U.S. EPA
Technical Systems Audit
Checklist for the Teledyne T640 or T640x PM Continuous Monitors

1. Introduction and Overview:

This checklist is intended to support auditors and managers in conducting a Technical Systems Audit of the Teledyne T640 or T640x PM continuous monitor.

2. Summary of method and description:

The Teledyne API Model T640 and T640x are real-time, continuous particulate matter (PM) mass monitors that use scattered light spectrometry for measurement; specifically, they employ broadband spectroscopy using 90° white-light scattering with a polychromatic light-emitting diode (LED).

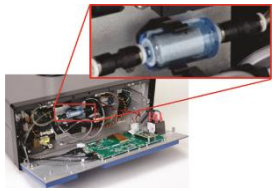
There are two designated methods of the T640 instrumentation. The model T640 with 640x option (T640x) is an approved Federal Equivalent Method (FEM) for $PM_{2.5}$ [EQPM-0516-238], PM_{10} [EQPM-0516-239], and $PM_{10-2.5}$ [EQPM-0516-240]. The T640x operates at a total flow rate of 16.7 lpm with 5.0 lpm entering the measurement cell and the remaining 11.7 lpm discarded as bypass flow. The model T640 is an approved FEM for $PM_{2.5}$ [EQPM-0516-236]. The T640 also measures PM_{10} and $PM_{10\text{-}2.5}$, but only the $PM_{2.5}$ fraction meets FEM requirements. The non-FEM channels of the T640 may be reported for AQI or other non-regulatory purposes of the data. The T640 operates with a single flow rate at 5.0 lpm.

3. Teledyne T640/T640x Set-up:

With two models (T640 or T640x) and two options for the location of the monitor (installed in an outdoor shelter or in a walk-in shelter), there are four basic set-ups of the method. While the available firmware and measurement principle are identical for each method and set-up, there are some differences in how the methods are configured. The key points and differences are noted in Table 1 below. Questions in the checklist are noted if they only apply to one method or one of the set-ups.

Table 1 – Models and Installation Set-Ups.

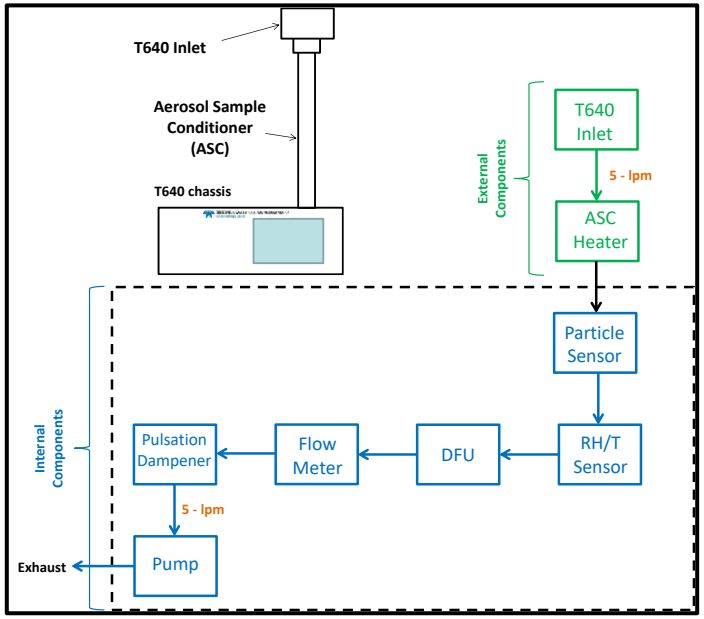
Installation set-up/Method	***T640*** 	***T640x*** 

Either Installation	• Inlet is essentially just protecting against precipitation as there is no well in the design.
	• Operates with one air pump, which is located inside the unit. This flow is identified as the "sample flow" with a nominal flow rate of 5 lpm.
	• With only one flow there is only one sample filter, located inside the front panel display of the monitor.
	 
	 
		• Inlet is a PM10 omni-directional sampling head designed to operate at 16.67 lpm.
		• There is no second stage impactor (VSCC or WINS).
		• Operates with two air pumps:
		  ○ The same sample flow (5 lpm) that works with a T640, and
		  ○ An external pump designed to provide the bypass flow so that the PM10 head operates at a total flowrate of 16.7 lpm. Thus, the bypass flow operates at 11.7 lpm.
		• A second sample filter is connected to the bypass port located on the back of the T640x monitor.
		 

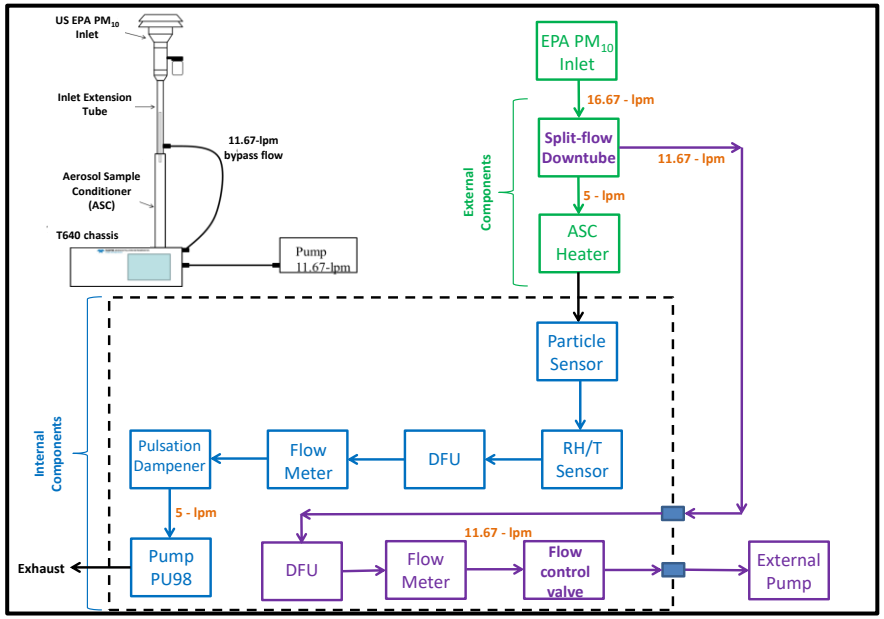
Walk-in shelter installation	• Preferred installation location when there is space available inside a walk-in shelter. • Downtube should be configured with a "Slip Coupler" so that sample flow (5 lpm) and SpanDust verification or calibration can be conducted inside the shelter while viewing the front panel display on the monitor. • Optional - recommend insulating downtube inside the shelter so that Aerosol Sample Conditioner (ASC) does not need to work as hard and sample air relative humidity is more likely to stay in control (i.e., ≤ 35% relative humidity). 
Outdoor shelter installation	• Alternate location for installation. Note: while outdoor set-ups are permitted with the method; care should be taken to avoid extreme heat inside the T640 chassis. This can be tracked with "box temperature".

Sample Flow Block Diagrams for each Method:

T640



T640x



4. On-site Technical Systems Audit of Teledyne T640 or T640x

Table 2 – Technical System Audit General Information:

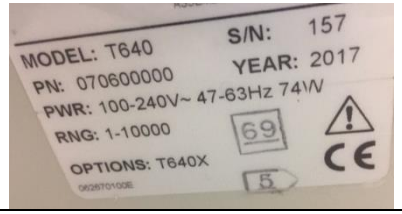
Date:		***Standard Time:***	
Auditor:		***Auditor Organization:***	
Site Name:		***AQS Site ID:***	
Monitoring Agency Staff:		***Monitoring Agency:***	

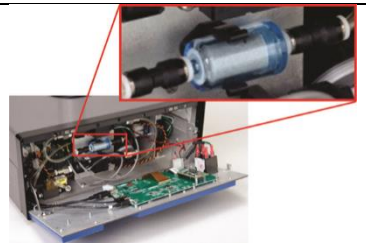
Conducting an on-site audit of the Teledyne T640 or T640x involves evaluating several aspects of the set-up, operation, maintenance, and reporting of the monitor. For this checklist we have grouped the questions into four areas:

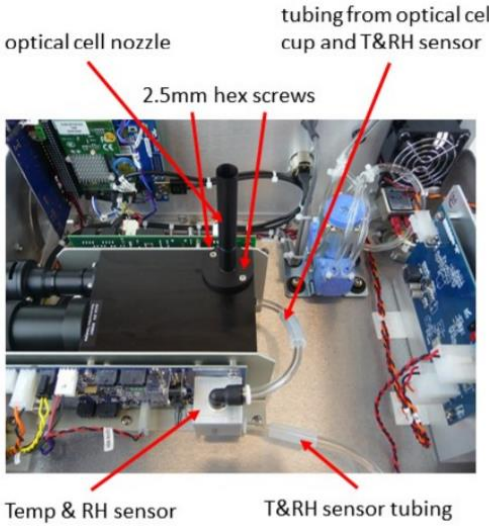
a. Items to review at the monitor
b. Items to review in the firmware and data logger
c. Items to review at the inlet.
d. Maintenance and QC records to review

Table 3 – Audit Questions for the Teledyne T640 or T640x PM Continuous Federal Equivalent Method:

Date:			
Question #	**Item**	**Response**	**Comments**
Items to review at the Monitor:			
1	Confirm the model and location of the $PM_{2.5}$ continuous monitor?	☐ T640 ☐ T640x	☐ Walk-in Shelter ☐ Outdoor Shelter
2	Does this method match what is identified in the annual plan and reported to AQS?	Annual Plan: ☐ Yes ☐ No	Reported to AQS: ☐ Yes ☐ No
3	Is there an FEM sticker on the $PM_{2.5}$ continuous Monitor?	☐ Yes ☐ No	*T640 = Automated Equivalent Method: EQPM-0516-236* *T640x = all of the following:* • *Automated Equivalent Method: EQPM-0516-238* • *Automated Equivalent Method: EQPM-0516-239* • *Automated Equivalent Method: EQPM-0516-240*

Date:			
Question #	**Item**	**Response**	**Comments**
			EQPM-0516-236 US EPA Continuous $PM_{2.5}$ FEM Ambient Particulate Monitor *Federal Equivalency Method (FEM) designations are in accordance with 40 CFR Part 53. The unit must be equipped with the designated accessories and operated in accordance with the operations manual. **EQPM-0516-238** US EPA Continuous $PM_{2.5}$ FEM Ambient Particulate Monitor **EQPM-0516-239** US EPA Continuous PM_{10} FEM Ambient Particulate Monitor **EQPM-0516-240** US EPA Continuous $PM_{10-2.5}$ FEM Ambient Particulate Monitor *Federal Equivalency Method (FEM) designations are in accordance with 40 CFR Part 53. The unit must be equipped with the designated accessories and operated in accordance with the operations manual.
4	What is the serial number and year of manufacture? These can be found on the back of the monitor. Serial number is identified as "S/N"	S/N: _____ Year: _____	Example from back panel of the monitor. 
5	Are there any concerns about the location of the monitor inside the walk-in shelter or small modular shelter?	☐ Yes ☐ No	This is largely professional judgement. Items of concern might include substantial vibration where monitor is set-up; AC blowing directly on down-tube with no insulation on downtube; or poor access to monitor.
6	Is an instrument manual for the $PM_{2.5}$ continuous monitor available at the station (hardcopy or digital)? If so, what is the date on the manual?	☐ Yes ☐ No Date: _____	The latest instrument manual version is dated: 20 April 2021. Please check the manufacturer's website for latest version. Note: one manual covers both the T640 and T640x.

Date:			
Question #	**Item**	**Response**	**Comments**
7	Is an SOP for the method available at the station? If so, identify approval date.	☐ Yes ☐ No Approval Date: _____	If available, look for approval before trip.
8	T640x only - How far is the external sample pump placed away from the monitor? Is the pump isolated to minimize vibration to the monitor?	☐ Yes ☐ No Estimated Distance: _____	Distance between the T640x and external pump will help to minimize vibration. Even placed a few feet away and not on same surface will help.
9	Describe any heat on or near the ASC. Is the downtube insulated?	☐ Yes ☐ No Heat Sources: _____	Although insulating the downtube is not required, this may help the ASC perform better.
10	Ask operator to open the front door of monitor. Observe internal filter and document a date of install (if noted) and condition of the filter (e.g. note color of filter or any darkness). Note:	Date of install: _____ Filter Condition: _____	 We recommend dating the filter with a date of install to track its life. Check logbooks. Note: direction of filter unit's installation may result in aerosol accumulating on the inner layer of the filter rather than outer layer; therefore, it may be difficult to observe without very careful examination.

Date:			
Question #	**Item**	**Response**	**Comments**
11	With front door of monitor still open, observe tubing that leads from the optical cell: 1. Is there any noticeable SpanDust [this will be white to beige in color]. 2. Is there any SpanDust visible in any other tubing?	☐ Yes ☐ No If yes, where: _____ ☐ Yes ☐ No If yes, where: _____	 Note: while it may be better to view tubing with the main cover off; that option is usually not available. Recommend using a flashlight or light on phone to get a better view of the tubing.
12	T640x only - Observe the filter connected to the back of the monitor. Document a date of install (if noted) and condition of the filter (e.g. note color of filter or any darkness).	Date of install: _____ Filter Condition if viewable: _____	 Check logbooks.
13	Ask the operator to show you the supplies and equipment used for cleaning the optics chamber. Are the appropriate supplies and equipment available?	☐ Yes ☐ No	Minimally, this should at least include: 1. Disposable lint-free cloth or similar. 2. Can of air designed to use with computer parts (do not use cylinder compressed air or similar as this may be too strong and damage parts). 3. Can use cotton tip applicator or similar for areas where cloth won't fit.

Date:			
Question #	**Item**	**Response**	**Comments**
	Note: some agencies take units to their lab to perform cleaning; therefore, equipment may not readily be available in the field.		
14	Walk-in shelter installations only – [does not apply to set-ups located in an outdoor shelter] – Does the downtube inside the shelter have a "Slip Coupler"? This allows the sample flow and SpanDust verification/calibration to be conducted inside the shelter.	☐ Yes ☐ No	Walk-in shelters should include use of a slip coupler. This allows flow verifications, calibrations, and audits of sample flow (5 lpm) from inside a walk-in shelter.  Slip Coupler in normal position (to the left). Slip coupler in open position (to the right). 
15	Walk-in shelter installations only – [does not apply to set-ups located in an outdoor shelter] – Ask the operator to show you a separate ambient temperature probe available for temporary use when flow verifications/calibrations are being conducted. Is this available?	☐ Yes ☐ No	This ambient temperature device will have a quick connect to temporally attach to the temperature connection at the back of the T640 chassis. A temperature probe for use inside the walk-in shelter is required as the ambient temperature probe attached to the monitor must represent the same air being used in the flow verification/calibration/audit.
16	Describe any other issues with the monitor.		
Items to review in the Firmware and data logger:			
17	Review Dashboard Parameters available through the front panel display of the monitor. Document the parameters listed and note any		

Amb P. (mm Hg/kPa)		Sample Temp. (°C)	
Amb T. (°C)		**Sample RH (%) [≤35%]**	
$PM_{2.5}$ Conc. (µg/m^3)		Current PMT hv	
PM_{10} Conc. (µg/m^3)		LED Temp. (°C)	

<table>
<tr><td>Date:</td><td></td><td></td><td colspan="4"></td></tr>
<tr><td>Question #</td><td>Item</td><td>Response</td><td colspan="4">Comments</td></tr>
<tr><td></td><td>outside of an acceptable tolerance or that may appear to be incorrect (e.g., a pressure that cannot represent ambient pressure). Parameters with an acceptable tolerance are identified in bold.</td><td colspan="5"><table>
<tr><td>PM_{10} STP (µg/m³) [T640x only]</td><td></td><td>Pump PWM (%) [<80%]</td><td></td></tr>
<tr><td>PMT Setting</td><td></td><td>Sample Flow (lpm) [±5%; 4.75 – 5.25 lpm)</td><td></td></tr>
<tr><td>Box T. (°C)</td><td></td><td>Valve PWM (%) [<85%]</td><td></td></tr>
<tr><td>ASC Heater Duty</td><td></td><td>Total Flow (lpm) [±5%; 15.87 – 17.54 lpm)</td><td></td></tr>
<tr><td>P3 Value</td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>18</td><td>Are there any alerts that have been initiated on the front panel display?</td><td>☐ Yes
☐ No</td><td colspan="4">List any alerts with date and time.</td></tr>
<tr><td>19</td><td>What version of software is identified on the monitor?

Firmware is listed on the dashboard as the “Package Version”</td><td></td><td colspan="4">Approved firmware includes:
1.0.2.126 or later
Latest version of firmware as of Spring 2022 is:
1.4.24.512
Note: it is <u>not</u> always necessary to upgrade to the latest firmware; check manufacturer’s web site for details.</td></tr>
<tr><td>20</td><td>Review the most recent zero-test data from monthly QC sheet. Does the zero-value read 0.0 for each PM metric (i.e., PM_{10} and $PM_{2.5}$)?</td><td>☐ Yes
☐ No</td><td colspan="4">Zero test may also be described as the leak test.</td></tr>
<tr><td>21</td><td>During the last Zero Test was any maintenance performed to get the PM metrics to 0.0 ug/m3?</td><td>☐ Yes
☐ No</td><td colspan="4">Describe/identify maintenance if any:</td></tr>
<tr><td>22</td><td>Observe the last $PM_{2.5}$ and PM_{10} data reported on the LCD screen and compare this to data reported at the</td><td>☐ Yes
☐ No</td><td colspan="4">Note, a T640x may be reporting both PM10 LC and PM10 STP.
A T640 monitor may only have PM10 LC for PM10.
PM10:
PM2.5:</td></tr>
</table>

Date:			
Question #	**Item**	**Response**	**Comments**
	station data logger; are they the same?		PM10-2.5:
23	Are data from this monitor being reported to AIRNow/AIRNowTech or their own agencies web site? If so, document the last hour for $PM_{2.5}$ (include PM_{10}, if available) on the data logger and compare to same hour from AIRNow/AIRowTech.	☐ Yes ☐ No Start Hour: Datalogger PM2.5: AIRNow PM2.5: Datalogger PM10: AIRNow PM10:	An AIRNowTech account is required to access the concentration data; however, the "obs" file page is available without a password at: http://files.airnowtech.org/?prefix=airnow/today/ Review monitor data for the appropriate hour in file: "pmfine_MMDDYY.obs" Note: There may be minor differences in what's viewed as AirNow truncates data as it comes in to 1 decimal place for $PM_{2.5}$ and integers for PM_{10}.
24	Is the clock on the T640/T640x set to run on local standard time (i.e., not day light savings time)?	☐ Yes ☐ No	
25	Compare time on T640/T640x to time of data logger; is there any difference in time and if so how many minutes?	☐ Yes ☐ No Monitor Time: _____ Datalogger Time: _____ Min Difference: _____	Differences of up to one minute should be considered acceptable. Even if there is a difference of more than a minute the data are still acceptable as the datalogger clock establishes the time period of record.

Date:			
Question #	**Item**	**Response**	**Comments**
26	If applicable, describe any other issues in the firmware or data logger?		
Activities to review at monitors' inlet:			
27	Is the PM inlet a "pie pan" design? Or a Teledyne TSP inlet?	☐ PM10 pie pan inlet ☐ Teledyne TSP ☐ Other?	 
28	Does the monitors inlet meet siting criteria?	☐ Yes ☐ No	2-15 meters above ground level; >2 meters from supporting structures; >10 meters from trees. See Table E-4 of Part 58 for more details.
29	Is the monitors inlet intended to be "collocated" with another PM monitor or sampler? And if it is, does it meet requirements for collocation?	☐ Yes ☐ No ☐ Yes ☐ No	The basic requirement is 1-4 meters in the horizontal plane. A waiver allowing up to 10 meters horizontal distance and up to 3 meters vertical distance (inlet to inlet) between a primary and collocated sampler may be approved by the Regional Administrator for sites at a neighborhood or larger scale of representation during the annual network plan approval process. See Appendix A to Part 58; section 3.2.3.4(c)
30	Open the inside of the PM_{10} inlet. Describe the cleanliness of the inlet well.		The PM_{10} inlet should only be inspected with data not being collected on the data management system.
31	Is there a gill screen or similar near the inlet that is also connected to the $PM_{2.5}$ continuous monitor to provide an ambient temperature reading?	☐ Yes ☐ No	

Date:			
Question #	**Item**	**Response**	**Comments**
32	Do the Inlet and down tube appear perpendicular to the ground?	☐ Yes ☐ No	Best judgement is fine.
33	Describe any other issues at the monitors' inlet?		
Maintenance and QC Records to review:			
34	Does the agency use an audit sheet for regular maintenance and verifications? Or logbook?	☐ Yes ☐ No	Describe what is being used: Is there a logbook for the site or monitor or both? Electronic or hardcopy logbooks:
35	<u>Monthly checks:</u> Is there a record documenting that the following checks are being performed at least monthly?	<u>Yes</u> <u>No</u> ☐ ☐ Zero Test (May be labeled as a leak check) ☐ ☐ Barometric Pressure ☐ ☐ Ambient Temperature check ☐ ☐ Total Flow - (T640x only) ☐ ☐ Sample Flow ☐ ☐ PM10 inlet well is cleaned is cleaned at least monthly - (T640x only)	
36	<u>Quarterly checks:</u> Is there a record documenting that the following checks have been performed within the last 3 months?	<u>Yes</u> <u>No</u> ☐ ☐ Span Dust check ☐ ☐ PM10 inlet (above the well) - (T640x only) ☐ ☐ T640 inlet - (T640 only)	
37	<u>6-month maintenance:</u> Is there a record documenting that the following maintenance has been performed within the last 6 months?	<u>Yes</u> <u>No</u> ☐ ☐ Internal monitor cleaning – RH and optical sensor? ☐ ☐ Temperature sensor cleaning? ☐ ☐ Down tube cleaning?	
38	<u>12-month maintenance:</u> Is there a record documenting that the following maintenance has been performed within the last 12 months?	<u>Yes</u> <u>No</u> ☐ ☐ New internal (5.0 lpm) Disposable Filter Unit (DFU) [inside front panel] ☐ ☐ New external (11.67 lpm) Disposable Filter Unit [at back of instrument] (T640x only)	

Date:			
Question #	**Item**	**Response**	**Comments**
39	Are the appropriate audit devices and equipment available as needed? Also, is certification within last 12 months? Expiration/Calibration date of flow audit device: _____	Yes No ☐ ☐ Barometric Pressure? ☐ ☐ Temperature? ☐ ☐ Flow for 16.7 lpm (T640x only)? ☐ ☐ Flow for 5.0 lpm?	
40	For the SpanDust, what is the stated value and expiration date on the side of the bottle? Is the SpanDust bottle secured in a manner such that ambient dust or dirt cannot get into the bottle while stored? (i.e., tubing is connected to both ports on top of bottle)	Value identified on Span dust bottle: _____ Expiration date of SpanDust listed on bottle: _____ SpanDust that is more than 12 months in age is expected to continue to function properly. EPA recommends using a SpanDust lifespan of 3 years when stored appropriately (dry and secured) – or longer where there is evidence to support it. Yes No ☐ ☐	
41	Describe any other preventative or routine maintenance being conducted.		

While on site, also perform the following:

a. Interview the operator and have routine procedures described.
b. Ask for documentation providing evidence that the flow standards being utilized by the operator and the agency's own auditor (these are required to be separate devices) are NIST traceable and within certification. The Agency office may need to be contacted for these.
c. Communicate any items that can be addressed in the field without compromising data quality.
d. Identify any photos collected for TSA documentation.