Particulate Matter Seminar

FDMS® Series 8500 Training

(Filter Dynamics Measurement System for the TEOM® Series 1400a Continuous PM Monitor)

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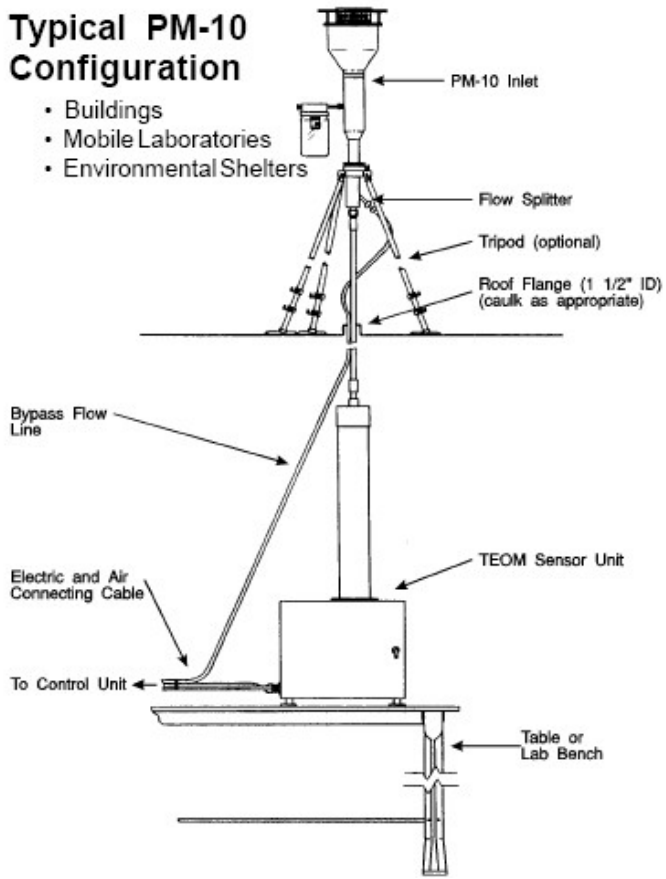
Overview of Presentation Slides

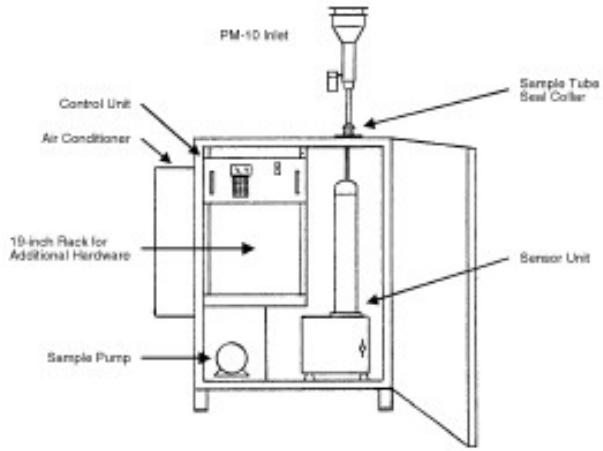
- *Installation*
- *Review the Plumbing Diagrams*
- *Routine Maintenance Procedures*
- *FDMS Data Handling*
- *Miscellaneous*
- *Disclaimer*

1400A Typical Installation

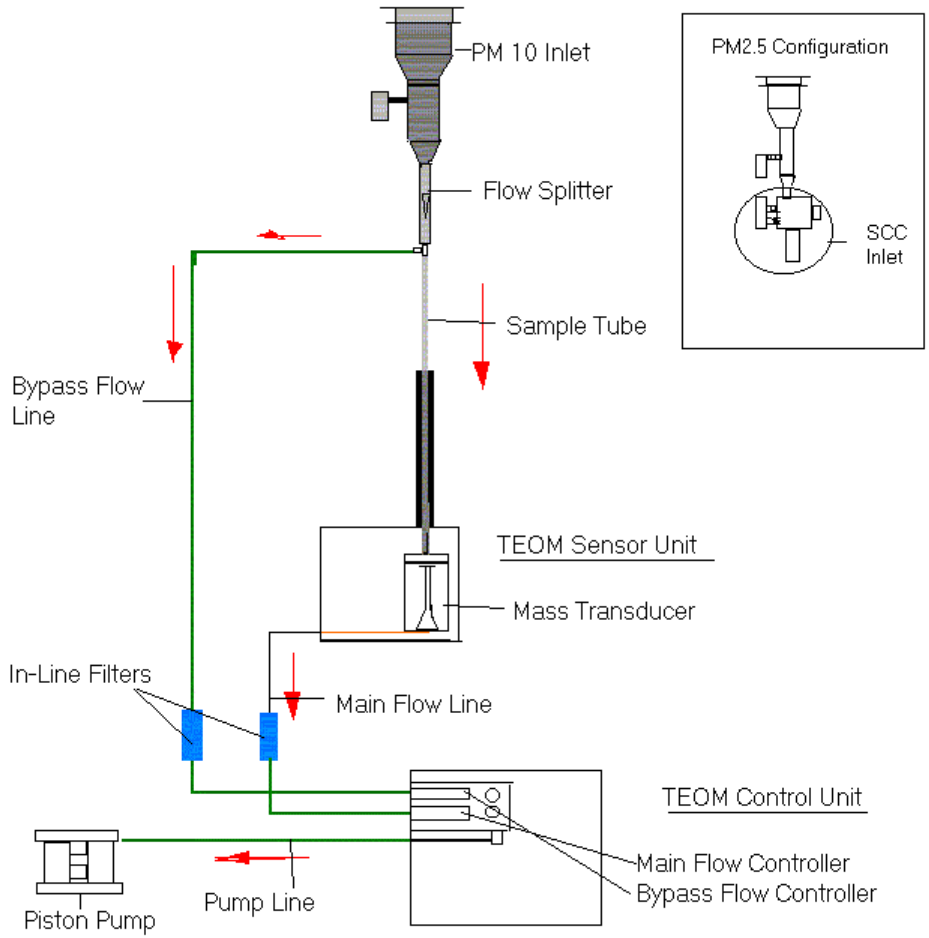


1400A Outdoor Enclosure

Complete Outdoor Enclosure



TEOM Series 1400a Plumbing Diagram



Filter Dynamics Measurement System (Rev B)

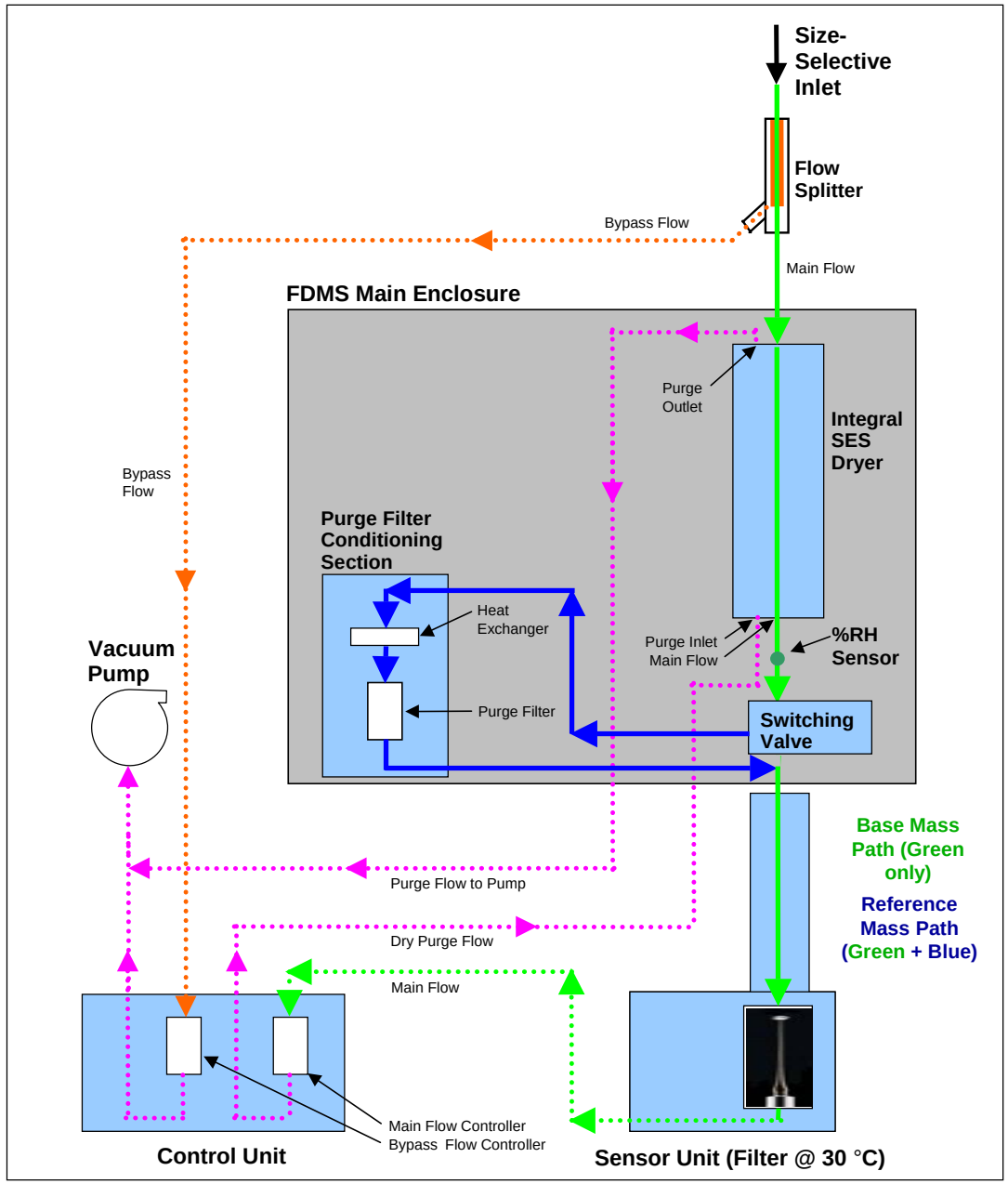
Series 8500 FDMS® System

The switching valve alternates the flow through the sensor unit between the sample (base) and purge (reference) flows every six minutes.

***Base mass** is Total PM + Δ*

***Reference mass** is Δ only*

Total PM = Base Mass – Reference Mass



8500 Typical Installation

8500 Outdoor Enclosure

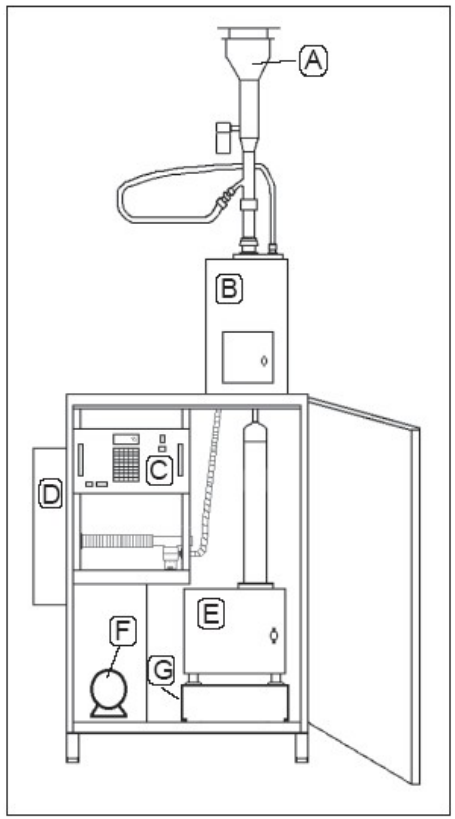
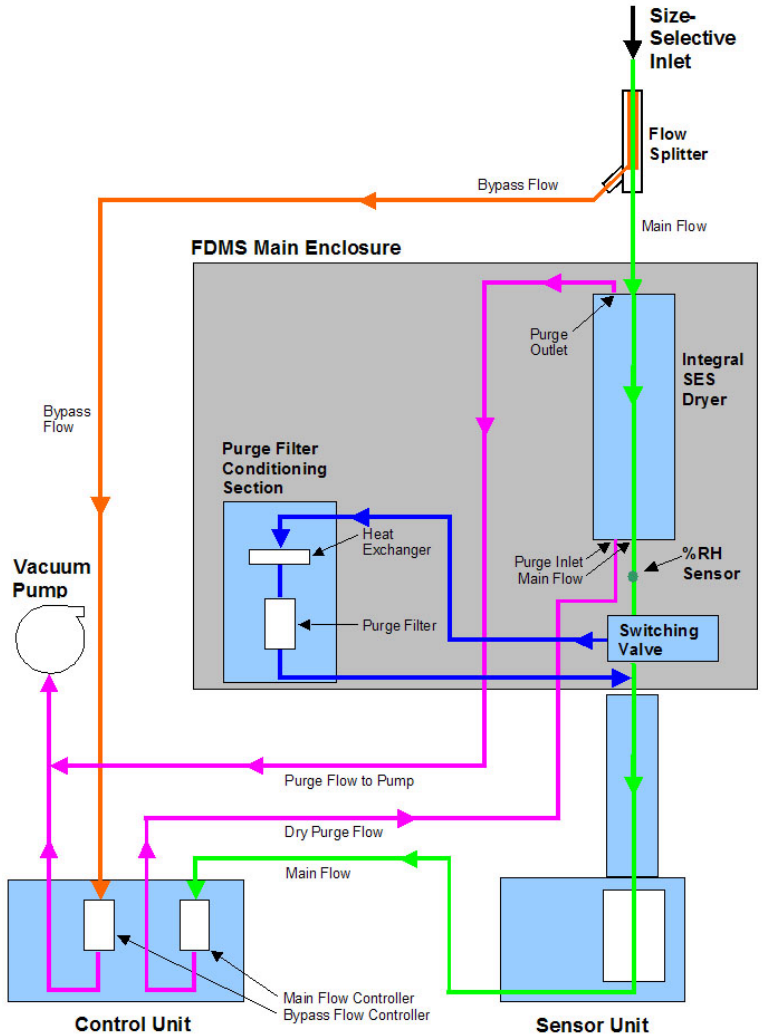
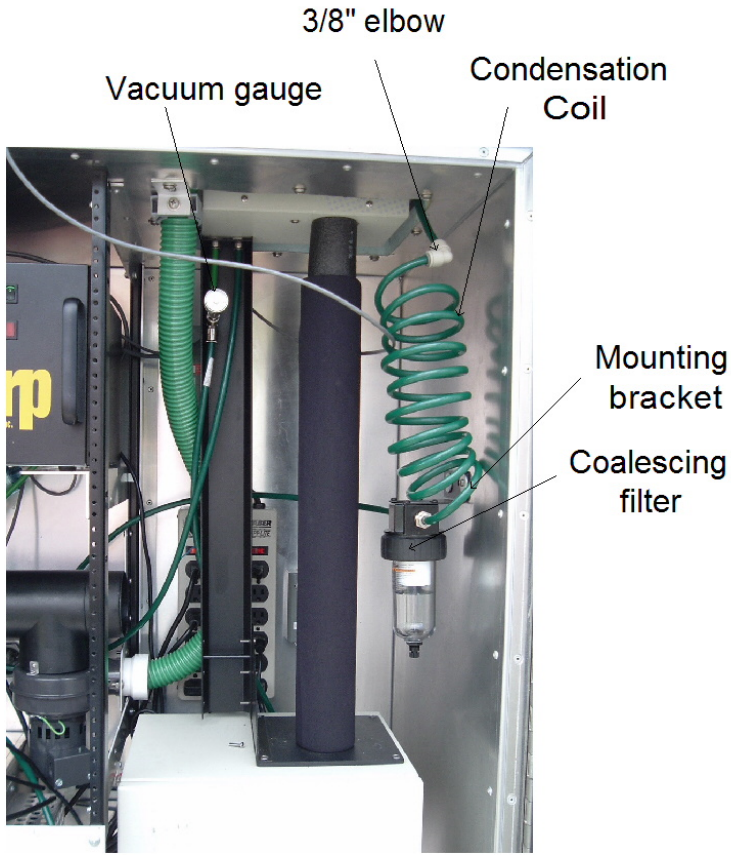


Figure K-66. Instrument placement inside the outdoor enclosure:
A: Sample inlet
B: 8500 module enclosure
C: Control unit
D: Air conditioner
E: Sensor unit
F: Pump
G: Spacer.

FDMS Series 8500 (Rev B) Plumbing Diagram



8500 Condenser Kit



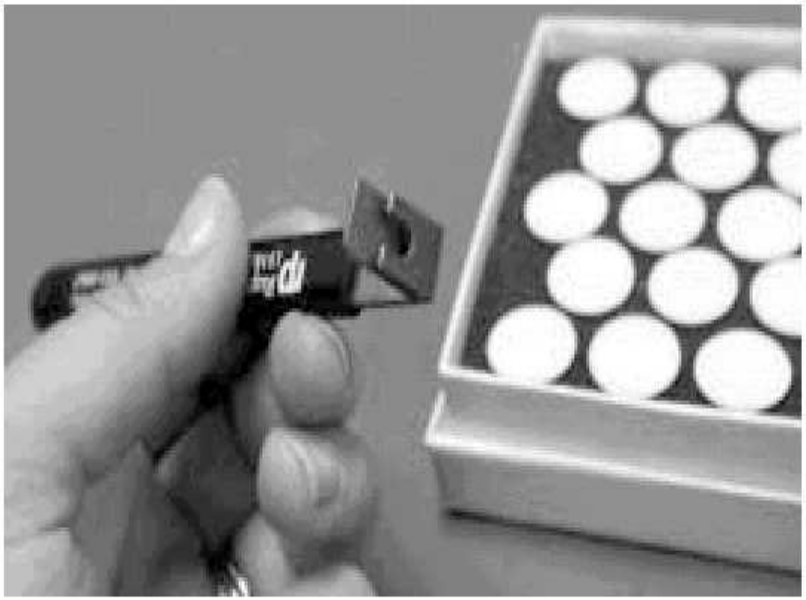
FDMS Series 8500
Routine Maintenance

- Exchange sample filter and purge filter simultaneously at same interval.
- Monitor the inline pump vacuum. It is recommended to stay above 65% of ambient pressure @16.7 LPM for efficient dryer operation.
  - Example: If the current ambient pressure is 29.92 inches Hg, then the inline vacuum gauge should read greater than 19.45 inches Hg at 16.7 l/min total flow rate. As the available vacuum approaches this limit value, it is highly recommended to rebuild or replace the vacuum pump. Do not wait until the vacuum pump fails an audit.

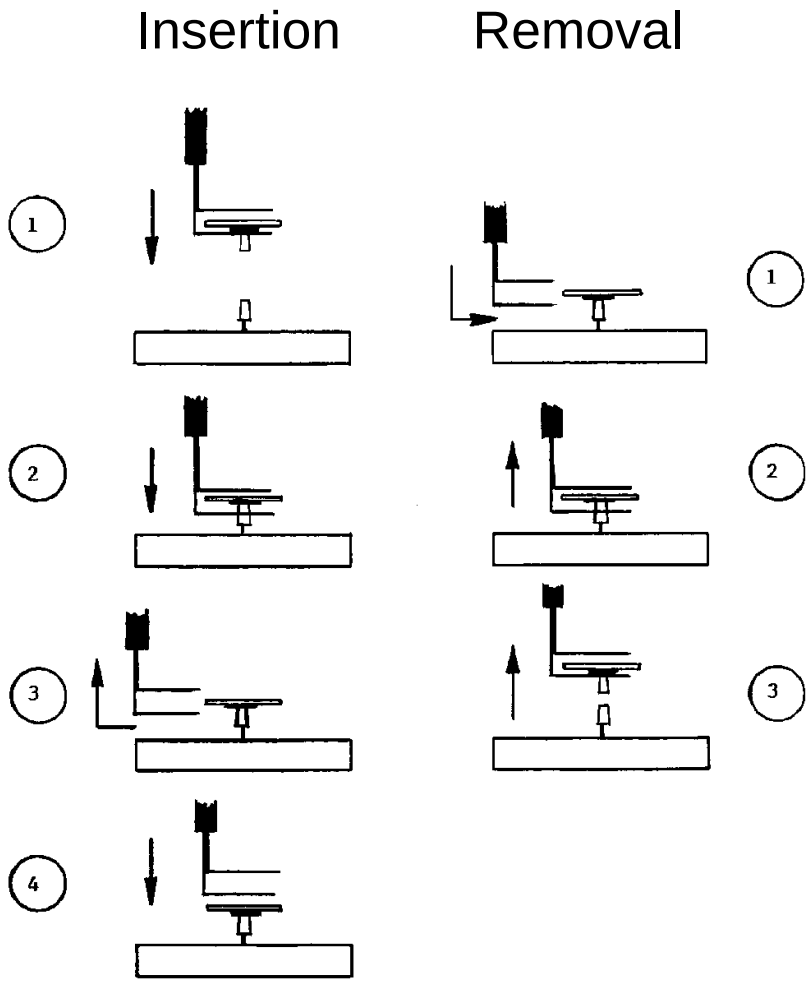
FDMS Series 8500
Exchanging Purge Filter

FDMS Series 8500
Exchanging Purge Filter

TEOM Series 1400a
Exchanging the Sample Filter



TEOM Series 1400a
Exchanging the Sample Filter



TEOM Series 1400a
Exchanging the Sample Filter

Figure A-3. Main screen.

```
OK     4+   11%   NU        09:39
Mass Conc>                   33.6
30-Min MC                    26.8
01-Hr MC                     12.5
```

Figure A-4. Main screen with additional lines displayed.

```
OK     4+   11%   NU        09:39
Mass Conc>                   76.4
30-Min MC                    72.3
01-Hr MC                     78.4
08-Hr MC                     85.8
24-Hr MC                     69.3
Tot Mass                   974.38
Case Temp                   50.00
Air Temp                    50.01
Cap Temp                    49.98
Main Flow                    3.00
Aux Flow                    13.66
---------<
Noise                        0.524
Frequency                245.55603
```

Approximately 2 to 5 minutes after performing the sample filter cartridge exchange, the oscillating frequency should vary less than ±0.00010 for each update interval (between 2 and 10 seconds depending upon firmware configuration)

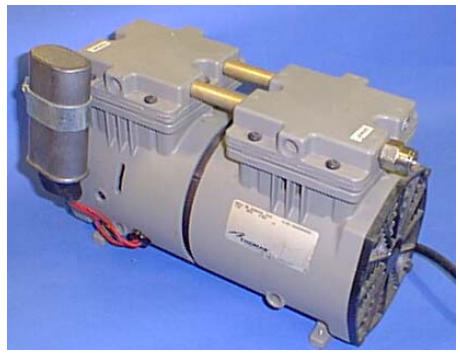
Vacuum Pumps

Maintaining Pump Assembly

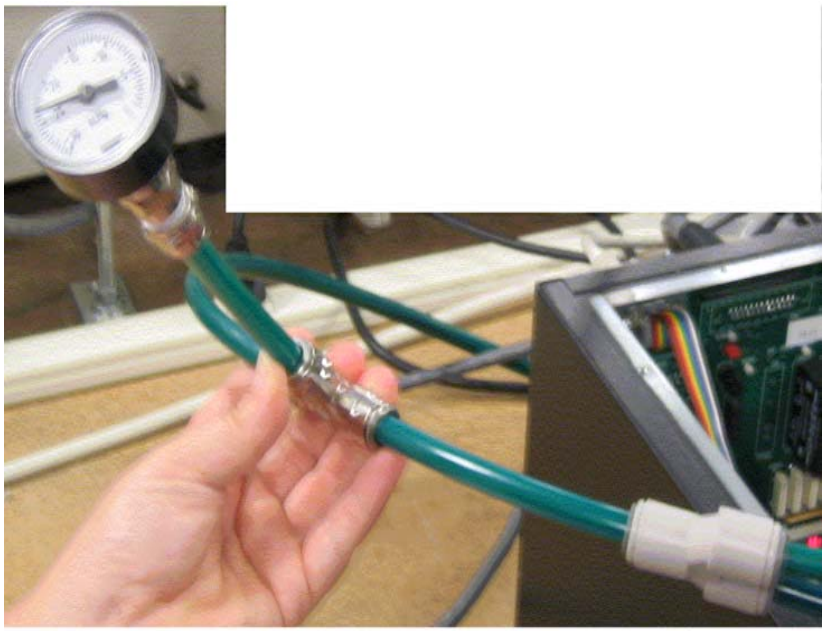
- *Pumps should be checked for quality vacuum every six months.*

Quality vacuum should be in the range of -27”Hg to -20”Hg at sea level
Range changes with elevation 80% new, low limit 65% of ambient pressure

Pumps should be rebuilt once every 12 months to ensure quality data



FDMS Series 8500
Inline Vacuum Pump Monitoring



- Recommended to operate best at 65% of Ambient pressure or better @ 16.7 LPM

Rebuild Kit Old Style Vacuum Pump

Part number: 59-001741

Rebuild Kit New Style Vacuum Pump

Part number: 59-008630

Dual Mass Flow Controller Assembly

1st Generation 2nd Generation

- 1st generation dual mass flow controller assembly (MFC) for TEOM Series 1400A rev B Monitor (January 1996 – 1st quarter 2001).
  - Routine maintenance (~ 6 months): orifices, seals, vent filters
  - Maintenance kit available
- 2nd generation MFC (1st quarter 2001 and later).
  - New proportional control valve
  - Routine maintenance eliminated
- 1st generation to 2nd generation MFC upgrade kit available (see bulletin)
  - Both generations use same mass flow sensor – comparable performance.
  - May require interface board swap.

FDMS Data Handling

What is it? How do we retrieve it?

Data Production

- Base Mass Concentration (PRC 102)
- Reference Mass Concentration (PRC 104)
- Total Mass Concentration (PRC 8)
  - Each of these values represents a one hour rolling average that is updated every six minutes
- Total Mass Concentration (PRC 57)
  - One hour average, updated at the top of the hour

Internal Data Storage

- Control unit has large internal storage capabilities
- Up to eight storage variables can be programmed
- Can be downloaded on-site or remotely using RPComm and/or RPData
- Data parameters are time stamped at the end of the measurement period (i.e.. 12:00 to 13:00, stamp is 13:00:05).

Data Output to Datalogger

- The data are stored and output through the analog channel by the FDMS system as hourly averages, no further averaging is required by the datalogger
- Hourly average data is typically used for reporting purposes

FDMS Data Calculation and Display

FDMS Series 8500 Mass Concentration Calculation and Display

	Time (6-minute intervals)																	
Time Interval, N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Example Time, T	10:24	10:30	10:36	10:42	10:48	10:54	11:00	11:06	11:12	11:18	11:24	11:30	11:36	11:42	11:48	11:54	12:00	12:06
Raw Base MC	+	*	+	*	+	*	+	*	+	*	+	*	+	*	+	*	+	*
Raw Reference MC		+	*	+	*	+	*	+	*	+	*	+	*	+	*	+	*	+
Raw MC		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
BASE MC (PRC 102)			B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
REFERENCE MC (PRC 104)			R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
MC (PRC 8)			C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
HOURLY MC (PRC 57)																	H	

Table symbols defined as follows:
N = number of the 6-minute interval
T = ending time for interval N
+ = mass concentration measured during time interval, N
* = mass concentration interpolated during time interval, N. Example: BASE MC(2) = (BASE MC(3)+BASE MC(1))/2
x = mass concentration calculated as BASE MC minus REFERENCE MC
B = Base Mass Concentration, PRC 102 (running 1-hour average updated every 6-minutes) [1]
R = Reference Mass Concentration, PRC 104 (running 1-hour average updated every 6-minutes) [1]
C = Mass Concentration, PRC 8 (running 1-hour average updated every 6-minutes) [1]
H = Hourly Mass Concentration, PRC 57 (hourly average updated on the hour)

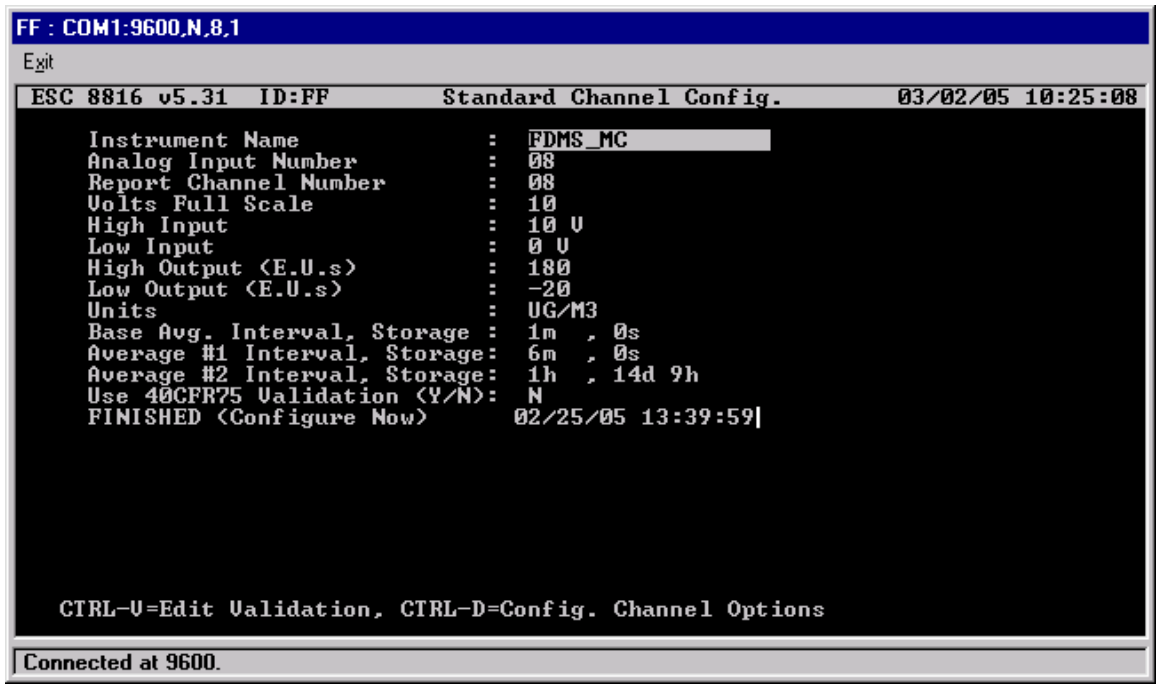
"MC" = Mass Concentration
"PRC" = Program Register Code

[1] Gray values indicate that the firmware displays these values, but they are not yet full 1-hour running averages. This occurs ONLY when the instrument is powered up or reset.

ESC Datalogger Setup Example

This configuration takes the readings from xx:57:00 to xx:58:59 and stores the average of those readings in the xx:00:00 hourly interval. (xx is the hour in this example) All other readings during this hour are flagged as invalid and not used to calculate the hourly average.

This screen shows the standard channel configuration scaled properly and only storing hourly averages for the channel.



Internal Data Storage (Diagnostic Mode)

- Variable 1: PRC 114 Amb DEW
- Variable 2: PRC 110 TEMP OUT
- Variable 3: PRC 111 RH OUT
- Variable 4: PRC 112 TEMP IN
- Variable 5: PRC 113 RH IN
- Variable 6: PRC 99 Sample DEW
- Variable 7: PRC 123 Amb Temp
- Variable 8: PRC 100 Amb RH
- Interval 360 (seconds)
- Variables 8 (quantity)

TEOM Series 1400a Mass Transducer

- Tapered element oscillates at its natural frequency (simple harmonic oscillator or tuning fork)
- Particulate matter collects on filter continuously
- Frequency decreases with accumulation of mass
- *Direct* relationship (derived from first principle physical law – not an approximation) between mass and frequency change:

$$\Delta M(g) = K_o\left(\frac{1}{f_1^{\,2}} - \frac{1}{f_o^{\,2}}\right)$$

- The approach is similar to that of a laboratory microbalance → the mass detected by the sensor results from the measurement of a change in fundamental physical parameter (e.g., frequency, instead of strain or displacement).

Tapered Element

TEOM Series 1400a
K0 (Mass Calibration) Verification

Figure 12-15. K0 Confirmation screen with additional lines displayed.

K0 Confirm	209.44188
>Filt Wght	0.07903
287.53182	209.44186
Audit K0	9683
Actual K0	9627
% Diff	0.58

TEOM Series 1400a
Mass Calibration Verification Kit

$$K_o = \frac{M_{filter}}{\frac{1}{f_1^2} - \frac{1}{f_0^2}}$$

$$\left[\begin{array}{l} M_{filter} = 0.07992\,g \\ f_o = 269.481\,Hz \\ f_1 = 200.536\,Hz \end{array}\right] \Rightarrow \text{Implied } K_o = 7202$$

$$\text{Original } K_o = 7186 \Rightarrow 0.22\,\% \text{ difference}$$

Available in 1-filter (standard) and 5-filter versions

Calibration Verification Performed at LIS-Essen, Germany

Disclaimer

- These slides provide a summary overview of the material presented at the workshop. They are not intended as a replacement for attending the workshop. R&P technical staff in attendance provided a hands-on interactive environment. Onsite course content is not fully represented.
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- For detailed technical information please consult the appropriate R&P documentation (operating guides, manuals, technical bulletins).