Standard Operation Procedures for Thermo 1405 TEOM® for use in a dilution tunnel
Version 1.0, May 17, 2019

Section 1. Introduction

This document covers operation concepts and procedures for use of the TEOM model 1405 to measure and report continuous particulate matter (PM) measurements in EPA Method 5G dilution tunnel or equivalent dilution method. The Thermo-Scientific model 1405 TEOM is designed for ambient real-time PM measurements. It is an inertial microbalance - a true continuous mass measurement method with resolution of 0.01 µg (0.00001 mg). The TEOM is highly configurable, allowing the instrument to be "tuned" to best meet the needs of a specific application. The version of the TEOM used here is the simplest, without any sample conditioning options such as "SES" or "FDMS". For dilution tunnel PM measurements, the TEOM flows, temperatures, and timing settings are changed from the normal ambient settings. There are no hardware modifications needed. Instrument manuals, software, and related support information are available from the NESCAUM TEOM document collection.[1]

Flow Setting
Recommended flow setting is 0.5 liters per minute (lpm) at EPA STP. If very low tunnel PM concentrations consistently less than 5 mg/m^3 are expected, higher settings of 1 to 3 lpm can be used. Higher flow gives better sensitivity but shorter filter life. The flow settings should be set to provide the needed sensitivity but also ensure reasonable filter life. For appliances where heavy loading is anticipated, a setting of 0.5 lpm shall be used. Appliances with lighter PM loading can use a setting of 1 or 2 lpm depending on the intended use of the data; high time resolution (10 seconds instead of 1 minute) requires higher flows to achieve the same sensitivity. The TEOM flow must be constant during a test run – it can not be changed while sampling.

Filter Temperature Zones Settings
The three TEOM filter temperature zones are normally set to 30 C (86 F). Temperatures can be set somewhat higher if laboratory temperature is expected to be over 80 F, but no higher than 33C (91F). Temperatures can not be changed during a sampling run. The TEOM filter temperature setting is always a trade-off between stability during highly dynamic burn conditions, minimizing loss of semi-volatile organic carbon mass, and avoiding condensing conditions at the filter temperature. Water is considered a semi-volatile mass (SVM) component, but standard practice is to minimize the amount of water measured as part of the PM. Based on current data, 30 C represents an appropriate setting assuming the dilution tunnel air dewpoint is controlled within reasonable limits (less than 30C).

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1 The TEOM manual is referenced in this SOP, and is available here:
https://www.thermofisher.com/order/catalog/product/TEOM1405
Additional support documents are at https://drive.google.com/open?id=0B4duMFtoHVUENk9uemxsbHRJczA

TEOM Filter Dynamics

Rapid changes in the sample matrix (PM, gases, water vapor) may result in transient TEOM PM (positive or negative) concentration excursions. This is not an instrument malfunction; it is a result of the mass dynamics occurring on both the TEOM and filter pull filters. The TEOM filter material (Emfab TX40), temperature (30 C), and filter loading are similar to the gravimetric sample train rate (the TEOM filter face velocity is 6.3 cm/sec at 0.5 lpm). Thus, the filter pull PM and TEOM PM measurements should be in agreement and highly correlated if both sampling systems are working properly.

While TEOM PM transients from filter dynamics are usually no longer than 1 or 2 minutes, there can be situations where these filter dynamics can result in data quality issues for an extended period of time. One example is a very rapid transition (a few minutes) from a very dirty burn (as much as 300 mg/m^3 in the tunnel) to a very clean burn (a few mg/m^3 or less), as experienced with some devices during startup or fuel reloads. For that scenario, it may be necessary to change the TEOM filter after a high loading phase to avoid a prolonged period of a large negative bias to the TEOM PM due to loss of SVM off of the filter from the high loading phase. See Section 6 for more information on when to do pre-emptive filter changes (filter changes done to prevent or minimize negative TEOM data).

The TEOM configuration used here allows for fast filter changes with minimal data loss (typically a few minutes) and does not require flows and temperatures to be within predefined instrument limits for valid data for PM concentrations to be reported. Critical instrument parameters are stored with the concentration data and can be used to invalidate data during review and processing as needed.

Instrument Software

RPComm (serial port interface) is the legacy TEOM program and can be used to display the last 15 minutes of data on a graph, download data, and read all key operating parameters easily. The ePort program (ethernet interface) is used to control the instrument remotely and to download data. Both programs can be used at the same time.

Section 2. Overview of Routine Operation Procedures for Thermo 1405 TEOM

This section is a summary of routine operating procedures.

A. Quality Assurance checks to be completed after initial installation, and routinely every 6 months:

1. Modify system settings as detailed in Section 10
2. Perform KO check detailed in Section 5
3. Perform leak check detailed in Section 5

B. Routine procedures before every test run to be conducted 2-3 hours prior to testing.

1. Set TEOM filter temperature for the run. Changing this setting requires at least one hour before valid data can be collected. Detailed instructions on this element can be found in Section 3.
    a. The TEOM filter temperature must be at least 1 C above the hottest lab temperature expected during the test. The normal setting is 30 C (84 F) but may be set as high as 33 C (91 F).
    b. All three (3) temperatures zones - cap, air, case – must be set to the same value.

2. Set TEOM flow settings for the run. Changing this setting requires at least one hour before valid data can be collected. Detailed instructions on this element can be found in Section 4. TEOM flow can only be changed before a test run – it can not be changed during a run when the TEOM is sampling.
    a. Set flow
        i. Anticipated tunnel concentrations >5 mg/m^3: 0.5 lpm
        ii. Anticipated tunnel concentrations <5 mg/m^3: 1-3 lpm
    b. Calibrate TEOM flows. This step must be completed whenever the flow is changed. An external mass flow meter such as the TSI 4140 is used for flow calibrations.

3. Check the TEOM time and set as needed.
    Changing the time causes an instrument reboot and loss of up to an hour of data. See note below.

4. Initial filter change
    a. Install a clean filter before each run.
    b. Use the “Advanced” filter change mode.
    c. Perform an external flow check with the clean filter or before the start of a run.
    d. The net flow reading shall be within 2% of the TEOM flow setpoint.

C. *One hour before testing*

Check TEOM settings for appropriate temperature, flow and time settings. Perform an external flow check as detailed in Section 4 and record the results. For valid results the flow check should be within 2% of the TEOM flow setpoint.

D. *Testing Operations*

1. Before initiating the test, run the TEOM while sampling dilution tunnel air for at least 5 minutes. The change of pressure in the tunnel can cause a transient TEOM response.

2. Filter Changes are done pre-emptively as described in Section 6 and whenever the TEOM filter loading reaches 130%, as reported on the TEOM, or when the sample flow starts to drop. The 1405 does NOT have any clear visual warning that the filter needs changing, but it is possible to use the TEOM digital outputs (relay contact closures) to trigger an external alarm at any desired filter loading.

   The "Advanced" filter change wizard mode shall be used to eliminate long equilibration period after the change; this stops the tapered element oscillation, resets the filter mass measurement, and simplifies filter changes. Detailed information on performing filter changes during testing is provided in Section 6 of this document.

3. At the end of the test perform an external flow check as detailed in Section 4 and record the result. For valid results flow check should be within 2% of the TEOM flow setpoint.

4. Download the test data using either the Thermo ePort software (preferred), RPComm, or to a USB thumb drive. Note: the data format may be different depending on how the data is downloaded.

Notes:

- It is normal for there to be "Warnings" present for the ambient T/RH sensors (not used). This is the only allowable warning once the system is warmed up and is in use for testing.

- When the TEOM is first turned on or rebooted, no data are recorded until the top of the next hour. If TEOM is not rebooted, data will be recorded regardless of instrument status.

- When the time is changed, the instrument reboots (after many seconds of being hung, with no information on the screen). When it reboots, no data are recorded until after the top of the next hour (see above).

- TEOM PM concentrations are in micrograms per cubic meter, at EPA STP (25C and 1 atmosphere) unless the instrument configuration is changed. Filter mass loading is reported in micrograms, with a resolution of 0.01 micrograms (10^{-8} grams).

Section 3. Filter Temperature Adjustment SOP for 1405 TEOM

The TEOM filter temperature has the capacity to be set between 30 and 55 degrees C, however for testing purposes the filter temperature should be set to between 30 and 33 C. If the temperature is too low (less than 1 C above room temperature), the instrument may not be able to maintain the temperature set-point, possibly resulting in loss of data. Temperatures higher than necessary may result in excessive loss of semi-volatile PM during sampling. There are three temperature settings - cap, air, case – that shall all be set to the same value.

Temperature Change Procedure.
The TEOM temperatures are set in the Instrument Conditions, Temperatures menu. Temperatures can not be changed during a sampling run.

Note: The **T-Air** temperature zone may take a very long time (30 minutes or more) to stabilize, especially when the temperature is higher than the setpoint. If the "Case" temperature is within 0.1 C of the setpoint, data are usually valid.

Section 4. Sample Flow Check and Adjustment for the Thermo 1405 TEOM

Checking the Sample Flow.
The TEOM should be warmed up for at least 30 minutes before checking or adjusting the sample flow. The sample flow can not be changed during a test run. The sample flow should be checked at the sensor inlet with an external mass flow meter that reads in STP; that flow should be within 2 % of the flow on the TEOM display. Flow checks must be done:

A. at the start of every sampling day (with a clean filter),
B. at the end of the run (with the dirty filter), and
C. whenever the flow setting is changed.

Record the external flowmeter reading without flow as the zero and subtract that value from the flowmeter reading with flow to get the measured flow value.

If the post-test flow check (with a loaded filter) is lower than the initial flow check (with a clean filter), that is an indication of a possible leak. A leak test should also be performed whenever the flow check difference (between the TEOM display flow and the external flow meter flow) changes.

If the external flow (at EPA STP, with zero offset correction) is more than 5% off from the TEOM display flow, measure the flow without a filter in the TEOM. If the external flow check result is low with a filter but higher or correct without a filter, that is an indication of a leak.

If the flow is the same with and without a filter and out of spec, the flow calibration routine should be performed. This routine should also be performed whenever the sample flow setting is changed.

Flow settings.
The TEOM sample flow can be set to between 0.5 and 3.0 LPM (all flows are at EPA STP of 1 atm. and 25 C). Lower flow gives longer filter lifetime and less sensitivity. Higher flow gives

shorter filter lifetime and more sensitivity. The flow should be set to provide reasonable filter lifetime (typically at least 30 minutes) for any given test scenario, since about 4 minutes of data are lost when the filter is changed.

For most cases when sampling off a dilution tunnel, the flow should be set to 0.5 LPM. If a high loading burn (tunnel PM greater than 20 mg/m^3) is anticipated, the flow must be set to 0.5 LPM. Flows higher than 1 LPM shall only be used when very light loading is expected (tunnel PM consistently below 2 to 3 mg/m^3).

The sample flow is set in Instrument Conditions, Flows, Flow Rates. Flow is calibrated using the wizard at Service, Calibration, Flow Calibration (page 5-39 of the TEOM manual).

NOTE: The TEOM sample flow cannot be changed during a test run.

Section 5. Leak Test and KO Check Procedure for 1405 TEOM

The Leak Test and K0 Checks described here do not need to be done on a routine basis. They should be done at least every 6 months, or as needed for troubleshooting.

Leak Check
A leak test measures the flow as reported by the TEOM's flow sensor with the inlet closed off. The TEOM leak test flow measurement must be corrected for the TEOM flowmeter's zero offset. To conduct a flow check, follow the procedures below:

1. With the TEOM warmed up for at least 30 minutes, read the TEOM reported flow with the pump turned off. This is the flowmeter zero reading.
2. Close off the inlet to the TEOM with a brass swage cap.
3. Turn on the TEOM pump.
4. Wait one minute and read the TEOM flow.
5. The leak test value is the difference between the reading without and with the pump on.
6. The leak test should be no greater than 0.05 lpm (net value).
7. Turn the pump off and remove the brass swage cap from the TEOM inlet.

K0 Check
In addition to routine pre- and post-sampling flow checks, a K0 check is another test that shall be completed to validate proper operation of the TEOM. K0 checks confirm the calibration factor for the tapered element mass transducer. It is done once per year and as needed. See page 5-50 of the manual.

Section 6. Filter Change Procedure for 1405 TEOM

The TEOM measures the pressure drop across the filter as % of maximum (~ 100 to 130 %), shown on the instrument's display. A clean filter has a loading of about 5% at 0.5 LPM and ~ 7% at 1 LPM. Filter lifetime will vary widely depending on the PM concentrations being sampled. At very high PM concentrations (several hundred mg/m^3), filter lifetime may be only 10 to 15 minutes. Under typical sampling conditions, lifetime is at least 30 minutes and up to an hour or

more with concentrations in the 20 to 50 mg/m3 range. With care, filter changes can be done such that only a few minutes of data are lost.

The TEOM filter must always be changed before the filter mass loading becomes too high and the filter plugs and the sample flow drops. TEOM filters can also be changed before they overload to minimize negative data.

There are three TEOM filter change scenarios for different applications:

1. EPA Method 5G or ASTM E2515 is the primary data source [the regulatory methods]. Teom data are used to parse the emission profile in the context of % attribution of full run regulatory filter data as described in Section 9. TEOM filters are normally only changed to prevent plugging. For this purpose, negative Teom data should be set to 0 in the final data set.

2. TEOM data are the primary data source.
The Teom filter gets changed whenever ANY of the following conditions are met. This minimizes negative or negatively biased Teom PM measurements.
2a. Filter plugs
2b. Filter mass loading exceeds 1000 ug AND the filter has been in use for at least 30 minutes. [both conditions have to be met]
2c. Persistent (at least several minutes) negative data of at least -2 mg/m^3 is observed that is not due to instrument noise when concentrations are very clean.
For this purpose, negative Teom data should be set to 0 in the final data set.

3. Validation of Teom PM against the regulatory filter PM methods under carefully controlled conditions.
This is a special case for method validation only, and is covered in Section 7. This is not for routine sampling.

<u>Filter change procedure.</u>

The following are filter handling procedures that shall be followed:

A. Unused clean filters should be stored in the original box, with the silica gel desiccant.
B. Two clean filters should be stored in the mass transducer.
C. Filters should only be handled with the filter change tool that is stored inside the TEOM cabinet.

The TEOM manual has illustrated procedures for filter changes starting on page 5-6. Try to minimize the time the mass transducer is open to minimize the time needed to re-stabilize after the filter change.

1. The filter change menu can be located by pushing the Service, Maintenance, Replace Filter. Select Advanced option, and then Next to proceed.

2. Open the TEOM cabinet door, open the box of clean filters, and open the mass transducer. Remove the old filter by sliding the filter tool onto the filter and pulling straight out. Do not twist the tool (to prevent damage to the glass tapered element).

3. Pick up a new filter (stored inside the mass transducer) with the tool. Position it directly over the tapered element and push the filter on gently. Once the filter is on, remove the tool from the filter and fully seat the filter by pushing firmly straight down on the filter with the bottom of the tool (see section 3 of the manual for more information). Store another new filter in the mass transducer.

4. Close the mass transducer, replace the filter box cover, and close the cabinet. Restart the TEOM by completing the filter change wizard.

5. If the PM concentration as read on the RPComm graph hasn't stabilized within 5 minutes, or if the Frequency is close to 0 (~10 instead of a few hundred Hz) the filter may need to be reseated or is defective, or the sensor latch is not closed properly. Repeat the filter change "advanced" procedure and take the filter off and re-seat it. Push it on firmly with the back of the filter tool and make sure the sensor is properly closed and latched. After two attempts, restart the procedure with another new filter.

Note: the PM concentration on the TEOM display will read 0 after a filter change until the top of the next hour. When valid data are being collected, the RPComm graph will indicate the concentration, and the "Total Mass" on the TEOM display will read something other than "0.00".

► There is one exception to this: after an instrument reboot for any reason (including setting the time), data are not stored until after the top of the next hour, even if the RPComm graph is showing data and the Total Mass is not 0.

Section 7. Filter Change Protocol for Method Validation: Matching Filter Pull and TEOM Filter Face Velocities and Mass Loadings for Control of semi-volatile mass loss.

This is a special case for method validation only, and is not used for routine sampling or regulatory testing. For this use, the filter pull and Teom filter face velocity, filter temperature, and filter mass loading are all closely matched to control for loss of semi-volatile PM components (SVOC and water). Since the filter media for both the filter pull and the Teom are the same (EMFAB TX40), if the filter face velocities and temperatures are properly matched, the mass loading should also be matched. Mass loading on the TEOM filter should not exceed 2.0 mg. The filter pull filter must be changed when the TEOM filter is changed. Start and end times of sampling on a filter must also be matched. This means that sample probes are put into and taken out of the dilution tunnel at the same time. The TEOM data must have stabilized after a filter change before sample probes are put into the tunnel. Filter pull filters must be weighed soon (< 2 hours) after each filter is finished sampling, and again after equilibration per the regulatory method.

Section 8: Data Storage and Download

The TEOM shall be set to store data every 10 seconds. There is storage for several days of data at this storage interval. Data can be downloaded while the TEOM is running.

Data are usually downloaded with the ePort software but if needed can also be downloaded to a USB thumb drive or with the RPComm TEOM software. The data file is in .CSV format for importing into a spreadsheet.

Data parameters are saved as follows:

1. Date, Time
2. PM-2.5 raw MC
3. PM-2.5 MC
4. PM-2.5 total mass
5. PM-2.5 30-Min MC
6. Operating mode
7. System status
8. PM-2.5 flow rate
9. PM-2.5 TEOM filter load
10. PM-2.5 TEOM filter pressure
11. Case temperature
12. Cap temperature
13. PM-2.5 air tube temperature
14. Enclosure temperature (temperature on the main TEOM circuit board)
15. PM-2.5 TEOM noise
16. PM-2.5 TEOM frequency
17. Vacuum pump pressure

The key parameters for data validation and analysis are:

1. Date and Time – reported as the end of the average interval
2. PM2.5 raw - PM2.5 raw is the same as PM2.5 MC except it is always reported even when the instrument status is invalid. This minimizes loss of data but also requires manual editing of the data file to remove invalid PM concentrations based on review of the data and critical parameters such as flow and temperatures. Concentration is in $\mu g/m^3$. A zero value for Mass Conc indicates no data.
3. PM2.5 total mass - the mass loading on the TEOM filter in µg.
4. PM2.5 flow rate - Flow is SLPM unless something else is used in the instrument configuration.
5. PM2.5 TEOM filter load - filter loading as % of maximum.
6. Case temperature, in degrees C.
7. Noise is a data stability metric and should normally be less than 0.10 when pm concentrations are low or zero.

Section 9. Data Validation and Calculations

TEOM data are recorded every 10 seconds to minimize data loss during filter changes. Data validation is performed on the 10 second data and then usually averaged up to 1-minute intervals for reporting use.

TEOM data are valid when all flows and temperatures are within the defined operating ranges specified below.

1. "Case" temperature is stable and within 0.1 deg C of set-point. Other temperatures can be off as long as the Case temperature is stable and close to the set-point.
2. Flow reported by the instrument should be within 5% of the flow setpoint.

Because of the way the Teom is run here [with a wait time of 0], it never invalidates any data. Thus the data must always be reviewed and cleaned up manually. The wait time is set to 0 to minimize data loss during a filter change, or when the "Cap" temperature is out of range but the data are ok. The Teom reports a concentration of 0 or repeating values when there are no valid data.

The "Raw MC" PM concentration parameter is reported regardless of instrument conditions and thus includes invalid data that need to be removed during data validation. Normally the only data that need to be removed are during a filter change that occurs during a run. When a filter is changed, the last valid concentration value is repeated until new valid data are available. These repeating data are removed manually during validation and considered as "missing" data.

Note: For cumulative PM emission measurements (total grams of PM emitted during a burn phase or run), missing data shall be filled in with best-estimates based on the 1-minute PM concentrations immediately before and after the filter change. Otherwise, the effective emissions for the period with missing data are zero, creating a negative bias in the measurement.

It is common for the TEOM PM concentration to be somewhat negative during some burn phases. This happens when the TEOM filter mass loading is large and PM emissions are relatively low (e.g., for a clean burn phase that follows a dirty burn phase), and the TEOM filter loses mass. This can be controlled by pre-emptive filter changes as described in Section 6. Small negative concentration up to a few mg/m^3 can still occur however. To minimize measurement bias, these small negative concentrations should always be set to 0 during data processing. Large and rapid negative data swings in concentration may indicate a problem with the instrument and should normally be considered invalid or missing data (not set to 0).

The output of the TEOM is PM concentration in the dilution tunnel, in $\mu g/m^3$ at 25 C and 1 Atmosphere (29.92 inches Hg) pressure. To correct TEOM data to the test or reporting conditions use the following:

$$\text{PM at local T and P} = \text{PM at STP} * (298/T) * (P/29.92)$$

The 1-minute TEOM PM concentration is converted into grams/hour using the tunnel flow as follows:

$$g/h = 0.000001699 * \text{tunnel flow (in CFM)} * \text{PM concentration (in } \mu g/m^3)$$

The values used for tunnel flow shall be the actual measured values, at intervals of no greater than 10 minutes. If the range of 10 minute tunnel flow measurements [100*(Max - Min) / average] is no greater than 5% of the run-average tunnel flow, the run average tunnel flow can be used for these calculations.

TEOM data can be used to apportion the PM emission rate (g/h) measured by a Method 5G or E2515 regulatory sample train to multiple burn phases by applying a correction factor to the 1-minute Teom data. The correction factor is the ratio of filter pull full run g/h to TEOM full run g/h. The 1-minute TEOM data is then adjusted by this correction factor.

Note: since actual measured tunnel flows are used to convert TEOM data into g/h, tunnel flow does not need to be controlled other than what is necessary to maintain proportionality between tunnel flows and regulatory method filter flows.

For calculation of lbs/mmbtu, total grams PM emitted is calculated by multiplying the average g/h rate for the test period of interest times the number of hours of that test period. Grams are converted to lbs by multiplying grams by 453.6.

Section 10: TEOM Configuration Changes for Fast Response and High PM Concentrations, and List of TEOM Parameter Configuration Values.

These settings are for the 1405 TEOM as used in this application that are different from instrument default settings. See the 1405 manual for detailed information on how to change these values.

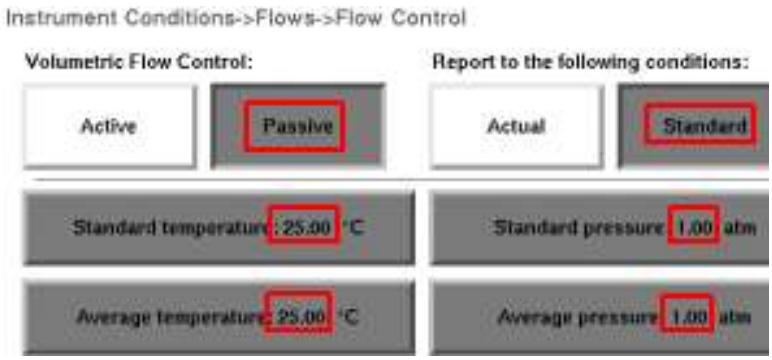
1. Remove the A and B factors [+3 and x1.03] that are used for PM10 FEM status. "Mass Constant A" is set to zero, and "Mass Constant B" is set to 1.00.

2. Change system filtering and wait time settings:
TM (Total Mass Avg time) from 300 to 15 seconds
MR-MC (Mass Rate/Mass Conc Avg time) from 300 to 15 seconds
Wait Time from 1800 to 0 seconds (disabled)

3. Change the sample flow from 3.0 to 0.5 lpm. The bypass flow is set to 0.

4. Change all 3 temperature zones [Case, Air, Cap] to 30 C.

5. Set both the "Avg" and "Std" T/P to 25 C / 1 atm - this is the default for systems without the external temperature sensor. Select Passive and Standard as shown below.



6. Change the Data Storage interval to 10 seconds.

A complete list of 1405 TEOM Settings that are modified from instrument defaults are listed below:

PRC	Description	Config Value	Unit	
12	storage interval	10	sec	
28	system wait time	0	sec	
35	mass average time	15	sec	See also PRC392 -- MRMC
48	case temperature set point	30	Deg C or higher as needed to maintain a stable case T	See also PRC 115 -- air tube T
59	cap temperature set point	30	Deg C or higher as needed to maintain a stable case T	
74	average temperature set point	25	C	These are for reporting PM at EPA STP
75	standard temperature set point	25	C	These are for reporting PM at EPA STP
76	average pressure set point	1	atm	These are for reporting PM at EPA STP
77	standard pressure set point	1	atm	These are for reporting PM at EPA STP
91	bypass flow mass set point	0		Can be used as a baseline param for rpcomm plots.
115	TEOMA air tube set point	30	Deg C, or higher as needed to maintain a stable filter T; see also PRC 48 and 59.	
136	analog output1 minimum	-5000	optional -- ug/m3 as needed for RPComm plot scaling	
144	analog output1 maximum	50000	optional -- ug/m3 as needed for RPComm plot scaling	
227	TEOMA flow set point	1	lpm; or 0.5 to 2 lpm as needed; flow must be recalibrated if changed!	
392	MRMC average time	15	sec	
407	TEOMA mass constant A	0		
408	TEOMA mass constant B	1		
	Note: all 3 temperatures must be set to the same value.			

Data Logging Parameters.

prc	description	var name in data file	Unit
244	raw mass conc	TEOMAMCRaw	ug/m3
245	mass conc	TEOMAMC	ug/m3
243	total filter mass loading	TEOMATotalMass	ug/m3
7	operating mode	OperatingMode	#
8	system status	StatusCondition	#
225	flow rate (STP)	TEOMAFlowMass	lpm
241	filter pressure	TEOMAFilterPressure	raw
242	filter load %	TEOMAFilterLoad	% of max
47	case temperature	CaseHeatTemp	C
58	cap temperature	CapHeatTemp	C
237	air tube temperature	TEOMAAirTubeHeatTemp	C
258	noise	TEOMANoise	ug
257	frequency	TEOMAFrequency	Hz