## Continuous Monitoring Meters

##### Use in conjunction with:

###### FT 1000 General Field Testing and Measurement

###### FT-series Field Testing SOPs for applicable parameters

###### FS 1000 General Sampling Procedures

###### FD 1000 Documentation Procedures

##### Introduction: This section presents standard operating procedures to be used to consistently conduct representative continuous monitoring measurements and observations. They include the parameters that are measured with installed, in-line (on-line) continuous measurement devices in facilities (refer to FT 1910) and for unattended instrument deployment *in situ* for ambient environmental monitoring (refer to FT 1920 and FT 1000 sections 2.2.5.1--2.2.5.4). FT 1900 contains the general requirements applicable to the FT-series field testing parameters for procedures related to continuous monitoring.

##### DEFINITIONS

##### Sonde or meter: A complete data logging instrument that collects, stores, and/or transmits information about its surroundings as directed by the user. May consist of interchangeable or fixed probes/sensors.

##### Probe or sensor: Individual measurement device which can be interchangeable between data sondes but cannot operate independent of data sonde/meter.

##### Data trimming: The process of removing data from the period of record that is not representative of the waterbody being sampled. This includes any data recorded (1) after calibration but prior to deployment in the waterbody, (2) after retrieval but before the continuing calibration verification and (3) during deployment and retrieval process in the waterbody when measurements are affected by those processes.

### continuous monitoring with installed meters

i, and total suspended solids (TSS) verification

##### Calibration and verification

##### Calibrate the continuous monitoring instrument **before installation** according to the manufacturer’s specifications for initial calibration. Ensure that the instrument has been calibrated and the calibration verified according to the requirements in the applicable DEP SOPs for the analyte(s) to be measured.

##### **On a daily basis,** measure a grab sample taken at or as near as possible to the same location as the in-line meter. The grab-sample test measurements must be taken with an instrument that has been properly calibrated and verified per the applicable DEP SOPs for individual parameter tests.

##### Compare the results of the daily verification with the continuous meter reading taken at the same time as the grab sample was collected. The continuous meter calibration is acceptable for the applicable parameters if the differences with the grab-sample results meet the following criteria (note that all grab samples are conducted with a second field instrument, except for TSS):

##### Dissolved Oxygen: no greater than 0.2 mg/L difference (or historically established criteria not to exceed 0.5 mg/L difference);

##### Specific Conductance: no greater than 10% of the calibrated instrument reading;

##### pH: no greater than 0.2 pH units difference (or historically established criteria not to exceed 0.5 pH units difference);

##### Temperature: no greater than 0.5oC difference;

##### Residual Chlorine: no greater than 20% of the calibrated instrument reading;

##### Turbidity: no greater than 20% of the calibrated instrument reading; and

##### TSS: lab result no greater than 1.0 mg/L different from the calibrated instrument reading.

##### When the comparisons performed in section 1.3 above indicate a changing trend in the difference between the grab sample measurement and the continuous meter measurement for any parameter, determine the cause of the problem and perform appropriate corrective actions, such as maintenance, repair, calibration or other activities needed for the proper operation of the continuous meter under calibrated conditions.

##### Perform the initial calibration (per section 1.1 above) each time the instrument is taken off-line, after every preventative maintenance activity, and **immediately** after determining that any of the criteria verifications in 1.3.1 through 1.3.7 above are not met.

##### All acceptable field data must be bracketed by acceptable calibration verifications (see section 1.3 above). Qualify data that are not bracketed by acceptable calibration verifications.

##### extended verification intervals

##### If historically generated data demonstrate that a specific instrument remains stable for longer periods of time, the time interval between initial calibration and calibration verifications may be increased.

##### The maximum time interval is one month or at the conclusion of the monitoring period, whichever is less.

##### Base the selected time interval on the shortest interval that the instrument maintains stability.

##### If an extended time interval is used and the instrument consistently fails to meet the final calibration verification:

##### The instrument may need maintenance to correct the problem; or

##### The time period is too long and must be decreased.

##### Retain all data associated with studies that support a decreased frequency of calibration verifications for at least five years after the procedure was last used.

##### Preventive Maintenance: Refer to FT 1000, section 3.

##### Documentation

##### Record all information specified in the individual field-testing SOPs.

##### Document the daily verifications of the continuous meter by recording:

##### Project name (if applicable)

##### Date and time (including time zone, if applicable)

##### Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)

##### Analyte or parameter measured

##### Reading from the continuous meter, including reporting units

##### Reading from the second instrument used for the grab-sample measurement, including reporting units

##### The name of the person conducting the verification

##### Unique identification of the specific instrument unit(s) used for the test(s)

##### Where applicable, record the differences for the results of meter comparisons as specified in section 1.3 above.

##### Calculate the differences in the results between the meter measurements of the grab sample with the corresponding measurements from the continuous meter for the applicable parameters. The calculated difference between the expected value and the meter value should be expressed with the same precision as the acceptance criteria.

##### Indicate the acceptability of the verifications per the criteria in section 1.3

### continuous monitoring for ambient in situ monitoring

Some sampling entities deploy field meters on docks, buoys or other structures to obtain continuous water quality measurements *in situ* in ambient waters. In order to determine and document the reliability of the data, the following procedures must be followed. USGS TM 1-D3 (2006) was used for informational purposes when developing the following procedures.

##### SITE SELECTION

##### Ensure that selected sampling location(s) are representative of the waterbody being monitored or meet project objectives.

##### Document details of the monitoring location to include (at a minimum):

##### Structure description (e.g., buoy, dock, installed cage/housing, etc.)

##### Latitude and longitude coordinates

##### Sensor depth relative to the water surface and sediment, note any variation due to expected water level changes (e.g., tides)

##### Photo documentation

##### For information on documentation requirements, see FD 4000.

##### EQUIPMENT AND SUPPLIES

##### When required, the FT-series SOPs outline the instrument specifications. A field instrument must meet the stated requirements.

##### The FT-series SOPs specify the calibration and verification requirements for each method. Although instruments may vary in configuration or operation, the specified calibration and verification requirements must be met, including for those instruments that can only be calibrated by the manufacturer or vendor (i.e., “factory-calibrated” instruments).

##### Where applicable to the FT-series SOP, use the minimum number of calibration standards specified.

##### Ensure all equipment is in proper working condition, calibrated, and batteries are properly charged before using the equipment for continuous field testing measurements.

##### For information on sampling equipment cleaning requirements, see FC 1000.

##### For information on documentation requirements, see FD 4000.

##### CALIBRATION AND VERIFICATION

##### Use of known standards for calibration and verifications

##### Continuous monitoring sondes and sensors must be calibrated and verified according to manufacturer instructions before and after field deployment. If the sonde or sensor can be calibrated and verified using known standards (i.e., if a standard can be read as if it were a sample) per FT-series SOPs, follow the applicable FT-series SOPs to meet calibration and verification requirements.

##### Initial calibration (IC), initial calibration verification (ICV), and continuing calibration verification (CCV) acceptance criteria must be followed according to Table FT 1000-1.

##### Chronological and quantitative bracketing requirements must be followed as described in FT 1000 section 2.2.

##### Do not perform maintenance, repair, or cleaning of the instrument or probe prior to conducting post-deployment CCV unless correcting for fouling (see FT 1920 section 4).

##### If the sonde or sensor cannot be calibrated/verified using known standards, the procedures in sections 3.2 and/or 3.3 below must be followed.

##### Mechanical verification checks

##### Certain sondes and their connected sensors cannot be calibrated and verified using known standards due to sonde size constraints and/or housing obstructions. If the sonde or sensor in use is too large to submerge in a known standard, follow the requirements below. However, if the sonde or sensor can feasibly be submerged in known standards, the procedure in section 3.1 above must be followed in addition to any manufacturer instructions.

##### If the sonde or sensor cannot be calibrated and verified using known standards, follow manufacturer instructions for calibration and verification procedures, such as factory calibration and the use of mechanical or “in-air” checks for verification.

##### Acceptance criteria for mechanical checks must be documented.

##### If you are unsure of the calibration and verification requirements described in the manufacturer's instructions for your instrument, contact DEP for assistance.

##### Instruments must be taken out of service and corrective actions implemented and documented when mechanical checks do not meet acceptance criteria.

##### Factory calibration

##### All records provided by the manufacturer from the factory calibration and/or verification must be maintained. Verifications performed at the factory before calibration provide important information about the performance of the sonde or probe since the last factory calibration.

##### Instruments should be sent to the manufacturer annually for calibration and/or according to the manufacturer’s stated frequency and the demonstrated performance of the instrument.

##### If conducting calibration and/or verification on individual sensors on an instrument, specify which sensor(s) are calibrated and/or verified and record all required documentation for individual parameters (see FT 1920 section 4.2). Sensors must be uniquely identified if they are used interchangeably between different sondes.

##### Verifications must be done at a frequency that is supported by instrument performance. Base time intervals of post-deployment verifications on the shortest time interval that the instrument maintains stability. If post-deployment verifications consistently fail, shorten the time between verifications or replace and/or repair the instrument. This requirement includes factory calibrated instruments.

##### POST-DEPLOYMENT VERIFICATION FOR DATA CORRECTIONS OR OTHER USES

##### Continuous monitoring programs may choose to correct data for instrument drift or fouling. If data are corrected for instrument drift or fouling, the process/method for data correction must be clearly documented, original sonde data must be maintained, and the basis for those corrections must be documented. If data are not corrected, follow verification procedures is Section 3.

##### Options for the basis of data correction include, but are not limited to one or more of the following:

##### Use of *in situ* measurements before and after cleaning:

##### Document the deployed sonde condition (e.g., housing intake, out of water, suspected vandalism, biological growth, etc.) and record deployed sonde measurements *in situ*.

##### Remove sonde from the monitoring location.

##### Clean sonde/sensors. Note: If a CCV is conducted on a cleaned instrument, then data correction for fouling is required.

##### Return cleaned sonde to monitoring location and record sonde measurements *in situ*.

##### Remove deployed sonde, rinse thoroughly and perform CCV.

##### The observed difference between the pre-cleaned *in situ* measurement and the post-cleaned *in situ* measurement is the result of fouling.

##### The difference between the CCV and the expected reading of the calibration standard solution is the result of sensor-calibration drift error.

##### If the CCV fails, quality data, clean and/or maintenance previously deployed sonde/sensor, and recalibrate the instrument. Immediately perform an ICV.

##### Use of field measurements with a second probe that has been calibrated and verified:

##### Document the deployed sonde condition (e.g., housing intact, out of water, suspected vandalism, biological growth, etc.) and record deployed sonde measurements *in situ*.

##### Using an independent meter that has been calibrated and verified, record readings and time as close as possible to the deployed sonde.

##### Remove deployed sonde from the monitoring location.

##### Clean sonde/sensors and perform CCV. Note: If a CCV is conducted on a cleaned instrument, then data correction for fouling is required.

##### The observed difference between the pre-cleaned *in situ* measurement and the second meter *in situ* measurement is the result of fouling and drift.

##### The observed difference between the CCV and the expected reading of the calibration standard solution is the result of sensor-calibration drift error.

##### If the CCV fails, qualify data, clean and/or maintenance previously deployed sonde/senor, and recalibrate the instrument. Immediately perform an ICV.

##### Use of verifications with known standards before and after cleaning:

##### Document the deployed sonde condition (e.g., housing intake, out of water, suspected vandalism, biological growth, etc.)

##### Remove sonde from the monitoring location.

##### Perform verification on the previously deployed sonde/sensors using known standard. Do not clean or remove antifouling materials prior to verification.

##### Clean sonde/sensors.

##### Perform CCV on the previously deployed cleaned sonde/sensors.

##### The observed difference between the pre-cleaned CCV and the post-cleaned CCV is the result of fouling.

##### The observed difference between the post-cleaned CCV and the expected reading of the calibration standard solution is the result of sensor-calibration drift error.

##### If pre-clean verification passes, the user may choose to correct data for fouling, but it is not required.

##### If the pre-clean verification fails, perform data corrections for fouling or qualify data.

##### If post-clean CCV fails, qualify data, clean and/or maintenance previously deployed sonde/sensor, and recalibrate the instrument. Immediately perform an ICV.

##### If only replacing sensors, remove deployed sensors and redeploy sonde with calibrated and verified sensors. If replacing the sonde, retrieve deployed sonde and deploy replacement sonde with calibrated and verified sensors.

##### When changing sondes at a site, ensure antifouling materials and/or deployment housing, if used, for new and previous sondes are identical or equally effective.

##### PREVENTATIVE MAINTENANCE

##### Cleaning

##### Follow the manufacturer’s instructions and refer to FC 1000 for cleaning procedures.

##### Sondes and sensors shall be cleaned after conducting the CCV before being redeployed.

##### Maintenance

##### Document the date, time and analyst performing any maintenance on the sonde or sensor.

##### If performing a factory reset on your instrument, perform an IC and ICV after factory reset and before sample collection.

##### Record the date, time and analyst performing the factory reset.

##### DATA EVALUATION

##### Do not remove any data from the period of record unless it is for pre- and post- deployment trimming (see FT 1900 section 1.3).

##### Retain all raw data during deployment. Raw data do not need to be published (e.g., non-sensical or erroneous data recorded during deployment) but must be retained in accordance with FD 1200.

##### Corrections for calibration drift or fouling are not required, but if they are conducted, corrected data must be qualified with “C.” Both the raw and corrected data must be retained.

##### If corrections for calibration drift or fouling are conducted, the procedures and calculations for making the corrections must be detailed in an organization’s internal SOP. The type of correction must be documented (for example, a constant correction, or a one-, two-, or three-point correction).

##### Any correction applied to a specified date range must use data from that specified date range to inform the correction values.

##### The maximum allowable limit between a recorded value and a corrected value must not exceed the following:

##### Temperature: no greater than 2.0°C difference;

##### Specific conductance: no greater than 30% difference;

##### Dissolved oxygen: no greater than 2.0 mg/L or 20% difference, whichever is greater;

##### pH: no greater than 2 pH units difference; and

##### Turbidity: no greater than 3.0 turbidity units or 30% difference, whichever is greater.

##### If the maximum allowable limit between a recorded value and a corrected value is exceeded, the data are considered invalid and must be qualified with “?” and a comment added.

##### Document the appropriate qualifier(s) from 62-160.700, F.A.C., for each data point, as applicable, when data are finalized and reported.

##### Note that other codes may be used within data processing software or non-public facing databases.

##### Regardless of correcting data, if the CCV fails, a “J” qualifier must be applied with an associated comment.

##### Data review status must be indicated for any data intended for or funded by and/or submitted to DEP as either provisional, in review, or approved.

##### Provisional: data have been uploaded from the sensor but have not been reviewed for QA/QC.

##### In review: data are currently undergoing QA/QC and/or need final approval.

##### Approved: data have been reviewed and approved for accuracy. Data corrections have been made, if desired, and applicable data qualifiers have been applied.

##### DOCUMENTATION

##### Follow requirements specified in FD 1000 and FD 4000.

##### The following must be documented during a site visit:

##### Date of deployment and retrieval

##### Time of deployment and retrieval

##### Sampling team

##### Physical condition of the deployed sonde (e.g., out of waterbody, visible damage, electronic communication issues, etc.)

##### Additional documentation requirements:

##### Sondes must have unique identification. Sensors must have unique identification if used interchangeably and must be accurately tracked in field documentation during site maintenance.

##### Presence or use of physical or chemical fouling prevention materials. Specific type of fouling prevention must be indicated.

##### Condition of sonde or sensor during post-deployment CCV: pre-cleaned or post-cleaned.

##### Deployment structure materials, configuration, and depth.

##### Cleaning, maintenance and repairs of sondes and sensors.

##### *In situ* values at time of deployment and retrieval, if applicable (see FT 1920 section 4).