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Environment, Safety, Health & Quality Directorate

Waste and Environmental Services

Standard Operation Procedure

Title: CALIBRATION VERIFICATION AND OPERATION OF THE TEOM 1400A PARTICULATE SAMPLER



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The Waste and Environmental Services work is categorized as low hazard/risk operation. Any work to be performed in a Moderate or High Hazard Facility shall be coordinated through the appropriate Facility Manager.

1.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) states the responsibilities and describes the process for operation of the TEOM (Tapered Element Oscillating Microbalance) for the Los Alamos National Laboratory (LANL) Waste and Environmental Services Division (WES).

All **WES workers** shall implement this procedure when operating the TEOM.

2.0 BACKGROUND AND PRECAUTIONS

2.1 Background

The TEOM (Tapered Element Oscillating Microbalance) draws ambient air through an inlet (total suspended particles [TSP], PM-10, PM-2.5, or PM-1) at a constant flow rate of 16.7 L/min (0.6 cfm). The flow is split. Three L/min (0.1 cfm) go to a Teflon-coated borosilicate glass filter which vibrates on a hollow tapered element. An electronic control circuit measures and records this frequency of vibration, which decreases as mass increases. The remaining 13.7 L/min (0.5 cfm) are directed to an exhaust stream. Mass concentrations are reported in $\mu\text{g}/\text{m}^3$ and are corrected for local temperature and barometric pressure. The use of hydrophobic filter material, along with sample collection at 50° C (above ambient temperature) eliminates the need for humidity equilibration. Retrievable data include (but are not limited to) a 10-minute average mass concentration (MC), 30-minute MC, 1-hour MC, 8-hour MC, 24-hour MC, temperature of the mass transducer and the sample stream at the base of the heated air inlet, and actual flows through the main flow controller and through the auxiliary flow controller. An RS-232 output allows a means of transmitting data to a serial printer or a personal computer. Data logging capabilities are available.

2.2 Precautions

All personnel assisting with the moving of the heavy instrument must wear safety shoes with toe protection.

More information on using and maintaining the TEOM 1400a may be found in the TEOM 1400a Operations Manual. Workers should familiarize themselves with the Operations Manual to know where to access more information and for troubleshooting and repairing the unit.

3.0 EQUIPMENT AND TOOLS

See the step by step process description.

4.0 STEP-BY-STEP PROCESS DESCRIPTION

4.1 Moving and Setting Up the TEOM

Worker	1.	The preferred method to move the TEOM is a truck with a lift gate. The TEOM can be walked onto the lift, lifted, then walked into the bed. Or, the smaller components of the TEOM may be removed from inside the outdoor enclosure, and the bulky enclosure can be tipped onto a piece of material (e.g., cardboard or carpet) in the bed of a pick-up and pushed into the bed.
	2.	Set the TEOM on appropriate blocks or other secure footings.

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Worker	3.	Check that all components (pump, sensor unit, filter, inlet head and control unit) are in their designated locations. Be sure the control unit is plugged into a surge protector and other electrical units are plugged into the power strip on the inside rear of the outdoor enclosure.
	4.	Ensure proper electrical connection. Connect power from a GFCI-protected circuit or extension cord. Note: The external plug (115 volt) has a special configuration for use on higher-amperage circuits. Consult an electrician for assistance.
	5.	Set the air conditioner to 80° F and the heater thermostats to 50° F.
	6.	Press the “Power” button on the Control Unit.
	7.	Turn on the pump.
	8.	Allow the instrument time to initialize. Note: Data collection will not occur until flow rates and temperatures reach tolerance levels and remain stable for 30 minutes. The Main Screen displays a status line that provides information on the initialization process, filter loading, and operational settings. It also displays informational lines that contain averages of mass concentrations, mass accumulation on filter, system temperatures, flow rates, and diagnostic indicators.
	9.	Check that a filter is installed in the mass transducer. If the filter loading (in percent) as displayed on the main screen is over 75% or will be over 75% before the next service, replace the filter. See section 4.3 <i>Filter exchange</i> in this procedure.
	10.	Determine operating parameters as desired by the principal investigator and set them by pressing “Data Stop” and entering “Setup Mode” and following the menus. See the section 4.2 <i>Setting operating parameters</i> in this procedure.

4.2 Setting Operating Parameters

Default parameters are set in the TEOM. If the default parameters do not meet program requirements, they may be edited in “Setup Mode.” Press “Data Stop” to enter the setup mode. To re-enter operating mode, press “Run.” In the setup mode, the user may either use the “Step Screen” button to step through the menu or directly enter a two digit identifier for the screen (followed by the “Enter” key) on which edits will take place. The following steps in this section will give the screen identifier code number and the name and function of the screen. More information may be found in the “TEOM Series 1400a” Operating Manual.

4.3 Filter Exchange

The filter loading (in percent) is displayed on the main screen. If this value is over 75% or will be over 75% before the next service, replace the filter as described below.

Worker	1.	Keep the sample pump running.
	2.	Press “Data Stop” on the control unit.

Worker	3.	Open the door of the white mass transducer protective cabinet.
	4.	Open the door of the mass transducer.
	5.	Remove the old filter by inserting the lower tine of the fork of the filter exchange tool (kept inside the mass transducer) under the filter. The upper and lower tines of the fork straddle the hub of the filter. Gently lift straight up on the filter. Do not twist or pull sideways. Discard the used filter.
	6.	Use the exchange tool to remove a new pre-conditioned filter (warm and dry) from the filter pocket in the mass transducer. Do not touch the filters with your fingers.
	7.	Insert the hub of the filter directly onto the tapered element and apply downward pressure to set the filter firmly in place.
	8.	Remove the filter exchange tool without disturbing the filter.
	9.	Place a new filter in the filter exchange tool and place it in the filter pocket to condition.
	10.	Gently raise the mass transducer to the closed position and secure the latch.
	11.	Close and latch the protective cabinet door.
	12.	Check the in-line bypass filter. This filter should be changed out every six months, or when the filter appears dark or discolored due to particulate buildup. Remove the existing filters with the quick-disconnect fittings and replace with the new.
	13.	Press "Run" to return the instrument to collection.
	14.	After five minutes have elapsed, open the mass transducer again and press straight down on the filter with the bottom of the filter exchange tool. This ensures the filter cartridge is properly seated after the temperature has increased.
	15.	Record in the TEOM logbook the date and time of the visit, the name of personnel on-site, and briefly describe the changes made to the station. The Task Leader may also request the recording of certain parameters.

4.4 Data Collection

The TEOMs may be set up to deliver data via modem to the base computer at the cave (54-1001). For set up and details, refer to the TEOM 1400a Operating Manual. When the TEOMs are set up for automatic collection at the cave, these data may be checked periodically to check that the TEOMs are functionally operating. Data may also be downloaded manually with to a personal computer in the field. To perform a manual download, follow the steps below.

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Worker	1.	Use a PC onto which TEOMCOMM software or RPCOMM has been loaded.
	2.	Connect the 9-to-9 pin cable from the RS-232 port on the monitor to the RS-232 port on the PC.
	3.	Press the RS-232 key on the TEOM or press "05" and "Enter."
	4.	Follow the user's manual for either the TEOMCOMM or RPCOMM software to download the data.
	5.	After the records are downloaded, immediately set the RS-232 protocol on the TEOM to "None." This will ensure the next download begins where the previous one left off.
	6.	Disconnect the RS-232 cable and exit the program. Return to main TEOM screen and check system operation as described in chapter "Setting operating parameters."
	7.	Record in the TEOM logbook the date and time of the visit, personnel onsite, and briefly describe the actions taken at the station. The Task Leader may also request the recording of certain parameters.

4.5 Cleaning the PM-10 inlet

The TEOM should be cleaned once per year, or more frequently if readings become erratic or inconsistent with other stations.

Materials needed for cleaning:

- General purpose cleaner
- Cotton swabs
- Small soft-bristle brush
- Paper towels
- Silicone-based stopcock grease
- Small Phillips screwdriver

Worker	1.	Press the <DATA STOP> key, and unplug the pump.
	2.	Lift off the PM-10 inlet.
	3.	Unscrew the top acceleration assembly from the bottom collector assembly.
	4.	Mark the top plate deflector cone and lower plate with a pencil to facilitate proper orientation during reassembly.
	5.	Remove the four pan head screws from the top plate and lift off the top plate.

Worker	6.	Lift the insect screen off the lower plate rain deflector and brush off. Replace.
	7.	Clean the top plate deflector cone and internal wall surface of the acceleration assembly with a general purpose cleaner and paper towels.
	8.	Clean the acceleration nozzle with a cleaner-dampened cotton swab.
	9.	Inspect the large diameter impactor nozzle o-ring for wear. Replace if necessary, or using a light coating of silicone grease, apply a thin film on the o-ring and a thin film on the aluminum threads of the acceleration assembly.
	10.	Align the top plate markings with the lower plate markings. Replace the four screws.
	11.	On the lower collector assembly, use the cleaner and paper towels and/or cotton swabs to clean the collector assembly walls and three vent tubes and the bottom side of the collector assembly, and the weep hole in the collector plate.
	12.	Remove the rain jar and clean. Before replacing, apply a thin coat of silicone grease to the cork gasket on the cap.
	13.	Inspect the 2 o-rings on the lower assembly. Replace if necessary. Coat lightly with silicone grease.
	14.	Reassembly the top and bottom assemblies. Hand tighten.
	15.	Replace the PM-10 inlet.
	16.	Plug in the pump, and press the <RUN> key to resume data collection.

4.6 System Leak Test and Audit

It is necessary to leak test the TEOM to ensure the correct quantity of air is going through the filter. The leak check and flow audit should be performed annually – it is usually performed prior to the calibration verification.

Worker	1.	Remove the filter cartridge from the mass transducer. This will prevent accidental damage from occurring to the sample filter cartridge when exposed to the high pressure drop that the leak test creates.
	2.	On the Main Screen, press the up/down arrows to display both the Main Flow and Auxiliary Flow.
	3.	Turn off the pump so there is no flow and record the readings for Main and Auxiliary Flows. These are the “zero flow offset” readings.
	4.	Turn on the pump.
	5.	Remove the size-selective inlet (PM-10 or 2.5 head) from the flow splitter and replace it with the Flow Audit Adapter. Close the valve on the Flow Audit Adapter.

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Worker	6.	Observe the reading for Main Flow. Subtract the “zero flow offset” number for the Main Flow from step 3. The result of this subtraction should be less than 2% of the maximum flow (0.1 L/min). Record values in the TEOM logbook.
	7.	Similarly, observe the reading for Auxiliary Flow. Subtract the “zero flow offset” number for the Auxiliary Flow in step 3. The result of this subtraction should be less than 2% of the maximum flow (0.4 L/min). Record values in the TEOM logbook.
	8.	If the leak test indicates a problem, check hose fittings and other critical locations in the flow system for leaks.
	9.	Attach the Dry Cal calibrator to the nozzle on the flow audit adaptor.
	10.	Turn on the Dry Cal calibrator. Press and hold the “read” button. Total flow rate should be within 10% of 16.7 (15.0 to 18.4) lpm. If not, see troubleshooting guide. Record values in the TEOM logbook.
	11.	Disconnect bypass line, plug splitter with Swagelock cap, and read Dry Cal for main flow rate: should be within 10% of 3.0 (2.7 to 3.3) lpm. If not, see manual section 8.2 or 8.4. Record values in the TEOM logbook.
	12.	Remove the flow audit adapter from the flow splitter and replace the sample inlet on the flow splitter.
	13.	Replace the filter on the mass transducer.
	14.	Restart data collection by pressing the <RUN> key.
	15.	Record any other work performed in the TEOM logbook.

4.7 Calibration Verification

The calibration of the TEOM mass transducer in the series 1400 monitors is determined by the mass transducer’s physical mechanical properties. Under normal circumstances, the calibration does not change materially over the life of the instrument. Each instrument’s mass transducer is permanently calibrated. A verification procedure is performed annually. This procedure should result in a calibration constant that differs no more than 2.5% from the original factory calibration. This verifies that the TEOM is still within the factory calibration.

Worker	1.	Press the <DATA STOP> key. Confirm that the K0 number entered into the instrument and the K0 number on the plate of the mass transducer are the same. The K0 numbers entered into the unit can be found in the K0 Confirmation screen as “Actual K0”. If this value needs to be changed, refer to the R & P TEOM Operating Manual.
	2.	Ensure the instrument is at the normal operating temperature and condition.
	3.	Ensure that the pre-weighted filter in the kit matches the humidity conditions for the test, as shown on the card provided with the kit.

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Worker	4.	Install the pre-filter assembly on the ½ inch tubing on the top of the sensor unit (by first removing the PM-10 head, then placing on the pre-filter). NOTE: DO NOT install a calibration filter on a system that does not have a pre-filter. Use of a pre-filter prevents the contamination of the calibration filter, which would change its weight.)
	5.	Open the mass transducer and remove the standard TEOM filter from the mass transducer. Close the transducer with no filter in place.
	6.	When in the K0 Confirmation screen, press the <EDIT> key. Enter the weight of the pre-weighed calibration filter into the field to the right of “Filt Wght” using the keypad.
	7.	Press the <F1> or <RUN> key. Wait 5 minutes until the frequency (displayed to the right of “K0 Confirm”) has stabilized. Press the <FIRST/LAST> key to record the first frequency value, (f0). NOTE: Ensure the frequency is stable prior to pressing the <FIRST/LAST> key. The last 2 digits will fluctuate due to noise, but the rest should remain steady.
	8.	Install the pre-weighed calibration filter into the mass transducer using the filter exchange tool that came with the calibration kit. DO NOT use the “dirty” filter exchange tool that lives in the transducer cabinet.
	9.	Wait 5 minutes until the frequency has stabilized, then press the <FIRST/LAST> key to record the second frequency value. (f1)
	10.	The instrument will automatically compute the audit value for the K0 number and difference between the K0 audit value and the actual K0 value entered into the instrument. If the percentage difference is greater than 2.5%, repeat the calibration verification procedure. If the difference is greater than 2.5% again, contact Thermo Electron Corporation. Record all values in the TEOM logbook.
	11.	Using the calibration filter exchange tool, remove the calibration filter.
	12.	Remove the pre-filter and replace the PM-10 head.
	13.	Install a standard TEOM filter and resume normal operation by pressing <RUN>.

4.8 Records Management

Worker	1.	Maintains and submits TEOM log books and log book copies, and submits to the Records Processing Facility according to EP-DIR-SOP-4004, Records Transmittal and Retrieval Process.
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5.0 DEFINITIONS

TEOM: Tapered Element Oscillating Microbalance. This instrument draws ambient air through a filter that is continuously weighed, giving real-time mass concentrations.

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PM-10, PM-2.5, and PM-1: Particulate matter with an aerodynamic diameter of 10µm, 2.5 µm, and 1µm, respectively.

6.0 ATTACHMENTS

None.

7.0 REVISION HISTORY

Revision No. <i>[Enter current revision number, beginning with Rev.0]</i>	Effective Date <i>[DCC inserts effective date for revision]</i>	Description of Changes <i>[List specific changes made since the previous revision]</i>
0	5/28/99	New document.
1	7/30/01	Add HCP as attachment, described hazards from moving TEOM instrument, and added chapter.
2	7/2/02	Quick-change revision to instructions on use of software for downloading data.
3	10/21/03	Add chapter on data storage, reduce filter loading to 75% for filter replacement, remove references to ACCU system, and modify risks in HCP.
4	3/16/06	Quick-change revision to convert Att 1 HCP to HR.
0	3/18/11	Re-format. This document supersedes RRES-MAQ-233 and RRES-MAQ-237 to ESH&Q format. Added procedure steps for calibration verification. New SOP number assigned.

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