STATEWIDE STANDARD OPERATING PROCEDURE

FOR

TELEDYNE T640x PARTICULATE MONITOR

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF AIR MONITORING

Prepared by: Florida PQAO Date: October 2023

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Designated Approving Manager

Document History

Revision No.	Date	Responsible Person	Description of Change
0	July 2018	PQAO	Initial Release
1	October 2020	PQAO	Revision
2	May 2022	PQAO	Added reference to new SA audit form. Also added new SA audit form.
3	March 2023	PQAO	Revised flow, temperature, and pressure limits in accordance with new validation templets
4	October 2023	PQAO	Updated Calibration/Verification Requirements

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1.0 PURPOSE

This document is prepared for site operators who use Teledyne Advanced Pollution Instrumentation (T-API) model T640x $PM_{10/2.5}$ analyzers during routine, periodic and calibration visits to ambient air monitoring sites in the Florida air monitoring network. This manual is designed to give the field operator specific operating instructions. It is not designed to cover all the technical details that are included in the API Model T640x factory manual, or quality assurance information found in 40 CFR Parts 50, 53, and 58, and related reference materials. Following this manual will enable the site operator to know and follow state-wide requirements. Site operators however, should be knowledgeable of and refer to the references noted in this Standard Operating Procedure (SOP).

2.0 SCOPE

The Florida Department of Environmental Protection and Florida Local Air Monitoring Agencies utilize the API Model T640x Particulate Matter Analyzer to quantify PM_{10} and $PM_{2.5}$ concentrations in the ambient air. The API T640x analyzer is designated as an equivalent reference method for both $PM_{2.5}$ and PM_{10} measurements. This document is intended to be used as a reference for the set-up, calibration, maintenance and operation of the T640x analyzer. The proper utilization of this procedure by the operator, in conjunction with the equipment manufacturer's operation manual (and addendums), will conform to the local, state and federal data quality objectives, the State of Florida Quality Assurance Project Plans (QAPPs) and the air monitoring regulations published in the Code of Federal Regulations (CFR). The air monitoring data generated as a result of implementing these procedures will be comparable to the National Ambient Air Quality Standards (NAAQS) and reported to the state and federal ambient air monitoring databases.

3.0 SUMMARY OF METHOD

The Teledyne API Model T640x is a real-time, continuous particulate matter (PM) mass monitor that uses scattered light spectrometry for measurement; specifically, it employs broadband spectroscopy using 90° white-light scattering with a polychromatic light-emitting diode (LED).

There are two designated methods using the T640 instrumentation. The model T640 with x option (T640x) is an approved Federal Equivalent Method (FEM) for PM_{10} [EQPM-0516-239], $PM_{2.5}$ [EQPM-0516-238] and $PM_{10-2.5}$ [EQPM-0516-240]. The T640x operates at a total flow of 16.67 lpm and this SOP is written specifically for this method.

The Model T640x PM Mass Monitor is an optical aerosol spectrometer that converts optical measurements to mass measurements by determining sampled particle size via scattered light at the single particle level according to the Lorenz-Mie Theory. Briefly, the sampling head draws in ambient air, which is dried (i.e., brought below 35% RH) with the Aerosol Sample Conditioner (ASC) and moved into the optical particle sensor where scattered light intensity is measured to determine particle size diameter. The particles move separately into the T-aperture through an optically differentiated measurement volume that is homogeneously illuminated with polychromatic light. The polychromatic light source, an LED, combined with a 90° scattered light detector, achieves a precise and unambiguous calibration curve in the Mie range, resulting in a large size resolution.

Each particle generates a scattered light impulse that is detected at an 85° to 95° angle where amplitude (height) and signal length are measured; the amplitude of the scattered light impulse is directly related to the particle size diameter. The T-aperture and simultaneous signal length measurements eliminate border zone error, which is characterized by the partial illumination of particles at the border of the measurement range.

The T640x operates at 16.67 lpm and uses a US EPA-approved PM_{10} inlet. This configuration is approved as an FEM for PM_{10}, $PM_{2.5}$, and $PM_{10-2.5}$. Sample volume is reported in actual conditions by using the instrument's ambient temperature and barometric sensor data. Specific component operation is described in Section 6 of the T640 User Manual, which can be found at http://www.teledyne-api.com/home (information concerning the T640x option is included in the T640 User manual).

4.0 DEFINITIONS

$PM_{2.5}$ is particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 µm. PM_{10} is particulate matter with an aerodynamic diameter less than or equal to a nominal 10 µm. $PM_{10-2.5}$ is coarse particulate matter with aerodynamic diameter in the nominal range of 2.5 to 10 µm.

Most technical terms in this SOP are defined as they are introduced. A few important definitions are provided in Table 4.1.

Table 4.0-1 Terms and Definitions

Term	Definition
Aerosol Sample Conditioner (ASC)	**The vertically oriented tube that connects the $PM_{2.5}$ sampler inlet to sampler components inside the sampler case. To check the sample flow rate, the sampler inlet is removed from the downtube and a flow rate standard is connected in its place. Also referred to as downtube.**
Accuracy	**The degree of agreement between an observed value and an accepted reference value; includes a combination of random error (precision) and systematic error (bias) components due to sampling and analytical operations.**
Actual conditions	**The actual ambient temperature and pressure of a gas at the time its volume (or volumetric flow rate) is measured.**
Bias	**The systematic or persistent distortion of a measurement process that causes errors in one direction.**
Calibration	**The act of adjusting an instrument after comparison with a standard.**
Flow adapter	**A tight-fitting connecting device, with an isolating valve, that is inserted in place of the $PM_{2.5}$ sampler inlet on the upper end of a sampler's downtube and used to connect a flow rate calibration or audit device to check the sample flow rate. In some cases the device may also be used for leak checks. Sometimes referred to as the flow shut-off valve.**
Flow calibration device	**A National Institute of Standards and Technology (NIST)-traceable flow determining apparatus (also called a flow rate standard) that is attached to the flow adapter device and used to assist in measuring and setting the volumetric flow rate of air into the sampler.**
Leak check	**A test to determine if any post-air flow is passing the expected flow path of the particulate sampler. In the T640x, this is commonly called a Zero Test when using the T640x and uses a HEPA filter.**
Precision	**A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions, expressed generally in terms of standard deviation.**
Verification	**The act of checking or verifying an instrument against a standard; involves no adjustment of the instrument.**

5.0 HEALTH AND SAFETY

To avoid damage to the monitor, ensure that the AC power voltage matches the voltage indicated on the monitor's model/specifications label located on the rear panel before plugging the T640x into line power. High voltages are present inside the instrument. Ensure that the power cord being used is capable of carrying the power rating of the instrument (see rear panel label).

Note: Power connection must have functioning ground connection. Do not defeat the ground wire on power plug. Turn off instrument power before disconnecting or connecting electrical subassemblies. Do not operate with cover off.

Some repair and troubleshooting operations need to be carried out with the monitor open and running. Use common sense when operating inside a running monitor. Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the monitor. Do not drop tools into the monitor or leave tools after performing maintenance procedures. Do not short or touch electric connections with metallic tools while operating inside the monitor. For small shelter maintenance, beware of external elements (i.e., weather conditions).

6.0 INTERFERENCES

There are no known interferences to the collection of $PM_{2.5}$ and PM_{10} using this method; however, surface roughness and other variables do affect sizing algorithms in all light scattering instruments.

7.0 PERSONEL QUALIFICATIONS

A basic understanding of the principles governing ambient air sampling is necessary. All field operations personnel should be familiar with environmental field measurement techniques. Those who service the analyzer in the field must be very conscientious and attentive to detail in order to report complete and high-quality environmental data. Installation, operation, maintenance, repair and calibration of the instrument and all support equipment should only be performed by properly trained personnel. The training will be provided by in house personnel, state or federal agencies when available. The training documentation will be maintained by the state or local agency where the personnel operate. Persons qualified to perform measurements of ambient PM_{10} and $PM_{2.5}$ concentrations should be able to:

a) Operate the T640x analyzer;
b) Calibrate, audit and troubleshoot the T640x analyzer

Operators are also required to read the manufacturer's instruction manuals supplied with the analyzer and supporting calibration equipment to become familiar with the various controls and components prior to attempting any operation described in this procedure. The manufacturer's manuals contain useful operation, maintenance and diagnostic information that may not be contained in this SOP.

8.0 EQUIPMENT AND SUPPLIES

Installation requires hand tools (flat blade screwdriver and adjustable wrench) and silicone sealant. Most shelters have the necessary roof perforation needed. If not, it may be necessary to work with the shelter manufacturer on the appropriate method for making the perforation. Alternatively, the T640x can be housed in an outdoor enclosure. Most of the routine equipment and supplies listed below will be needed for the initial installation to ensure the instrument is operating properly.

The following equipment, supplies, and expendables are required for sensor checks, adjustments, and operation:

- HEPA filters (x2) configured with adapter to connect to downtube for zero testing.
- Auditing device (NIST-traceable pressure and temperature standard and flow standard) used for pressure, temperature, and flow verifications and calibrations. Auditing device is required to have certification within the last 12 months.
- SpanDust™ used for photomultiplier tube (PMT), verification and adjustment as needed
- Adapter for reading 16.67 lpm flow
- O-ring grease packets or tube or vacuum grease.
- Canned air for electronic use (e.g., Dust Off, Blow Off electronics dusters)
- Lint free washable microfiber rags or lint free disposable wipes
- Distilled water in a spray bottle
- Mild detergent
- Swagelok® Cap for ¼” tubing
- Allen wrench
- Philips screwdriver
- Cleaning brushes
- Cotton tipped applicators
- Pull rope assembly (used for pulling cleaning rags or tube brush through the inlet tube)
- Disposable Filter Unit’s (DFU’s)
- USB flash memory drive

9.0 INSTALLATION AND START-UP

With all hardware and electrical in place, power-up the T640x. The monitor will take a few minutes to work through its start-up routine. Ensure the data system is not logging data at this point, except as necessary to ensure data transfer is appropriately bringing in information from the T640x. The following activities should be performed after the unit is brought online:

Note: references to the operational manual are provided, where applicable.

Before setting up the T640x sampler at the site, it is recommended to perform the following procedures inhouse.

1. Check the firmware; upgrade firmware to latest version, if necessary.
2. Adjust the clock on the T640x to local standard time (LST).
   Note: if clock does not adjust after pressing "done", instrument must be power cycled for change to take hold. Teledyne is aware of the issue and currently working on removing this glitch.
3. From the Home menu select parameters to display on front panel home screen.
4. To select parameters, press the configuration button: Users can select whichever parameters are most important to them. Our straw recommendation is to include:
   a. Sample Flow (5.0 lpm)
   b. Bypass Flow (11.67 lpm)
   c. Total Flow (16.67 lpm)
   d. $PM_{2.5}$ Concentration
   e. PM_{10} STP Concentration (refer to step 6 in Section 9.1.1)
   f. Ambient Temperature
   g. Ambient Pressure
      a. Recommend using units of mmHg for pressure. To change pressure units to mm Hg, go to Setup >Vars >Pressure Units >mmHg
   h. Sample RH.
   i. Additional parameters can be included in the dashboard.
5. Inspect Disposable Filter Units (DFU) to ensure they appear new.
6. Open front panel and inspect all connections.
7. Upon startup, sampling begins. Allow a minimum of 10-minute warming period for reliable readings.
8. Review concentration data from panel display and ensure all parameters appear reasonable compared to current conditions. Compare T640x data to other available data at current site or nearby site, if available.
9. Document startup in T640x Maintenance Tracking Form (DEP 03-23-B).

9.1 INSTALLATION INSTRUCTIONS

9.1.1 Indoor/Outdoor Installation

This section presents the various connections for setup and preparing the instrument for

operation. The T640x can be installed in an indoor or outdoor shelter with roof penetration or in an outdoor enclosure.

Note: After installation of sampler, please refer to Section 10.0 Calibration/Verification for steps on how to complete Calibration. Sampler will not collect valid data until a Calibration is performed.

1. Ensure that the rack installation ensures proper ventilation clearance (minimum of 1" from the sides and top of instrument and 4" from the back of instrument) and inlet height (2 m above ground level).
2. Aerosol Sample Conditioner (ASC) Connections and Installation

    a. The ASC requires an inlet nozzle and an adapter for installation. The black inlet nozzle to the optical sensor is specific to the instrument (not interchangeable to other T640x instruments). Please note, the final assembly differs slightly between the T640x ASC and the T640 ASC option.
    b. Insert the black inlet nozzle through the center of the support collar into the top of the optical sensor, seating it tightly so that the nozzle's upper O-ring flange is flushed with the upper surface of the sensor body.
    c. Slide the aluminum adapter over the black inlet nozzle, ensuring its base is flushed with the top of the optical sensor.
    d. Attach the water collector to the inlet.
    Note: If the instrument is to be installed in a shelter with roof penetration, do not attach the water collector at this time
    e. Assemble the inlet and the ASC, ensuring the parts fit snugly with no gaps.
    f. Lower the ASC into the support collar, ensuring it fits straight with no gaps.
    g. Plug the ASC wiring into the rear panel connector. Please refer to figure 9.1 for a diagram on how to connect the ASC tube.
3. Temperature Probe Connection:
    a. Plug the ambient temperature probe connector into its respective rear panel electrical port.
    b. Route probe outside and insert into solar shield, ensuring solar shield maintains vertical orientation.
4. Power Connection:
    a. Adhering to the warning messages, insert the power cord between the instrument's AC power connector and a properly rated power outlet.
5. Communications Interface Connections:
    a. For network or Internet communication with the instrument, connect an Ethernet cable from the analyzer's rear panel Ethernet interface connector to an Ethernet port. The address settings default to automatic configuration by Dynamic Host Configuration Protocol (DHCP). Most users will want to configure the instrument with a static IP address; however you should consult your network administrator to discuss other potential options. For firmware updates and data downloads, use a flash drive inserted into the front panel USB port.
6. Configuring PM_{10} STP

Note: The T640x must be configured to display PM_{10} STP to be FEM approved. The internal data logger configuration must be set to tag PM_{10} STP conc.

a. Enter "929" by touching the Log-in icon  on top of screen.
b. Go to SETUP>VARS and locate "PM10STP Display Option Show" on the VARS configuration. Highlight it, and touch "Edit" button.
c. Select the option "SHOW" and exit this menu.
d. Touch the Log-in icon to go back to the default "818" password.
e. To add the PM10STP to the internal data logger configuration go to Setup>Data Logging.

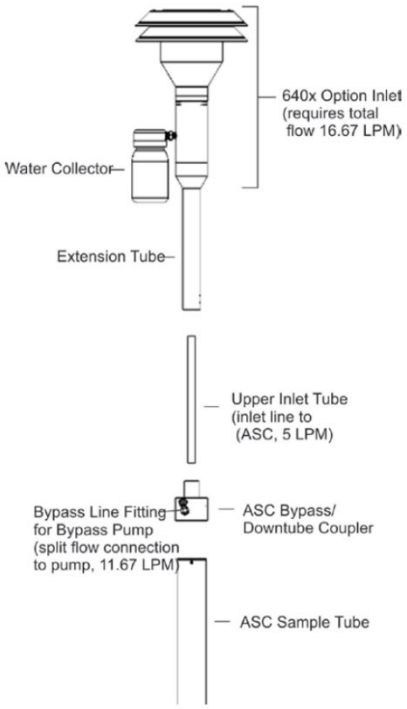

Figure 9. 1 T640x Option and ASC assembly

9.1.2 Shelter Installation with Roof Penetration (if applicable)

1. Determine the location of where the T640x will operate in the shelter.
2. The instrument should be in a location where the top of the ASC will be no less than two feet from the top of the ceiling/roof line or the instrument should be placed at a height within the shelter so that after the ASC and 8’ extension sample line are installed, the inlet (on top of the 8’ extension sample line) is 1 to 2-m above the roof and equal height with any other PM instrument inlets.
3. Align all pieces before making any cuts in the roof.
4. Drill a hole in the roof to accommodate the diameter of the 8’ extension sample line (5/8” OD).
5. Install the provided roof flange over the hole.
6. Make sure to use good quality roof sealant for the base of the roof flange to ensure weather tightness and to prevent any leaks into the shelter.
7. Without locking it down, set up the sample line tripod so that its sample line hole aligns with the hole in the roof.
8. The tripod should be setup at such a height to properly support the sample line with the inlet on top.
9. Without the inlet installed on the top of the ASC, line up the instrument so that the opening at the top of the ASC is in-line with the sample line hole/roof flange on the shelter roof.
10. Slide the 8’ sample line extension down through the tripod and the roof penetration until it meets the opening at the top of the ASC.

11. The sample line should be plumb to prevent any strain on the instrument and to prevent pneumatic leaks.
12. The sample line should slide into the top of the ASC (about 2") and bottom-out when in completely.
13. Lightly tighten the tripod cord grip and the roof flange cord grip around the sample line to hold it in place.
14. At the top of the sample line (on the roof), place the provided inlet collar so that its top is 3" from the top of the sample line. This is for proper clearance from the base of the inlet and to prevent any instrument flooding if the inlet were to ever get water inside of it.
    a. Lock down the collar once it is determined to be at the proper spot 3" from the top of the sample line.
15. Place the inlet on top of the sample line.
16. Make sure the inlet is secure (i.e., that the collar holding it is not sliding). Proper installation should have the inlet 1 to 2-m above the roof.
17. Plug the ASC connector into the proper fitting on the rear panel of the T640x.
18. Connect the power cable and ambient temperature sensor at back of instrument.
19. Before sealing the cord grips, power up the instrument and make sure it is running properly.
20. Once the T640x instrument is determined to be installed and working properly, tighten up the roof flange cord grip around the sample line.
21. Apply clear silicone caulk generously around the top end of where the cord grip rubber grommet meets the sample line to ensure complete sealing from the weather.
    Note: Silicone caulk seals well and can easily be removed and reapplied if the instrument needs to be removed for servicing.
22. Additionally, tighten up the tripod cord grip and lock down the feet of the tripod to fully secure the sample line.
23. Inspect PM10 well to ensure its clean

9.1.3 Outdoor Enclosure Installation (if applicable)

1. Place enclosure in the location where the instrument is to run.
2. The T640x instrument should be installed in the enclosure at a height where the inlet will be at least 2-m above ground (from ground level to the inlet height).
3. Make sure the optical sensor nozzle and nozzle to ASC adapter are installed on the optical sensor according to manufacturer's instruction.
4. Once the T640x is in the enclosure and lined up with the cord grip opening on the top of the enclosure, insert the ASC into the cord grip, and slide it down gently until it inserts into the ASC support of the T640x.
5. The ASC should go into the T640x level and plumb and is in completely when it is felt to bottom-out onto the top of the optical sensor. This can be checked by lowering the front panel of the T640x and making sure the base of the ASC is touching the top of the optical sensor flush.
6. Plug the ASC connector into the proper fitting on the rear panel of the T640x.
7. Connect the power cable and ambient temperature sensor at back of instrument.
8. Before sealing the cord grip, power up the instrument and make sure it is running properly

9. Once the T640x instrument is determined to be installed and working properly, tighten up the cord grip around the ASC.
10. Inspect PM10 well to ensure its clean
11. Apply clear silicone caulk generously around the top end of where the cord grip rubber grommet meets the ASC to ensure complete sealing from the weather.
12. Silicone caulk seals well and can easily be removed and reapplied if the instrument needs to be removed for servicing.

10.0 VERIFICATION/CALIBRATION

This section details the verification/calibration procedures periodically required to maintain accurate particulate sampling of the T640.

10.1 Verification/Calibration Procedures

There are five basic verification checks listed below. Three of these verifications can also be calibrated, if necessary. There is no adjustment for either the zero test or ambient temperature and as such, failure of one or both checks results troubleshooting or part replacement. The flow procedure calls to verify the total flow (16.67 lpm) and then the sample flow (5.0 lpm); however, total flow cannot by itself be calibrated. Instead, if the total flow does not meet its required tolerance, the sample flow and bypass flow are calibrated, if necessary. The five checks should always be performed in the order shown below:

- Zero Test (Every 30 Days or as needed)
- Pressure sensor verification (Every 30 Days or as needed)
- Pressure sensor calibration (Every 365 Days or as needed)
- Temperature sensor verification (Every 30 Days or as needed)
- Temperature sensor calibration (Every 365 Days or as needed)
- Flow sensor verifications (Every 30 Days or as needed)
- Flow sensor calibrations (Every 365 Days or as needed)
- PMT verification and adjustment, if needed, using SpanDust™ (Every 90 Days or as needed)

Additionally, time checks and adjustments are performed during annual verification/calibrations.

Note: For the Pressure Cal and the two Flow Cal menus, note that the "Measured" parameter provides the value measured by the T640x, and the "Actual" parameter is the value that is to be input from the reading measured by the external auditing device.

Verifications will not include any adjustments. If adjustments are required, please use the Annual Flow, Temperature and Pressure Verification form (DEP 03-23-C). For monthly checks, the following checks

- Zero Test;
- Pressure sensor verification;
- Temperature sensor verification;
- Flow sensor verifications and calibrations (total, and sample flow);
- PMT verification (once per quarter)

Note: Channel must be disabled in the DAS system, before beginning any procedure which could impact instrument sampling.

10.1.1 Zero Test

The internal components of the T640x are not meant to be under strict vacuum as what would normally be done in a leak test. To avoid damage to internal components, it is recommended that the inlet never be capped (airtight) while the instrument pump is running. The Zero Test is a way to check for leaks that do not involve pulling a vacuum on the system.

Note: No adjustment is made if the zero test is reading less than or equal to 0.2, instead troubleshoot the instrument until resolved.

1. Remove the inlet and fit a HEPA filter to the sample port. Ensure tubing is not kinked.
2. Observe the PM values on the front panel display.
3. Within 10 to 15 minutes, the PM values should be at zero (0.0) for each PM metric.
4. If the PM values are not reading zero, then it's likely to be one of two issues: There may be a leak in the system above the optical sensor (i.e., from the optical sensor nozzle up to where the HEPA filter was fitted). Troubleshoot by checking each connection between monitor and HEPA filter and ensuring there is a good seal or it is possible the HEPA filter being used is either bad or leaking. It is recommended to have a second filter handy to check. If after ten to fifteen minutes values don't reach zero (0.0), troubleshoot and repeat steps above.
5. Once PM values reach zero (0.0) for each PM metric, disconnect the HEPA filter.
6. Record on Form DEP 03-23-A Monthly Visit Form.

10.1.2 Pressure Verification and Calibration

*Note**:** Follow the procedure listed below for pressure verification when performing the semi-annual flow rate audits. These audits must be carried out using an independent NIST traceable transfer standard and the results should be recorded on Form DEP 03-21/23-O, Semi-Annual Flow Rate Audit T640/T640X, April 2022.*

The pressure measurement of the T640x is for the ambient pressure in which the instrument is operated. No direct pneumatic connection to the instrument needs to be made to perform this check/calibration and data are not affected. To change pressure units to mmHg, go to Setup>Vars>Pressure Units>mmHg.

1. With the Pressure Standard operating and measuring the ambient pressure in the same room as the T640x monitor, navigate to the Pressure Cal menu: >Calibration >Pressure Cal
2. Compare the "Measured Pressure" in this screen to the Audit Pressure Standard
3. If the two values differ by more than +/- 10.1 mm Hg, first press "Start" then press the value button in the "Actual Pressure" field, enter the value measured by the Pressure Standard, and press the "Calibrate" button on this screen.
4. The Measured Pressure value should change to closely match the Actual Pressure within a few seconds. Once values match, press "Stop".

5. Record on Form DEP 03-23-A Monthly Visit Form.

10.1.3 Ambient Temperature Verification

Note: Follow the procedure listed below for ambient temperature verification when performing the semi-annual flow rate audits. These audits must be carried out using an independent NIST traceable transfer standard and the results should be recorded on Form DEP 03-21/23-O, Semi-Annual Flow Rate Audit T640/T640X, April 2022.

The ambient temperature probe can be verified, however, there is no available way to calibrate this sensor. Temperature probes that do not meet the expected tolerance of ±2°C from a temperature standard should be inspected and cleaned. Cleaning of the gill screen may also help to ensure air can pass freely to the probe. A spare temperature probe should be available in case the verification continues to fail the acceptable tolerance. The following procedure applies to a temperature verification:

Note: Temperature verifications can be conducted either with the instrument in normal operation, without disabling the DAS channel.

1. Hold the temperature probe of the audit device near the gill screen holding the ambient temperature probe of the T640x. If there is direct sun, ensure the audit probe is held behind the gill screen relative to the sun so that the gill screen casts a shadow on the audit device temperature probe.
2. Wait at least one minute for the audit device temperature to stabilize.
3. Record audit device ambient temperature and T640x ambient temperature to the data sheet.
4. Compare audit to T640 ambient temperature and if off by more than +/-2°C, troubleshoot and repeat.
5. If verification cannot meet tolerance replace temperature probe.

10.1.4 Flow Verification.

Note: Follow the procedure listed below for flow verification when performing the semi-annual flow rate audits. These audits must be carried out using an independent NIST traceable transfer standard and the results should be recorded on Form DEP 03-21/23-O, Semi-Annual Flow Rate Audit T640/T640X, April 2022.

The T640x uses a sample flow of 5.00 lpm and a bypass flow of 11.67 lpm to achieve the 16.67 lpm necessary for the total flow. For annual calibrations/verifications, after the flows have been measured and adjusted, the inlet is replaced, and each flow will be read from the dashboard and recorded on form DEP 03-23-C. For monthly checks, after performing all the required checks, a total flow is performed to assure that the system is being left operational.

10.1.4.a Verification of Total Flow (16.67 lpm):

To verify Total Flow, an adapter is used to fit the audit device to the extension tube.

1. Ensure DAS channel is disabled.
2. Set up your NIST-traceable flow standard transfer device with the appropriate inlet for the flow to be calibrated.
3. Remove the inlet from the extension tube. Connect the Flow standard to the extension tube using an appropriate adapter. Ensure the tubing connecting the inlet to the Flow Standard is not kinked.
4. With the T640x running, go to main menu or Dashboard to review Total Flow (16.67 lpm).
5. Wait at least one minute for the flow to re-stabilize.
6. Record audit device flow and T640x total flow to the Form DEP 03-23-A Monthly Visit Form.
7. Compare the **T640x Total Flow** to the transferred standard flow and determine if these values differ by more than 4.1% from the transfer standard or 5.1% of the design flow value of 16.67LPM using Equation 1 below.

   Equation 1: Percent Difference

   $$\% \text{ Difference} = \frac{\text{Instrument} - \text{Flow Standard}}{\text{Flow Standard}} \text{ x } 100\%$$

8. Proceed to Section 10.5

Note: If total flow is out of tolerance, a direct calibration of total flow is not possible. Rather the sample and bypass flows are individually calibrated till all three flows are within tolerance. The flow verifications and calibrations should be conducted in the following order:

1. *Verify Total Flow.*
2. *Verify Sample Flow. If both Total flow and Sample flow are within limits, no further action is needed. If Sample flow reading is not within limits, perform adjustment and repeat Step 1. If Total Flow is not within limits, but Sample Flow is within limits, proceed to next step.*
3. *Adjust Bypass Flow. Repeat Step 1.*

10.1.4.b Verification and Calibration of Sample Flow (5.0 lpm)

1. Ensure DAS channel is disabled.
2. Disconnect auxiliary flow line from side of ASC. Ensure auxiliary flow line is not blocked and only pulling in ambient air.
3. Cap Swagelok fitting at side of ASC.
4. Set up your NIST-traceable flow standard transfer device with the appropriate inlet for the flow to be calibrated. Ensure audit device is appropriately sized for 5.0 lpm flow.
5. Remove the inlet from Upper Inlet Tube. Connect the Flow Standard to the top of the Upper Inlet Tube. Ensure the tubing connecting the inlet to the Flow Standard is not kinked.
6. With the T640x running, go to the Calibration > Sample Flow Cal menu. Wait at least one minute for the flow to re-stabilize.

7. Compare the "Measured Flow" in this screen to the Flow Standard and determine if these values have a percent difference greater than 4.1%. The acceptable flow rate tolerance is 4.75 – 5.25 lpm.
8. Record audit device flow and T640x sample flow to the Form DEP 03-23-A Monthly Visit Form.
9. If sample flow meets expected tolerance, then you are done with the flow verification. If sample flow is outside of the acceptable tolerance, continue with step 10 to perform a calibration of the sample flow.
10. If sample flow is off by more than 4.1% from standard, first press "Start" then press the value button in the "Actual Flow" field, enters the value measured by the Flow Standard, and press the "Calibrate" button on this screen.
11. The Measured Flow value should change to closely match the Actual Flow within a few seconds.
12. If no further adjustment is necessary, press "Stop".
13. Record audit device flow and T640x sample flow to the Form DEP 03-23-A Monthly Visit Form.
14. Disconnect Swagelok cap from ASC.
15. Verify Total flow according to procedure in 10.4 once more. If total flow verification is acceptable, the flow verification is complete. If total flow is not within acceptable limits, proceed to Section 10.6.

10.1.4.b Verification and Calibration of Bypass Flow

Bypass flow calibration (11.67 lpm) is **only** needed if the total flow verification does not meet the acceptable tolerance and the sample flow has already been verified and/or calibrated.

1. Ensure DAS channel is disabled.
2. Connect the NIST-traceable flow transfer standard device to the Bypass line that was disconnected in the sample flow verification procedure above.
3. Ensure fitting(s) connecting flow transfer standard and bypass line are secure and not leaking.
4. With the T640x running, go to the flow calibration menu: >Calibration >Bypass Flow Cal. Wait a least one minute for flow to stabilize.
5. Compare the "Measured Flow" in this screen to the Flow Transfer Standard and determine if these values differ by more than 4.1%. The acceptable bypass flow tolerance is 11.10 – 12.30 lpm. However, values approaching the 4.1% tolerance or the boundary of the flow tolerance should also be considered for a calibration since the bypass flow check is expected to be performed infrequently.
6. Record audit device flow and T640x bypass flow to the Form DEP 03-23-A Monthly Visit Form.
7. To calibrate the bypass flow, first press "Start" then press the "Value" button in the "Actual Flow" field, enter the value measured by the Flow Standard, and press the "Calibrate" button on the screen.
8. The Bypass Measured Flow value should change to closely match the Actual Flow within a few seconds.
9. If no further adjustment is necessary, press "Stop".

10. Record to data sheet. Reattach bypass line to ASC.
11. Repeat Section 10.4 to verify that total flow is now within all limits.

10.1.5 PMT Verification and Adjustment

The Particle Sensor PMT Adjustment uses SpanDust™, a monodisperse dust with a specific refractive index. All T640x instrument PMTs have a very specific response to this span dust which allows for the sensor to be checked and adjusted in the field for drift caused by contamination of the optics. This is not a calibration of the optical sensor based on the mass of dust being used, but simply a mechanism to check and adjust the PMT response to particles with a specific and known refractive index.

Note: Although the PMT verification is a very useful check that tells the user if the performance of the monitor spectrometer is as expected, multiple checks of the PMT or individual verifications that lead to too must span dust entering the monitors optics can itself lead to poor performance of the monitors spectrometer and/or RH sensor. Careful attention needs to be made to ensure a minimum amount of span dust enters the sample tube during a verification and that repeats of verifications are kept to a minimum. It is recommended that after 12 span dust checks, the optical bench be cleaned.

Note: Follow the procedure listed below for PMT verification when performing the semi-annual flow rate audits. These audits must be carried out using an independent NIST traceable transfer standard and the results should be recorded on Form DEP 03-21/23-O, Semi-Annual Flow Rate Audit T640/T640X, April 2022.

1. Ensure DAS channel is disabled.
2. Navigate to the PMT Adjust screen: >Home >Calibration>PMT Adjust.
3. Press the Start button on this screen to suspend normal data acquisition and start this adjustment process.
4. Remove the T640x sample inlet. Prepare the SpanDust™ bottle by uncapping the “air intake” tubing on the cap of the bottle.
5. Place the tube from the SpanDust™ bottle into the top of the Upper Inlet Tube of the instrument.
6. Ensure that the silicone tube fits snugly inside the aluminum inlet tube, and do not allow the bottle to hang, as it could dislodge the silicone tube from the inlet tube. Gently tap the SpanDust™ bottle to barely agitate the contents just enough to allow the dust to be pulled into the sensor and allow 30 seconds for the Peak Channel reading in this screen to respond.
7. Record the maximum Peak Channel, PMT Setting and Peak Channel Counts in the “Monthly QC and Maintenance Sheet”.
8. If the Peak Channel reading matches the span dust bottle within ± 1.5, then proceed to step 12. If the Peak Channel is not acceptable, then retry one more time.
9. If after two tries the Peak Channel reading matches the span dust bottle within ± 1.5, then adjust the PMT Setting by pressing the Peak Adjust left

(decrement) or right (increment) buttons to center the Peak voltage. Each press of a button is 1 volt, so press the Peak Adjust button by as many times as the number of volts the reading is off.

10. Allow 30 seconds for the Peak Channel reading in this screen to respond, and if it is not at ± 1.5 of the span dust bottle's Peak at Channel number, repeat the process.
11. This could take several tries over a long period when conducted in a humid environment.
12. Once the Peak Channel reading is at ± 1.5 of the span dust bottle's Peak at Channel number, record in "Monthly QC and Maintenance Sheet".
13. Reattach the sample inlet and press the Stop button to stop the adjustment process and resume normal data acquisition.
14. Wait 10 minutes, review data on home screen of T640x to assure unit is correctly sampling.
15. Record PMT verification to the Form DEP 03-23-A Monthly Visit Form.

11.0 MAINTENANCE PROCEDURES

This section provides cleaning and maintenance information for the inlets and filters. Always allow at least 10 minutes of operation after a procedure to ensure reliable operation.

> *Note: Prior to any maintenance procedures, a zero check and flow verification must be performed. Before resuming data collection, an additional zero check, and total flow check must be performed.*

11.1 Maintenance Schedule

As a part of routine system management, preventive maintenance includes inspections, cleaning, verifications and calibrations. Refer to the instrument manual that describes a list of actions and their frequencies.

Table 11.1 T640x Maintenance Schedule

Maintenance Action	Tolerance	Frequency
Check for leaks with zero filter	Stated as "Zero", (≤0.2 for each PM metric)	**Every 30 Days**
Clean Inlet and PM10 Well	NA	**Every 30 Days**
Check/Adjust PMT with SpanDust 1.28	SpanDust™ Peak Channel (typical value 11.1) +/-1.5 (eg. 9.6 to 12.6)	**Every 90 Days**
Check Pump Performance	(Pump PWM value < 80%, Valve PWM <85%)	**Every 30 Days**
Ambient Pressure	+/- 10.1 mmHg	**Every 30 Days**
Ambient Temperature	+/- 2.1°C	**Every 30 Days**
Flow rate checks **Total flow: 16.67 lpm**	+/- 4.1% of standard or +/-5.1% of flow rate design (15.86 – 17.52 lpm). For our purposes use +/-5% of flow rate design.	**Every 30 Days**
Flow rate checks **Sample flow: 5.0 lpm**	+/- 4.1% of standard; +/-5.1% of flow rate design (4.75 – 5.75 lpm). For our purposes use +/-5.1% of flow rate design.	**Every 30 Days**

Bypass Flow: 11.67 lpm	+/- 4.1% of standard; +/-5.1% of flow rate design (11.10 – 12.30 lpm). For our purposes use +/-5.1% of flow rate design.	**As needed if total or sample flow does not meet criteria. Use same tolerance as total and sample flow.**
Inspect and clean optical chamber and relative humidity/temperature (RH/T) sensor	NA	**Every 180 Days, every 12-span dust introduction, or as needed, e.g. high dust load**
Change Disposable Filter Unit (DFU) for 5- lpm sample flow and 11.67 lpm bypass flow (if installed)	NA	**Annually or when pump PVM value approaches 80%.**
Inspect inner and outer sample tubes	**NA**	**Monthly or as needed**

11.2 Cleaning the T640x Inlet

a. Ensure DAS channel is disabled.
b. Power off the pump from the Setup>Vars>Pump Control menu. Pump choices are auto, off and cleaning cycle. Press ‘edit’ and then ‘off’ to turn off the pump. Remove the sampling inlet from the downtube.
c. Disassemble the sampling inlet (four screws on the underside of inlet base plate). Carefully and thoroughly remove any dust deposits from inside the inlet.
d. Remove any insects or other debris from the filtering screen.
e. Clean all the components using water and a mild detergent, if necessary.
f. Dry all components thoroughly with a clean cloth and blow canned air through nozzles. Check and, if needed, replace the O-rings located on the outside and the inside of the base plate, and grease them with vacuum grease.
g. Re-assemble the sampling inlet, sliding the baseplate back into the base of the inlet body, making sure to line up with the screw holes. The screws should be put back with hand-tight pressure only.
h. Reconnect to sampling line.
i. Power up the pump from the Setup>Vars>Pump Control menu. Press ‘edit’ and then ‘auto’ to turn the pump back on.
j. Allow 10 minutes for the system to return to reliable operation.
k. Ensure the data acquisition system is reengaged.

l. Record event in the form DEP 03-23-B Maintenance Tracking Form.

11.3 Cleaning the PM10 well

a. Ensure DAS channel is disabled.
b. Power off the pump from the Setup>Vars>Pump Control menu. Pump choices are auto, off and cleaning cycle. Press 'edit' and then 'off' to turn off the pump. Remove the sampling inlet from the downtube.
c. Unscrew the top of sampling inlet from the base of the inlet to expose the PM10 well. Using a moist lint free towel or wipe, clean the inside base of the PM10 well. Using cotton tipped applicator (or similar) saturate the tip of the applicator with DI water and clean out each of the three nozzles in the PM10 well.
d. Carefully inspect and remove for any insects or spider webs. If there is a spider web present, make note of it on form DEP 03-23-B Maintenance Tracking form.
e. If needed, dry all components thoroughly with a clean cloth. Blow canned air through the three nozzles. Inspect and clean, as necessary the bottom connection of the downtube with a lint free towel or wipe. Inspect and clean the water collector if any debris or water are present.
f. Check and, if needed, replace the O-rings located on the outside and the inside of the base plate, and grease them with vacuum grease.
g. Carefully re-assemble the top and base of the sampling inlet, but do not overtighten. Reconnect to sampling line.
h. Power up the pump from the Setup>Vars>Pump Control menu. Press 'edit' and then 'auto' to turn the pump back on.
i. Allow 10 minutes for the system to return to reliable operation.
j. Ensure the data acquisition system is reengaged.
k. Record event in the form DEP 03-23-B Maintenance Tracking Form.

11.4 Changing the Disposable Filter Units (DFUs)

There are two DFUs on the T640x, one internal filter for the 5.0 lpm pump and one external for the 11.67 lpm pump. If changing one filter, it is recommended that the other filter also be changed.

Note: DFUs may appear dirty but are still functioning acceptably. DFU need to be changed annually or as Pump PWM approaches 80% or Valve PWM approaches 85%.

a. Ensure DAS channel is disabled.
b. Internal Pump Filter: Power off the internal pump from the control menu: Setup> Vars> Pump > Edit> Off >Done. Remove screws at sides of front panel, if installed.
c. Pull open the instrument's front panel, using the front panel finger grips. Write "New" and todays date on the filter with a permanent marker (recommended).
d. Noting its orientation, remove the old DFU by detaching from the pneumatic quick-connect fittings, and replace with a new DFU matching the orientation.
e. Power on the internal pump from the control menu: Setup> Vars> Pump > Edit> Auto >Done.
f. Review internal pump flow in Dashboard or Home Screen to ensure the 5.0 lpm flow is reading as expected: >Main Menu > Home >Dashboard.
g. External Pump Filter: Unplug or turn off electrical switch, if available, to the

external pump (operates at 11.67 lpm).

h. Write "New" and todays date on the filter with a permanent marker (recommended). Noting its orientation at back of instrument, detach the filter from the quick-connect fittings and replace with new filter.
i. Ensure the filter is seated snugly with no gaps.
j. Plug the bypass pump electrical cord back in or otherwise turn on pump.
k. Review external pump flow in Dashboard or Home Screen to ensure the 11.67 lpm flow is reading as expected: >Main Menu > Home >Dashboard.
l. Allow 10 minutes for the system to return to reliable operation.
m. Ensure the data acquisition system is reengaged.
n. Record event in the form DEP 03-23-B Maintenance Tracking Form.

11.5 Checking Pump Performance

There are two pumps associated with the T640x. One pump is internal (operating at 5 lpm). The second pump is external (operating at 11.67 lpm). The 5 lpm pump must maintain proper flow for measurement accuracy, while the combined flow of the internal and external pump (i.e., 16.67 lpm) ensure that the PM10 inlet is operating at its designed flow for a PM10 cut point.

Check performance levels in the Dashboard. If these parameters are not found in the Dashboard, configure the Dashboard to add them (see Section 3.1.9 of the T640 User Manual). Pump PWM should be running between 35% and 80%. Valve PWM should be running between 35% and 85%.

11.6 Cleaning the Optical Chamber and the RH/T Sensor.

a. Ensure DAS channel is disabled.
b. Power down the monitor and unplug.
c. Remove the ASC support, which straddles the sensors. Four screws secure that support to the floor of the instrument, two on each footing.
d. Locate the optical cell (the cup at the bottom of optics chamber and its tubing) and the Relative Humidity and Temperature (RH/T) sensor.
e. Remove optical cell from optics chamber, and remove cup, including its tubing, from optics chamber bottom. Detach RH/T sensor tubing from DFU filter.
f. Clean the optics chamber interior surfaces, including the windows, with a lint-free cloth.
g. Use canned air made specifically for dusting electronics to blow any dust or other debris from the optics chamber, from the cup, from the bottom of the optics chamber and from the tubing.
h. When finished, reassemble optics chamber components; reinsert cup to bottom of optics chamber; reconnect tubing from cup in bottom of chamber to RH/T sensor and from RH/T sensor to the DFU filter; and reinstall the ASC support.
i. Close instrument and power back online.
j. Perform a PMT sensor check with the SpanDust™ (Section 10.7)
k. Record event in the form DEP 03-23-B Maintenance Tracking Form.

11.7 Inspecting the Sample Tubes

Look inside the sample tubes for debris or dust on the walls. If needed, push a rag or a paper towel through the tubes, then use canned air made specifically for electronics to blow through the line for final cleaning. However, do not completely block a sample tube still under vacuum, as the sample flow should never be blocked while the unit is still operating. Record event in the form DEP 03-23-B Maintenance Tracking Form.

11.8 Troubleshooting

This section provides guidance for resolving fault conditions and possible flow and calibration problems. To review Alerts select >Alerts.
Document any alerts, including date and time in the for DEP 03-23-A Monthly Visit Form. To clear alerts, select the following: >Alerts >Select >Clear Selected. Then select the home button. If alerts reappear, then troubleshooting is required Table 11-2 lists common alerts and their possible solutions.

Table 11.9 Alerts and Recommendations

Message	Description	Possible Solution(s)
System Reset	Warning raised when the system is reset	**Normal power cycle occurred? If not, check external power source.**
Sample Flow High	The Sample Flow is greater than 5.25 lpm	**Check pneumatic fittings. Re-calibrate flow.**
Sample Flow Low	The Sample Flow is less than 4.75 lpm	**Check pneumatics. Check for blockages. Re-calibrate flow.**
Bypass Flow High	The Bypass Flow is greater than 12.30 lpm	**Check pneumatic fittings. Re-calibrate flow.**
Bypass Flow Low	The Bypass Flow is less than 11.10 lpm	**Check pneumatics. Check for blockages. Re-calibrate flow.**
Sample RH High	The Sample RH is above the set point	**Check if ASC is plugged in. Check control board if ASC control LED is illuminated. Check if water is in the sensor.**
Check LED	If the LED temperature is equal to the box temperature, the LED may be OFF	**Cycle power. Call Tech Support.**
Check PMT	The PMT HV setting is out of range (800–2200)	**Check Sensor with SpanDust™. Perform an optical chamber cleaning. Call Tech Support.**

Sample Flow Slope OOR	The Sample Flow Calibration Slope is Out of Range (OOR)	**Check pneumatics for leaks. Re-run flow calibration. Call Tech Support.**
BYPS Flow Slope OOR	The Bypass Flow Calibration Slope is Out of Range	**Check pneumatics for leaks. Re-run flow calibration. Call Tech Support.**
Check Int Pump	Check the internal pump if the PWM is > 80	**Check pneumatics for blockages. Check pneumatics for leaks. Check flow calibration. Replace pump.**
Check Ext Pump	Check the external pump and/or bypass flow control valve if valve PID > 85	**Check pneumatics for blockages. Check pneumatics for leaks. Check external pump. Check flow calibration. External pump, or bypass flow control valve may need replacing.**
Sample Temp Warning	Sample Temperature Warning (>60)	**Check ASC (is it latched ON?) Ensure proper climate and ventilation for instrument.**
Box Temp Warning	Box Temperature Warning (>60)	**Ensure proper climate and ventilation for instrument.**
AMB Press Slope OOR	**Ambient Pressure Calibration Slope is out of range**	**Check calibration (make sure units match calibration device). Replace pressure sensor. Call Tech Support.**

If a flow auditing device indicates any problems with flow, check to ensure the following:

- All connections are seated tightly and evenly (no gaps);
- The inlet is not clogged or blocked;
- The pump is running and is within its PWM range (35% - 80%);
- The DFU appear reasonably clean and changed within last 12 months.

After making any adjustments, run a flow calibration and recheck the flow rate. If problems persist, contact Teledyne-API Technical Support for assistance.

12.0 QUALITY ASSURANCE & QUALITY CONTROL

The instrument will be operated in accordance with the manufacturer's recommendation. The maintenance recommendations presented above, including the recommended verifications and adjustments, will be followed. Alerts (diagnostic codes) issued by the instrument will be reviewed and appropriate corrections will be initiated when indicated. The alerts will be retained as part of the instrument data. Daily review of instrument output is made to ensure operability. Data reasonableness will also be assessed to ensure instrument output is consistent with expectations for the instrument location, time of day, typical concentrations, and season.

Table 12-1 QA/QC Schedule

QA/QC Procedure	Tolerance	Frequency
Zero Test	≤ 0.2 µg/m^3	**Every 30 Days**
Ambient Pressure Verification	± 10.1 mmHg	**Every 30 Days**
Ambient Pressure Verification/Calibration	± 10.1 mmHg	**On installation, then every 365 days**
Ambient Temperature Verification	± 2.1° C	**Every 30 Days**
Ambient Temperature Verification/Calibration	± 2.1° C	**On installation, then every 365 days**
One Point Flow Rate Verification **Sample flow: 5.0 Lpm**	± 4.1% of ± 5.0 LPM flow rate design value (4.79 – 5.21 LPM). *Note: PQAO adopted warning limit is ≥ ±3%	**Every 30 Days separated by 14 days**
Flow Rate Verification/Calibration	± 2.1%	**Every 365 days and 1/ calendar year**
Check/Adjust PMT	**± 1.5 of the Certified Peak Channel value on Span Dust bottle label (e.g., if the Certified Peak Channel value is 11.3, the tolerance is 9.8 to 12.8)**	**Every 90 Days**

13.0 DATA ACQUISTION AND RECORD MANAGEMENT

Data collected by the T640x at the monitoring site will be stored on a data acquisition system (DAS). Data can be remotely polled for upload into a centralized database. Ensure data backups are conducted a regular basis.

The in-situ DAS will be a commercially available computer-based unit capable of retrieving digital records from the station instruments via an Ethernet connection. It will store 1 minute averages from the instruments. The instrument will store approximately 1 year of data internally and data can be retrieved at any time to fill in any missing data in the database due to transfer issues.

Table 13.0 lists the parameter, method, and unit codes for the T640x and T640 data. **Use the green highlighted information. The FEM PM 10 status must have the correct parameter codes.**

Table 13.0: Parameter, method, and unit codes

Parameter Description	Parameter Code	Method Code for T640	Method Code for T640x	Units	Unit Code
PM2.5	88101	236/636	238/638	Micrograms/cubic meter (LC)	**105**
PM10 - LC		236/636	239/639		
PM10-2.5 LC	86101	236/636	240/640	Micrograms/cubic meter (LC)	**105**
PM10 STP	**81102**	**not available**	**239**	**Micrograms/cubic meter (25C)**	**001**

13.1 RECORD MANAGEMENT

Field site visits will be stored in site logbooks documenting access to the monitoring sites and the key activities performed. Details on routine QC and maintenance are recorded to forms DEP 03-23-A, Monthly Visit Form, and DEP 03-23-B, Maintenance Tracking Form.

14.0 REFERENCES

Quality Assurance Project Plan for the State of Florida Ambient Air Quality Monitoring Program, FDEP QAPP-002, Revision 2, December 2022, Florida Department of Environmental Protection, Tallahassee, FL.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II (EPA-454/B-17-001, January 2017).

Model T640PM Mass Monitor User Manual, Part Number 08354A DCN7303, 13 July 2016.

15.0 APPENDIX A--FORMS

15.1 DEP 03-23-A Maintenance Tracking Form

T640x Maintenance and Verification Form

Form No. DEP 03-23-A
Rev. No. 3
Effective: March 2023

Identification Block			
Year:	Site Name:	AQS #:	
Instrument Mfr:	Model:	Serial #:	

Minimum Maintenance Frequency:		Monthly				Quarterly	Semi-Annual	Annual				
Date	Operator	Flow and Leak Check	Temperature and Pressure Check	Clean/Replace PM_{10} Head	Inspect/Clean Inner and Outer Sample Tube	Span Dust Check	Clean RH and Temp. Sensor	Inspect/Clean Optical Bench*	Change 5 lpm DFU**	Change 11.67 lpm DFU***	QA Verification	QA Date
ENTER DATE LAST PERFORMED:												
	Due Dates:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Span Dust Counter	
	Warnings:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	PASS

*** Inspect/Clean Optical Bench either annually or when span dust counter reaches 12, whichever comes first**
**** Change 5 lpm DFU when Pump PWM > 80%**
***** Change 11.67 lpm DFU when Valve PWM >85%**

Operator Comments:

QA Comments:

Instructions:

Identification Block

Year….	Year that maintenance form will be used
Site Name …	Written site name
AQS # …	AQS number attributed to site
Parameter …	Select PM2.5/PM10 if using T640x
Instrument Mfr …	Analyzer's manufacturer
Model …	Analyzer's model number
Serial # …	Analyzer's serial number
Data Logger Mfr …	Data logger's manufacturer
Model …	Data logger's model number
Serial # …	Data logger's serial number
Date …	Date maintenance was performed
Operator ….	First initial and last name of operator who performed the maintenance
Maintenane Listed …	Maintenance is listed on the top row. For each maintenance select an appropriate dropdown
	"performed" or similar response is used if maintenance was performed for any reason
	"not performed" if maintenance was scheduled but could not be performed
	"not due" if maintenance is not past due and was not performed
QA Verification …	First initial and last name of personnel who verified the maintenance was performed
QA Date …	Date QA Verification was performed
Span Dust Counter …	Increase value each time span dust is introduced into the system (may be multiple times per adjustment). Reset value to zero after optical bench is cleaned.

15.2 DEP 03-23-B Monthly Visit Form

Form No. DEP 03-23-B
Rev. No . 3
Effective: March 2023

T640x Monthly Visit Form

Identification Block						
Date Performed:		Site Name:		AQS #:		Procedure:	
Sampler Manufacturer:		Model:		Serial #:		Date Calibrated:	
Data Logger Manufacturer:		Model:		Serial #:		Date Calibrated:	

Standards Block							
Flow Standard Manufacturer:		Model:		Serial #:		Date Certified:	
(Optional) Flow Standard Manufacturer:		Model:		Serial #:		Date Certified:	
Temp Standard Manufacturer:		Model:		Serial #:		Date Certified:	
Pressure Standard Manufacturer:		Model:		Serial #:		Date Certified:	
Time Standard Manufacturer:		Model:		Serial #:		Date Certified:	
Span Dust Lot Number:		Peak Channel:		Valid Until:			

Parameters Block					
Sample Flow Slope (0.85-1.15)		Pump PWM (<80%)		Box Temp (°C) (0-60°C)	
P3 Value (45-55)		Valve PWM (<85%)		Ambient Temp (°C) (-40-60°C)	
PMT HV Setting (1100-2200V)		Sample RH% (≤50%)		Sample Temp (°C) (0-60°C)	
Heater Duty		LED Temp (°C) (≤70°C)		Firmware and Version	

DAS Comparison

	T640x (µg/m³)	DAS (µg/m³)	Difference	Limit	Result
$PM_{2.5}$			N/A	±2 µg/m³	N/A
PM_{10} STP			N/A	±2 µg/m³	N/A

PMT Check/Adjustment

	Peak Channel Count	PMT Setting (V)	Peak Channel	Span Dust	Difference	Limit	Result
As Found				N/A	N/A	± 1.5	N/A
Adjusted				N/A	N/A	± 1.5	N/A

Time Check

	T640x	Standard	Difference	Limit	Result
Time			N/A	± 1 minutes	N/A

Ambient Temperature and Pressure Check

	T640x	Standard	Difference	Limit	Result
Temperature (°C)			N/A	± 2.1 °C	N/A
Pressure (mmHg)			N/A	± 10.1 mmHg	N/A

Monthly Check

	Flow Check							Zero Test			
	T640x (lpm)	Standard (lpm)	% Difference	$PM_{2.5}$ T.S. Limit: ± 4.1%	PM_{10} T.S. Limit: ± 4.1%	Design Limits	Design Result	Instrument	T640x	Limit	Result
Total Flow			N/A	N/A	N/A	15.82 - 17.52 lpm	N/A	$PM_{2.5}$		≤0.2 µg/m³	N/A
Sample Flow			N/A	N/A	N/A			PM_{10} STP		≤0.2 µg/m³	N/A

Post Maintenance Check (Enter information below for flow check/zero test performed after maintenance)

	Flow Check							Zero Test			
	T640x (lpm)	Standard (lpm)	% Difference	$PM_{2.5}$ T.S. Limit: ± 4.1%	PM_{10} T.S. Limit: ± 4.1%	Design Limits	Design Result	Instrument	T640x	Limit	Result
Total Flow			N/A	N/A	N/A	15.82 - 17.52 lpm	N/A	$PM_{2.5}$		≤0.2 µg/m³	N/A
Sample Flow			N/A	N/A	N/A			PM_{10} STP		≤0.2 µg/m³	N/A

Operator Comments

Performed by: Date:

QA Comments

QA by: Date:

Instructions

Identification Block	
Date Performed …	Date the monthly check was performed
Site Name …	Site name
AQS # …	AQS # associated with site
Procedure …	Select from dropdown either monthly check OR monthly check + span dust if a span dust needs to be performed
Sampler manufacturer …	Manufacturer of sampler
Model …	Model of sampler
Serial # …	Serial number of sampler
Date Calibrated …	Latest calibration date for sampler
Data Logger Manufacturer …	Manufacturer of data logger
Model …	Model of data logger
Serial # …	Serial number of data logger
Date Calibrated …	Latest calibration date for data logger
Standards Block	
Flow Standard Manufacturer…	Manufacturer of flow standard
Model …	Model of flow standard used
Serial # …	Serial number of flow device used
Date Certified …	Latest certification date for flow standard
Temp Standard Manufacturer	Manufacturer of temperature standard
Model …	Model of temperature standard
Serial # …	Serial number of temperature standard
Date Certified …	Certification date for temperature standard
Pressure Standard Manufacture	Manufacturer of pressure standard
Model …	Model of pressure standard
Serial # …	Serial number of pressure standard
Date Certified …	Certification date for pressure standard
Time Standard Manufacturer	Manufacturer of time standard traceable to the NIST Boulder, Co number at 303-499-7111
Model …	Model of time standard
Serial # …	Serial number of time standard
Date Certified …	Certification date for time standard
Span Dust Lot Number …	Lot number lsited on span dust bottle
Peak Channel …	Peak channel listed on span dust bottle
Valid Until …	Valid until date listed on span dust bottle.
Parameter Block	
Parameter …	Write the associated value taken either from the dashboard or diagnostic menu of the sampler
DAS Comparison	
PM2.5	Write the current instantaneous PM2.5 concentration seen on both the sampler main screen and the data logger
PM10 STP	Write the current instantaneous PM10 STP concentration seen on both the sampler main screen and the data logger
PMT Check/Adjustment	
Peak Channel Count …	Write the Peak Channel Count shown on the sampler's PMT Adjust screen
PMT Setting …	Write the PMT Setting shown on the sampler's PMT Adjust screen
Peak Channel …	Write the Peak Channel shown on the sampler's PMT Adjust
Date and Time Check	
Date …	Write the current date seen on both the sampler main screen and the time standard
Time …	Write the current time seen on both the sampler main screen and the time standard
Temperature and Pressure Check	
Temperature …	Write the current temperature seen on the sampler and the temperature standard
Pressure …	Write the current pressure seen on the sampler and the pressure standard

Note: For T640x, Total Flow (~16.67 lpm flow reading) is entered for both $PM_{2.5}$ and PM_{10} one-point flow verification

Monthly Check	
Flow Check	
Total Flow…	Write the total flow shown on the sampler dashboard and on the flow standard (NOTE: If flow is out of range, use form 03-23-C to document adjustment)
Sample Flow …	Write the sample flow shown on the sampler dashboard and on the flow standard (NOTE: If flow is out of range, use form 03-23-C to document adjustment)
Zero Test	
PM2.5 …	With zero test filter securely fastened, write the concentration of PM2.5 listed on the sampler's dashboard
PM10 …	With zero test filter securely fastened, write the concentration of PM10 listed on the sampler's dashboard
Post Maintenance Check	
Note: If no post maintenance check is performed, enter "N/A"	
Flow Check	
Total Flow…	Write the total flow shown on the sampler dashboard and on the flow standard (NOTE: If flow is out of range, use form 03-23-C to document adjustment)
Sample Flow …	Write the sample flow shown on the sampler dashboard and on the flow standard (NOTE: If flow is out of range, use form 03-23-C to document adjustment)
Zero Test	
PM2.5 …	With zero test filter securely fastened, write the concentration of PM2.5 listed on the sampler's dashboard
PM10 …	With zero test filter securely fastened, write the concentration of PM10 listed on the sampler's dashboard
Performed By …	Name of operator who performed monthly check
Date …	Date of monthly check
QA By …	Name of personal who verified the montly check
Date …	Date of monthly check's verification

15.3 DEP 03-23-C Annual Flow, Temperature, and Pressure Verification

Form No. DEP 03-23-C
Rev. No.3
Effective: March 2023

T640x Annual Flow, Temperature and Pressure Verification

Identification Block							
Date Performed:		Site Name:		AQS #:		Procedure:	
Instrument Manufacturer:		Model:		Serial #:		Date Calibrated:	
Data Logger Manufacturer:		Model:		Serial #:		Date Verified:	

Standards Block							
Flow Standard Manufacturer:		Model:		Serial #:		Date Certified:	
(Optional) Flow Standard Manufacturer:		Model:		Serial #:		Date Certified:	
Temp Standard Manufacturer:		Model:		Serial #:		Date Certified:	
BP Standard Manufacturer:		Model:		Serial #:		Date Certified:	

Ambient Temperature and Pressure Check

	T640x	Standard	Difference	Limit	Result
Temperature (°C)			N/A	± 2.1 °C	N/A
Unadjusted Pressure (mmHg)			N/A	± 10.1 mmHg	N/A
Adjusted Pressure (mmHg)		N/A	N/A	± 10.1 mmHg	N/A

NOTE
ANNUAL VERIFICATIONS MUST USE DIFFERENT STANDARD DEVICES THAN MONTHLY CHECKS

Flow Check

	Unadjusted Flow						Adjusted Flow				
	T640x (lpm)	Standard (lpm)	% Difference	T.S. Limits	T.S. Result		T640x (lpm)	Standard (lpm)	% Difference	T.S. Limits	T.S. Result
Total Flow			N/A	± 2.1%	N/A	Total Flow			N/A	± 2.1%	N/A
Sample Flow			N/A	± 2.1%	N/A	Sample Flow			N/A	± 2.1%	N/A
Bypass Flow			N/A	± 2.1%	N/A	Bypass Flow			N/A	± 2.1%	N/A

Final Flow Rate Verification

	T640x (lpm)	Design Value (lpm)	% Difference	Design Limits	T.S. Limits	Design Result	T.S. Result
Total Flow		16.67	N/A	± 5.1%	± 4.1%	N/A	N/A
Sample Flow		5.00	N/A		± 4.1%		N/A
Bypass Flow		11.67	N/A		± 4.1%		N/A

Zero Test

	T640x (µg/m³)	Limit	Result
$PM_{2.5}$		<0.2 µg/m³	N/A
PM_{10} STP		<0.2 µg/m³	N/A

Operator Comments

Performed by: Date:

QA Comments

QA by: Date:

Instructions	
Identification Block	
Date Performed …	Date the monthly check was performed
Site Name …	Site name
AQS # …	AQS # associated with site
Procedure …	Select from dropdown either monthly check OR monthly check + span dust if a span dust needs to be performed
Sampler manufacturer …	Manufacturer of sampler
Model …	Model of sampler
Serial # …	Serial number of sampler
Date Calibrated …	Latest calibration date for sampler
Data Logger Manufacturer …	Manufacturer of data logger
Model …	Model of data logger
Serial # …	Serial number of data logger
Date Calibrated …	Latest calibration date for data logger
Standards Block	
Flow Standard Manufacturer…	Manufacturer of flow standard
Model …	Model of flow standard used
Serial # …	Serial number of flow device used
Date Certified …	Latest certification date for flow standard
Temp Standard Manufacturer	Manufacturer of temperature standard
Model …	Model of temperature standard
Serial # …	Serial number of temperature standard
Date Certified …	Certification date for temperature standard
BP Standard Manufacturer	Manufacturer of pressure standard
Model …	Model of pressure standard
Serial # …	Serial number of pressure standard
Date Certified …	Certification date for pressure standard
Time Standard Manufacturer	Manufacturer of time standard
Model …	Model of time standard
Serial # …	Serial number of time standard
Date Certified …	Certification date for time standard
Temperature and Pressure Audit	
Temperature …	Write the current temperature seen on the sampler and the temperature standard
Unadjusted Pressure …	Write the current pressure seen on the sampler and the pressure standard before any adjustments are performed
Adjusted Pressure …	Write the current pressure seen on the sampler and the pressure standard post adjustment. Place "N/A" if no adjustment was performed
Flow Check	
Unadjusted Flow	
Total Flow…	Write the total flow shown on the sampler dashboard and on the flow standard before any adjustments are performed
Sample Flow …	Write the sample flow shown on the sampler dashboard and on the flow standard before any adjustments are performed
Bypass Flow …	Write the bypass flow shown on the sampler dashboard and on the flow standard before any adjustments are performed
Adjusted Flow	
Total Flow…	Write the total flow shown on the sampler dashboard and on the flow standard post adjustment. Place "N/A" if no adjustment was performed
Sample Flow …	Write the sample flow shown on the sampler dashboard and on the flow standard post adjustment. Place "N/A" if no adjustment was performed
Bypass Flow …	Write the bypass flow shown on the sampler dashboard and on the flow standard post adjustment. Place "N/A" if no adjustment was performed
Final Flow Rate Verification	
Total Flow …	After inlet reassembly, record the total flow listed on the sampler's dashboard
Sample Flow …	After inlet reassembly, record the sample flow listed on the sampler's dashboard
Bypass Flow …	After inlet reassembly, record the bypass flow listed on the sampler's dashboard
Zero Test	
PM2.5 …	With zero test filter securely fastened, write the concentration of PM2.5 listed on the sampler's dashboard
PM10 …	With zero test filter securely fastened, write the concentration of PM10 listed on the sampler's dashboard
Performed By …	Name of operator who performed monthly check
Date …	Date of monthly check
QA By …	Name of personal who verified the montly check
Date …	Date of monthly check's verification

15.4 DEP 03-21/23-O Semi-Annual Flow Audit T640/T640X

Form DEP 03-21/23-O
Effective April 2022
Revision 1

FLORIDA PRIMARY QUALITY ASSURANCE ORGANIZATION
SEMI-ANNAL FLOW RATE AUDIT FOR THE T640, T640X

Agency:		Performed By:	
Site Name:		Parameter:	
Site AQS#:		Audit Date:	
Audit Start Time:		Audit End Time:	

Ambeint Particulate Monitoring Equipment			
Data Acquisition System			
Brand/Model	Serial #:	Channel #:	Comparison Date:

Particulate Analyzer			
Analyzer:		Sample Flow Slope:	
Serial Number:		Sample RH (%):	
Date Calibrated:		Pump PWM (%):	
Firmware version:			
Head Inlet # :			

Audit Equipment				
Measurement Device	Brand/Make	Model	Serial #	Certification Date
Flow Standard				
Temperature Standard				
Pressure Standard				
Time Standard				
	Version	Validity Date	Lot Number	Peak
Spand Dust 1.28				

Meterological Audit			
Analyzer Component	Analyzer Measurement	Audit Device Measurement	Difference
Analyzer Time (hh:mm)			
Data Logger Time (hh:mm)			
Ambient Temperature (°C)			
Ambient Pressure (mmHg)			

Mass (PMT) Audit	
Peak Channel	Difference
Peak Channel Count:	
PMT Setting:	

Zero Test			
	PM_{10} ($\mu g/m^3$)	PM_{25} ($\mu g/m^3$)	Difference
Pre Audit			
Post Audit			

Flow Rate Audit			
	Analyzer Reading	Audit Device Reading	Acceptance Results
Total Flow			
	Audit Device Reading	Design Value	Acceptance Results
Design Flow			

Audit Comments:

QA Reviewer: _____ Review Date: _____

QA Comments:

Instructions:

The preceding audit form is designed to be completed by operators during the semi-annual flow rate audits using an independent NIST traceable transfer standard.

1. Compete the Identification Block at the top of the form as well as the Audit Start Time field.
2. Complete the Ambient Particulate Monitoring Equipment block consisting of the Data Acquisition System fields and the Particulate Analyzer fields.
3. Compete the Audit Equipment fields, making sure to include calibration, verification or certification dates as appropriate.
4. Record the time the T640 data logger channel was taken offline in the Audit Start Time field.
5. In the Meteorological Audit section, begin by performing a concurrency check between the T640, data logger and NIST traceable standard and recording the results in the appropriate fields.
6. Compare the T640's ambient temperature and pressure readings against the NIST traceable standard and record them in the Analyzer Measurement and Audit Device Measurement fields respectively.
7. Perform a leak check and record the results in the Pre-Audit Leak Check fields under the Flow Rate Audit block.
8. In the Flow Rate Audit block, record the indicated flows as found on the front panel for Main and Total in the Analyzer Reading fields and those from the NIST traceable standard in the Audit Device Reading fields.
9. Perform a Mass (PMT) Audit and record the results in the appropriate fields of the Mass (PMT) Audit block. (Refer to page 19 for more information on Span Dust checks.)
10. Perform a second leak check and record the results in the Post-Audit Leak Check fields under the Flow Rate Audit block.
11. Record the time the T640 data logger channel was placed online in the Audit End Time field.
12. Note any comments in the Audit Comments field.

Once the audit is completed the form should be e-mailed to Cadedra Hodge, Daisy Anderson and Patrick Washington of the Data Validation team.

16.0 Appendix B - Glossary

AC	Alternating Current
API	Advanced Pollution Instruments
ASC	Aerosol Sample Conditioner
CFR	Code of Federal Regulations
DAS	Data Acquisition System
DHCP	Dynamic Host Configuration Protocol
DFU	Disposable Filter Unit
EPA	Environmental Protection Agency
FEM	Federal Equivalent Method
FDEP	Florida Department of Environmental Protection
IP	Internet Protocol
LED	Light Emitting Diode
Lpm	Liters per minute
LST	Local Standard Time
NIST	National Institute of Standards and Technology
OD	Outside Diameter
PMT	Photo Multiplier Tube
PWM	Pulse Width Modulation
PM	Particulate Matter
PM2.5	Particulate Matter with aerodynamic diameter of 2.5µg or less
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RH	Relative Humidity
RH/T	Relative Humidity/Temperature Sensor
SOP	Standard Operating Procedure
TAD	Technical Assistance Document
TSP	Total Suspended Particle
USB	Universal Serial Bus