu

Option	Description
SOFTWARE VERS.	Shows the installed software version.
SERIAL NUMBER	Shows the serial number of the instrument.
INT TEMP	Shows the internal temperature of the instrument electronics in °C.
DEFAULT SETUP	Sets the settings to the factory default settings. Makes the current calibration invalid.
POWER CHECK	Shows the electrical statistics for the instrument.

Table 4 DIAG/TEST menu (continued)

Option	Description
SERVICE MODE	Enable or disable service mode—On or Off (default).
SERVICE DIAGS	Passcode protected. Menu options are only available to service personnel.

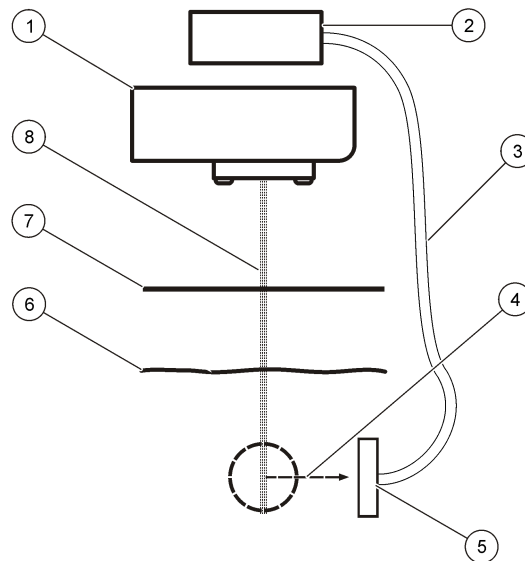
Theory of operation

The FilterTrak 660 sc nephelometer uses nephelometric detection of light scatter from particles in a sample. The optical design is shown in Figure 9. The geometry of the incident light source and the centerline into the detector receive fiber is fixed at 90 degrees, which is consistent with the detection angle associated with current nephelometry technology.

The light source is a laser diode with a wavelength of 660-nm. The response system is optimized to detect this specific wavelength. In addition, the incident light is collimated into a narrow beam, resulting in a relatively high beam power density. This high power density results in higher scattered intensity from smaller particles. In addition, the portion of the narrow beam that passes through the sample without being scattered is absorbed by a light trap at the bottom of the nephelometer body. These features combined to create a measurement system with dramatically lower stray light.

The FilterTrak 660 sc nephelometer detection apparatus is coupled with fiber optic technology to convey the scattered light signal to the detector. The high power source and very sensitive detector combine to produce a strong signal even at the lowest of turbidity levels. The optimization of the optical components results in an increase in sensitivity of more than two orders of magnitude over the sensitivity that is achieved with the best turbidimeters in use today. This allows for a very stable baseline capable of detecting a change in turbidity down to 0.05 mNTU (1.000 NTU = 1000 mNTU). Since sensitivity is defined as the detection of a change in turbidity, the lowest numerical value that an instrument can read is not as significant as the smallest change that it can detect.

Figure 9 Laser nephelometer optical configuration



1 Laser module	5 Light receiver
2 Light detector	6 Water level
3 Optical fiber	7 Aperture
4 Scattered light	8 Incident light beam

RSD parameter

The FilterTrak 660 sc offers a complementary parameter to the laser nephelometry measurement. This parameter is known as the relative standard deviation (RSD). RSD is a dimensionless parameter that provides a quantitative assessment of the variability (fluctuation) of the laser turbidity measurement. Studies have shown that the baseline of a turbidity measurement will often increase in fluctuation before the actual

laser turbidity measurement will begin to increase in response to a particle event. In addition, the RSD parameter has been shown to be more sensitive to a turbidity event in addition to serving as a precursor event to a turbidity spike. The Hach Technical Information bulletin "Introduction to Laser Nephelometry: An Alternative to Conventional Particulate Analysis Methods", Literature piece 7044, Appendix B provides more information on the application and use of the RSD parameter.

The sensitivity of the RSD parameter is directly related to the instrument design of the FT660 sc nephelometer. This is due to the optical creation of a very small analysis volume within the turbidity sensor. (The analysis or view volume is that volume of sample within the turbidimeter body that is in view by the detector window.) This volume is small but well defined by the optical design. This volume also contains a high energy density from the incident light beam, which can easily be scattered by a single or low number of particles. When a particle passes through the view volume, there is a rapid increase in the scattered light signal while that particle is in the view volume. When the particle passes out of the view volume, the signal decreases rapidly. The change in signal is infrequent and this instability of signal is quantified by the RSD parameter.

The RSD value is calculated as the standard deviation divided by the mean for a given set of measurements. The result is multiplied by 100 and is expressed as a percent. Equation 1 provides the calculation used to determine the RSD value:

$$\text{RSD} = (\text{standard deviation}_n \div \text{mean}_n) \times 100$$

Where n = number of measurements used

The RSD calculation is accomplished through a process of evaluating the most recent seven displayed turbidity measurements. From the seven measurements, the standard deviation and the average are calculated. The value is then displayed on the secondary measurement line of the SC controller. When a new turbidity measurement is displayed, the value replaces the oldest of the seven measurements and the RSD is recalculated and displayed. This is referred to as the continuous RSD measurement and it is updated once every second.

The RSD parameter is treated as a separate and independent monitoring parameter relative to the laser turbidity measurement. The parameter is updated every second, which is the same rate the laser turbidity value is updated. The parameter is best used as an early

warning parameter to an impending turbidity event and as a complementary parameter to the turbidity parameter. (A turbidity spike will also be complemented by a spike in the RSD parameter.) The parameter has been designed to be very responsive to particles in the 1–10 µm range at very low concentrations. While the laser turbidity parameter is currently approved for regulatory monitoring, the RSD parameter is not a regulatory approved monitoring parameter.

Correlation study between kaolin standards and measured turbidity

A study was done on the FilterTrak 660 sc (FT660 sc) laser nephelometer to identify the specific correlation between kaolin and the NTU value recorded using the FT660 sc. Two sets of kaolin standards were prepared for turbidity measurement. Each set was prepared from an independent lot of kaolin stock standard that was supplied by the manufacturer. Each test standard was prepared using ultra-filtered water immediately before measurement.

After preparation, each standard was put in the FT660sc, starting with the lowest value. Measurements on the standard were done at 30-second intervals, and 15 to 25 measurements were recorded for each standard. From the measurement on a specific test standard, the respective average and standard deviation was calculated.

Table 5 shows the:

- Averaged turbidity measurements from each of the two lots of kaolin standard
- Pooled standard deviation from these two lots of kaolin standards
- 95% confidence interval (predicted) and the percent error expected in the preparation for each standard value

The results show a strong correlation between mg/L kaolin and NTU. The correlation is better than one percent over the measurement range of the FT660 sc. The summarized correlation values for the entire study are shown in Table 6.

Even though there was a strong correlation between the mg/L and the NTU values when using the FT660 sc, the reproducibility of these measurements was not good at the lowest two kaolin standards. This is shown in Table 5, where the pooled standard deviations and predicted

95% confidence intervals are very high. The error was primarily traced to the lot-to-lot variability in the preparation and subsequent measurement for each standard.

From the data collected in this study, it was identified that 1.0 mg/L kaolin is equivalent to 1.0 NTU turbidity.

Table 5 Summary: Correlation between kaolin mg/L values and NTU turbidity values on the FT660 sc

Standard value (theoretical) in mg/L kaolin	Averaged turbidity in NTU for kaolin lots A and B	Pooled standard deviation for kaolin lots A and B	Predicted 95% confidence range +/-NTU from the averaged kaolin value	Percent uncertainty at 95% confidence
0.10	0.098	0.0273	0.0546	55.6%
0.20	0.169	0.0594	0.1187	70.3%
0.41	0.339	0.0239	0.0479	14.1%
0.80	0.754	0.0504	0.1009	13.4%
1.01	0.999	0.0534	0.1069	10.7%
1.20	1.186	0.0414	0.0829	7.0%
1.59	1.573	0.0870	0.1740	11.1%
1.80	1.850	0.0487	0.0974	5.3%
2.10	2.065	0.0480	0.0960	4.6%
2.40	2.338	0.0466	0.0932	4.0%

Table 6 Statistical summary of the correlation between mg/L kaolin and NTU

	Slope	Correlation coefficient	Averaged % error (over the full range)
Pooled standard deviation for kaolin lots A and B	0.9932	0.9990	0.6804

Replacement parts and accessories

Note: Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.

Replacement parts

Description	Quantity	Item no.
Cover, bubble trap	1	5201200
Drain plug for the FT660 sc	1	4411600
Body of the FT660 sc	1	5230300
Head assembly of the FT660 sc*	1	6016100
Sensor cap	1	5791100

* Only compatible with 5230300.

Accessories

Description	Quantity	Item no.
Aperture plate	1	6735600
Cleaning brush	1	68700
Calibration kit (includes the calibration body, 1 L of 800 mNTU StabiCal Standard and a funnel)	1	5236400
Deionized (demineralized) water	1 L	27256

Replacement parts and accessories (continued)

Description	Quantity	Item no.
Detergent, Liquinox	0.946 L	2088153
Drain assembly funnel	1	5237100
Dry standard quick check verification (VQC) kit, includes:	1	6735500
- Dry standard	1	6735800
- Protective case for the dry standard	1	6735400
- Disposable wipes	1	2097000
Floor stand	1	57432-00
Flow meter, 500–700 mL/minute	1	4028200
Funnel	1	5237100
Load termination box*	1	5867000
Plug, sealing, conduit opening	1	5868700
100 mNTU, StablCal Certified Standard for verification of the FT660 sc	1 L	27233-53
300 mNTU, StablCal Certified Standard for verification of the FT660 sc	1 L	26979-53
500 mNTU, StablCal Certified Standard for verification of the FT660 sc	1 L	26980-53
800 mNTU, StablCal® Certified Standard for calibration and verification of the FT660 sc**	1 L	2788453
1000 mNTU (1.00 NTU), StablCal Certified Standard for verification of the FT660 sc	1	25897-56
Strain relief, Heyco	1	16664
Tubing, sample in, ¼-inch O.D., Polyethylene	0.3 m (1 ft)	4215200
Tubing, sample out, ½-inch I.D., ¾-inch O.D., Tygon R3603	0.3 m (1 ft)	5126300

* Required if the distance between the instrument and sc controller is greater than 31 m (101 ft)

** EDA approved for calibration.

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