

# 1405-DF FDMS TEOM Operation Key Points

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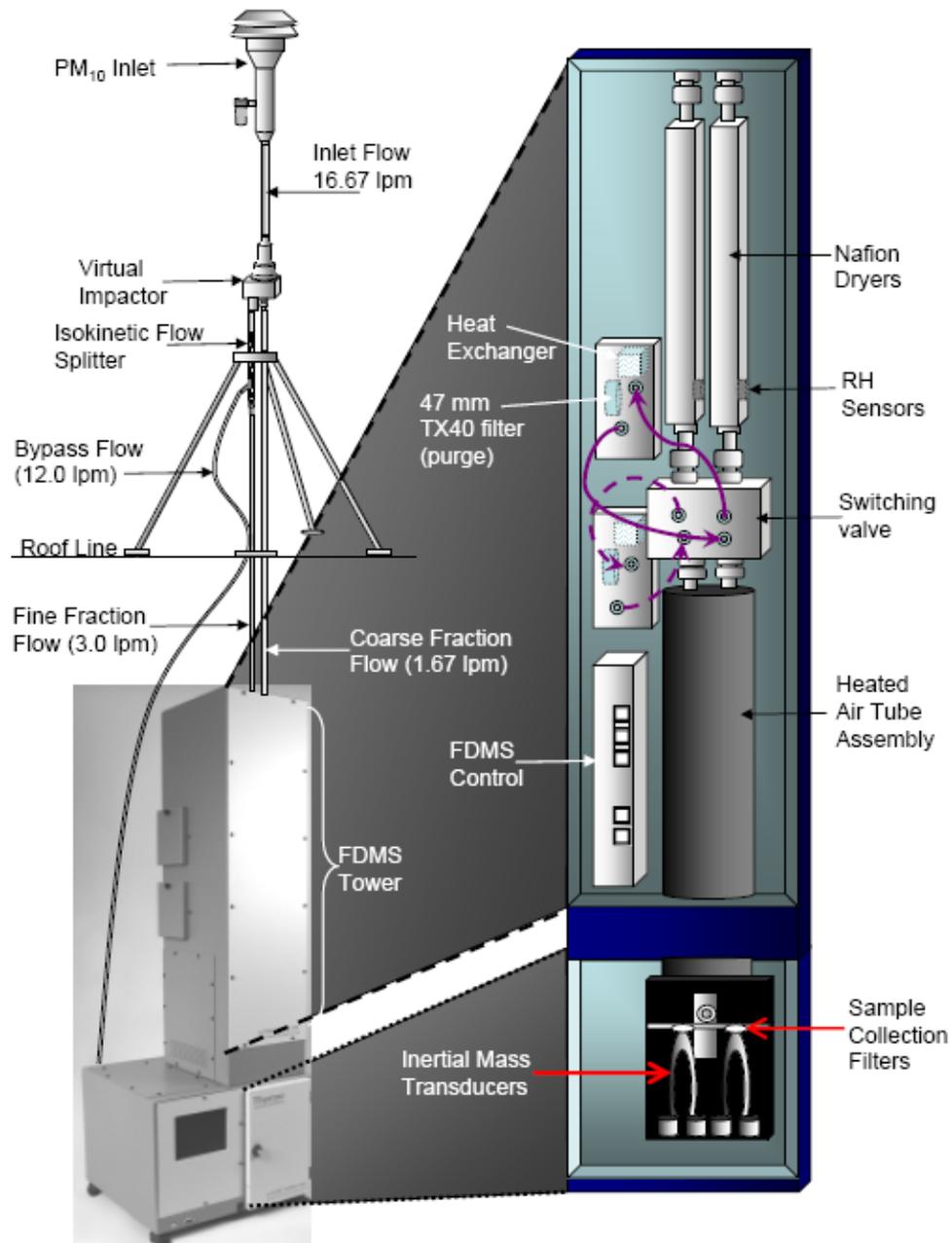
# Introduction

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- A consensus standard operating procedure (SOP) is available for the newly designated **Thermo Scientific TEOM<sup>®</sup> 1405-DF Dichotomous Ambient Particulate Monitor with FDMS<sup>®</sup>**, now designated as Federal Equivalent Method EQPM-0609-182 for PM<sub>2.5</sub>.
- SOPs help ensure consistency in operation, validation, and ultimately reporting of high quality data in real time for AIRNow, state, and local websites and for comparison to the National Ambient Air Quality Standards (NAAQS).
- These slides summarize key operational issues for the FDMS TEOM.



Schematic for Thermo Scientific TEOM® 1405-DF Dichotomous Ambient Particulate Monitor with FDMS® Federal Equivalent Method EQPM-0609-182 for PM<sub>2.5</sub>



# Topics

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- Maintaining the dryers
- Understanding flow streams
- Understanding concentrations
- Aliasing
- Communicating with the instrument
- Understanding PRCs
- Time stamps
- Averages
- Condensation



# Maintaining the Dryers

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- Proper dryer operation is integral to accurate sampler operation.
- Dryers should be replaced annually at a minimum. It is useful to keep a spare dryer on hand.
- In areas with high humidity, dryers may need to be replaced more frequently.
- High particulate matter (PM) events can adversely affect dryer life.
- The dryer efficiency can be estimated by monitoring “TEOM A Dryer Dew Point” and “TEOM B Dryer Dew Point”.



# Understanding Flow Streams

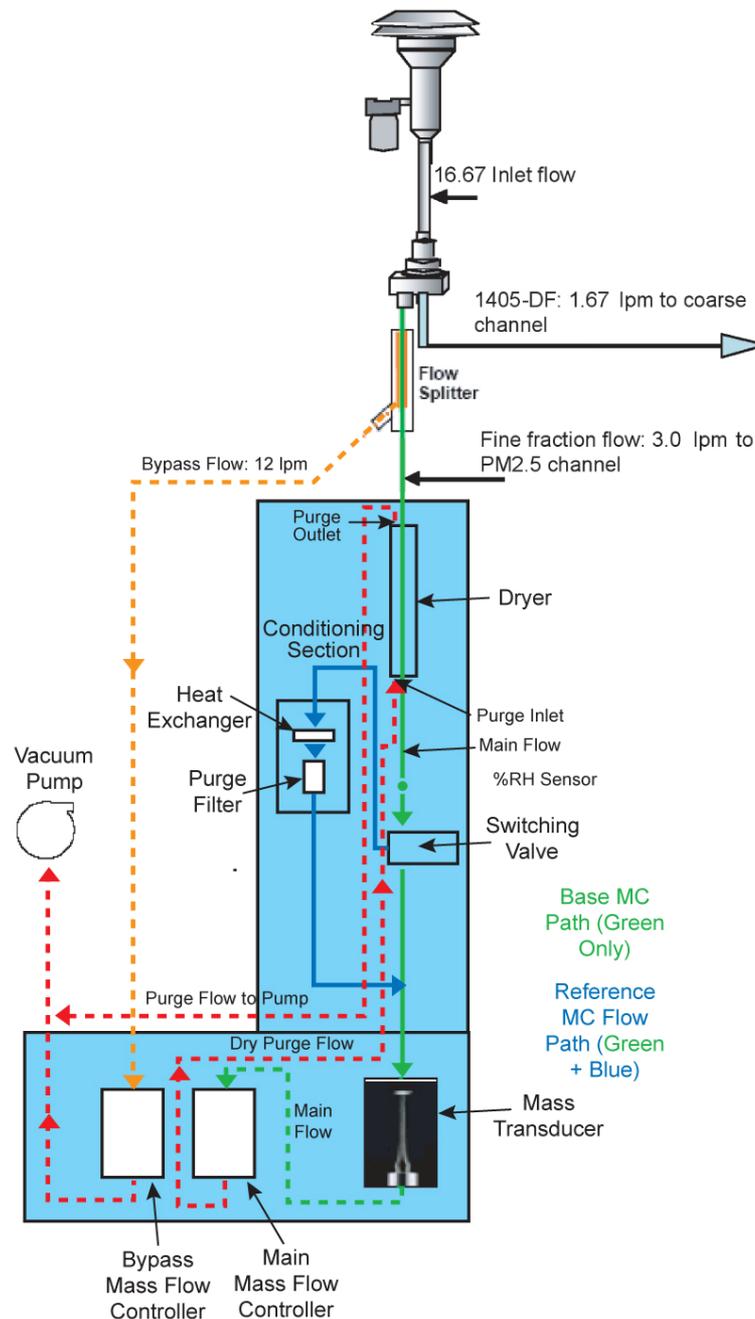
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- Inlet flow
  - 16.67 lpm required to achieve cut points
- Sample flows
  - Parallel flow system after virtual impactor
  - PM in the flow stream is deposited on respective TEOM sample collection filters
    - Fine (PM<sub>2.5</sub>)—3.0 lpm
    - Coarse (PM<sub>10-2.5</sub>) —1.67 lpm
- Bypass flow (portion of flow vented to exhaust to reduce flow rate and sample volume)
  - 12.0 lpm



# Understanding Concentrations (1 of 5)

Schematic representation of the Base MC and Reference MC flow paths for the PM<sub>2.5</sub> sample air stream. (Original schematic courtesy of Puget Sound Clean Air Agency.)



# Understanding Concentrations (2 of 5)

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- Base cycle—switching valve directs the air stream to the sample collection filter
  - Pallflex TX40 TEOM filter cartridge (Teflon-coated borosilicate)
  - Operated on a 6-min. cycle
  - Operated at 30°C
  - Filter may lose volatile components of sample
  - Measures mass concentration of particle-laden ambient air stream
  - Provides base mass concentration (Base MC)
  - Usually a positive number



# Understanding Concentrations (3 of 5)

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- Reference cycle—switching valve directs the air stream to the FDMS “purge” filter
  - Standard FRM-style 47-mm filter cassette with a TX-40 filter (Teflon-coated borosilicate)
  - Operated on 6-min. cycle
  - Maintained at 4°C
  - Volatile PM components condense on the filter
  - Reference air is then routed to the mass collection filter to provide
    - an air stream free of both non-volatile and volatile PM components
    - reference mass concentration (Ref MC)
    - an estimate of the volatile PM losses that occur during sampling of ambient particle-laden air
  - May be a negative number



# Understanding Concentrations (4 of 5)

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- Parallel Sample Streams
  - PM<sub>2.5</sub> Mass Concentration
    - Represents fine fraction Ref MC subtracted from the Base MC
    - Updated every 6 min. at end of cycle
  - PM<sub>10-2.5</sub> Mass Concentration
    - Represents coarse fraction Ref MC subtracted from the Base MC
    - Updated every 6 min. at end of cycle



# Understanding Concentrations (5 of 5)

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- FEM PM<sub>2.5</sub> Mass Concentration
  - PM<sub>2.5</sub> Mass Concentration is adjusted by an algorithm developed to match the concentration from an FRM sample during equivalency certification testing.



# Aliasing

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- Refers to false data concentration swings due to short-term temperature changes in the shelter.
  - Swings can overwhelm the actual mass concentration.
  - Swings can be both positive and negative.
- For best results, locate the 1405-DF in an environment with relatively slow temperature fluctuations. Avoid locations in direct sunlight or near heating or air-conditioning outlets.
- Of particular concern—avoid a 12-min. air-conditioning (A/C) cycle.



# Communicating with the Instrument (1 of 4)

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- Four ways to communicate with (i.e., obtain data from) the 1405-DF:
  - Digital signal
  - USB flash drive download from the instrument
  - Access through the 9-pin RS-232 serial port
  - Analog data capture
- Experience has shown that the best form of communication is digital.
  - Some data and error codes can only be retrieved digitally.
  - An Ethernet port is available.
  - Data can be polled remotely.
  - Up to 20 variables plus diagnostic data can be collected.
  - Use Thermo Scientific ePort software.



# Communicating with the Instrument (2 of 4)

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- If digital data capture is not used, the next best data capture technique is to download data from the instrument with a USB flash drive.
  - No software is needed
  - Allows the operator to collect digital data
  - Up to 20 variables plus diagnostic data can be collected
  - Requires a site visit



# Communicating with the Instrument (3 of 4)

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- After digital data capture, the next best method is to use the 9-pin RS-232 serial port.
  - Allows collection of PRCs, which are labels given to variables
  - Data can be polled remotely
  - Up to 20 variables can be collected, but NO diagnostic data can be obtained
  - Use Thermo Scientific RPComm software



# Communicating with the Instrument (4 of 4)

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- If none of the previous methods can be used to obtain data, the last resort is analog data retrieval.
  - Analog collects voltages converted to engineering units.
  - Data can be polled remotely.
  - Up to 8 variables can be collected, but NO diagnostic data can be obtained.
  - Use Thermo Scientific RPComm software.



# Understanding PRCs

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- Program Register Codes (PRCs) are labels given to the user-selected data storage variables.
- They are used when data are captured through the 9-pin RS232 serial port using RPCComm software.
- Numerous PRCs are available from the instrument, but a limited number can be retrieved at any one time. Therefore, it is important to carefully select the PRCs of most use to data validation.



# Useful PRCs (1 of 2)

| PRC Code | Variable               | Comment                           |
|----------|------------------------|-----------------------------------|
| 8        | System Status          | hexadecimal code                  |
| 61       | Ambient Temperature    | °C from outdoor sensor            |
| 63       | Ambient Humidity       | %RH from outdoor sensor           |
| 66       | Ambient Pressure       | atm, from outdoor sensor          |
| 90       | Bypass Volumetric Flow | lpm, Useful to monitor inlet flow |
| 96       | Vacuum Pump Pressure   | atm, Should be <0.3 atm           |
| 226      | TEOM A Flow Rate       | Volumetric flow in lpm            |
| 242      | TEOM A Filter Loading  | %, OK if filter loading is < 80%  |
| 243      | TEOM A Total Mass      | µg, Total mass on filter          |
| 258      | TEOM A Noise           | µg, Should be <0.1                |



# Useful PRCs (2 of 2)

| PRC Code | Variable                  | Comment   |
|----------|---------------------------|---|
| 271      | TEOM A Dryer Temperature  | °C, Should be > shelter temperature and < 30 °C   |
| 272      | TEOM A Dryer Dew Point    | °C<br><2°C at dryer operating temperature of 4°C<br><8°C at dryer operating temperature of 10°C |
| 287      | TEOM A Cooler Temperature | °C  |
| 310      | TEOM B Flow Rate          | Volumetric flow in lpm  |
| 326      | TEOM B Filter Loading     | %, OK < 80%   |
| 327      | TEOM B Total Mass         | µg, Total mass on filter  |
| 342      | TEOM B Noise              | µg, Should be <0.1  |
| 361      | TEOM B Dryer Temperature  | °C, Should be > shelter temperature and < 30°C  |
| 362      | TEOM B Dryer Dew Point    | °C<br><2°C at dryer operating temperature of 4°C<br><8°C at dryer operating temperature of 10°C |
| 373      | TEOM B Cooler Temperature | °C  |



# Time Stamps

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- Instrument data time stamps are applied at the end of the hour.
- In reporting data, most agencies use a begin-hour time stamp and therefore must develop a strategy to transform the FDMS TEOM data.
- Data transformation can be made
  - Through post-processing of the data
  - By changing data logger time by ~3 min.

While this method allows the 1-hr average to have the correct time stamp, the method can shift rolling averages so that they are not representative.



# Averages

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Concentrations output by the instrument are *rolling averages* updated every 6 min.

- Smaller incremental data (measured every few seconds) are used to calculate longer interval data such as Base MC and Ref MC, which then are used to compute longer interval data such as the 1-hr average.
- Sample MCs are based on Base and Ref MC
- 8- and 24-hr average concentrations are based on 1-hr average.
- The time at which data collection starts to calculate rolling averages matters if the time stamp is to be representative of the data collected. *This timing issue is being addressed.*



# Condensation

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Condensation can be a problem in humid areas in summer.

- Forms when hot, humid air enters an air-conditioned shelter.
- Water in the sample train can overwhelm readings and damage the sampler.
- **Methods for resolving instrument condensation problems.**
  - In-line traps may work, but require frequent servicing.
  - An addition of 10°C to the FDMS set point may help.



A Consensus SOP is planned for availability on AMTIC  
[www.epa.gov/ttn/amtic](http://www.epa.gov/ttn/amtic)

A.E. Ray and D.L. Vaughn (2009) Standard Operating Procedure for the Continuous Measurement of Particulate Matter: Thermo Scientific TEOM® 1405-DF Dichotomous Ambient Particulate Monitor with FDMS® Federal Equivalent Method EQPM-0609-182 for PM<sub>2.5</sub>. Prepared by Sonoma Technology, Inc. for EPA. STI-905505.01-3466-WP. September, 2009.

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