

# Met One Instruments

## BAM-1020 "2X"

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# Agenda

- BAM-1020 "2X" Product Upgrade
- BAM-1020 "2X" Designation Test
  - $PM_{2.5}$
  - $PM_{10-2.5}$
- Operational advantages
  - Semi-continuous v. continuous
  - BAM v. other

# BAM-1020 "2X" Upgrade

- Technical Modifications
- Performance Specifications
- Impact of changes on Designation
  - $PM_{10}$
  - $PM_{2.5}$
  - $PM_{10-2.5}$

# BAM-1020 "2X"

- Improve sensitivity without sacrificing accuracy or simplicity/reliability of previous design
- Maintains simplicity/reliability of BAM-1020
- Maintains accuracy of BAM-1020
- Improves sensitivity of BAM-1020 by approximately 2x



# BAM-1020 "2X" Reliability

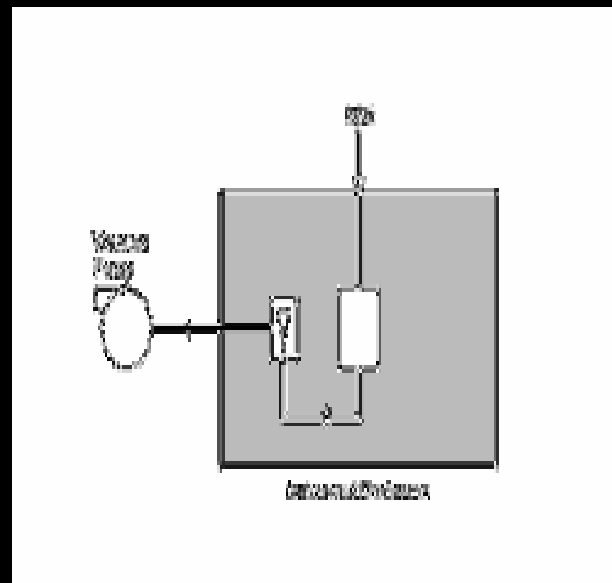
- Technology is "stable"
- "2X" upgrade is more evolutionary than revolutionary
- BAM-1020 "footprint" does not change

# BAM-1020 "2X" Simplicity

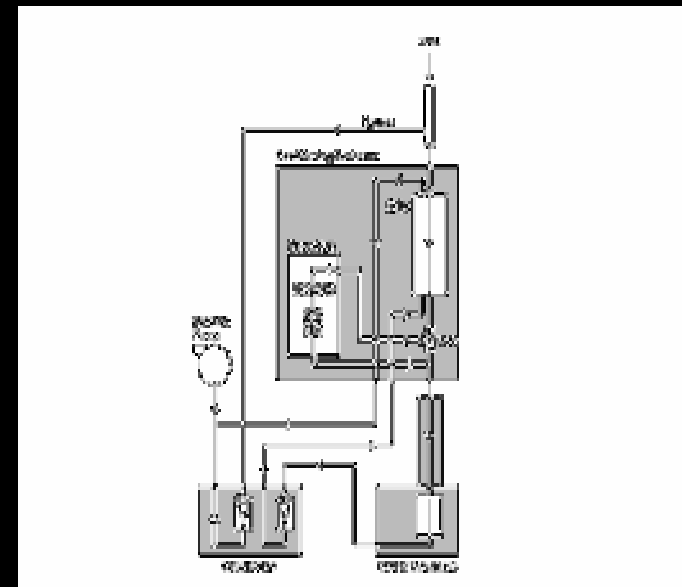
- Lower limit of detection ( $2\sigma$ )  $< 3.0 \mu\text{g}/\text{m}^3$  (1 hour)
- BAM-1020 "2X" not require auxiliary equipment such as nephelometer, Nafion dryers, complex plumbing, etc., etc., etc.

# BAM-1020 "2X" Simplicity

BAM-1020 Flow Diagram



Competing Technology



# Technical Improvements

- Sensitivity enhanced by  $\sim 2 \times$
- Software
  - User-selectable beta count (4, 6 or 8 minutes)
  - Temperature compensation added
- Hardware
  - Tape drive optimized for added sensitivity
  - Source moved closer to detector
  - Temperature compensation



# BAM-1020 2X Specifications

Parameter	Performance Specification
Measurement Ranges	0-1,000 $\mu\text{g}/\text{m}^3$ standard
Measurement Cycle	1 hour standard, others available
Sampling period per measurement cycle	40-50 minutes user selectable depending on counting period per cycle
Counting period per measurement cycle	4, 6 or 8 minutes
Lower Limit of Detection ( $2\sigma$ ) 1 hour	$< 3.0 \mu\text{g}/\text{m}^3$
Lower Limit of Detection ( $2\sigma$ ) 24-hours	$< 0.6 \mu\text{g}/\text{m}^3$
Root mean square (RMS) error (1-hour)	$< 1.5 \mu\text{g}/\text{m}^3$
Root mean square (RMS) error (24-hours)	$< 0.3 \mu\text{g}/\text{m}^3$
Source Composition and Activity	$^{14}\text{C} < 100 \mu\text{Ci}$

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# Additional Information

- All BAM-1020 monitors sold after mid-1999 can be upgraded
- PM<sub>10</sub> Designation has been amended to reflect "2X" upgrade
- Upgrade price ~\$2,800 plus PMT replacement if necessary.

# BAM-1020 PM<sub>10</sub> Designation

- Existing PM<sub>10</sub> designation amended to reflect improvements (10/2006)
- 4, 6 or 8 minute count time are designated for PM<sub>10</sub> equivalency
- Smart heater settings 35-45% RH
- $\Delta T$  control off

# BAM-1020 PM<sub>2.5</sub> Designation

- Met One will seek PM<sub>2.5</sub> Class 3 FEM designation on BAM-1020 "2X"
- Site selection is in progress
- Winter sites needed in Midwest, California, and Rocky Mountain West cities
- Summer sites needed in California and Northeast cities

# BAM-1020 PM<sub>2.5</sub> Designation

- Current plans are to run designation testing at  $\leq 35\%$  moisture,  $\Delta T$  off
- VSCC will be necessary
- No current plans to seek REM Designation
- States seeking REM should contact Met One on this matter

# BAM-1020 PM<sub>2.5</sub> Designation

- All BAM-1020 monitors sold after 1999 will be upgradeable to PM<sub>2.5</sub> FEM designation once it is achieved
- Factory modification and recalibration will be required

# BAM-1020 "2X" PM<sub>10-2.5</sub> Designation

- 2 BAM-1020 "2X" can be used with optional software to provide □ results
- Met One has also developed a single device capable of measuring PM<sub>10-2.5</sub>
- Met One is currently evaluating long term market potential for both approaches



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# Theory of Operation

- Beta rays are measured across clean filter tape. The measured value –  $I_0$
- Air containing particulate matter is sampled and deposited on the filter tape.
- Beta rays are measured across dirty filter tape. The measured value –  $I$

# BAM-1020 Calibration

- Calibration occurs once at the factory against a transfer standard in a “smoke room”
- There are NO environmental correction factors EVER that need to be employed
- Zero and Span are checked once per hour during operation. No changes are ever made however

# Mass Calculation

$$I = I_0 e^{-\mu x}$$

$$x = -\frac{1}{\mu} \ln \left( \frac{I}{I_0} \right)$$

$$C = \frac{Ax}{V}$$

# Mass Calculation

- DEFINITIONS:

- $I$  – beta measurement across clean filter
- $I_0$  – beta ray measurement across dirty filter
- $\mu$  – calibration coefficient ( $\text{m}^2/\mu\text{g}$ )
- $x$  – mass density on filter tape ( $\mu\text{g}/\text{m}^2$ )
- $A$  – dust spot deposition area on filter tape ( $\text{m}^2$ )
- $V$  – sampled volume ( $\text{m}^3$ )
- $C$  – particulate matter concentration ( $\mu\text{g}/\text{m}^3$ )

# Semi-Continuous v. Continuous

- Aerosol chemistry is complex and depends on:
  - Temperature
  - Humidity
  - Chemical composition
- Two step measurement process superior under these conditions
  - Higher reliability
  - Higher sensitivity

# Semi-Continuous v. Continuous

- Tape advancement on regular basis reduces the “memory” issue
- Measurement is taking place in a controlled environment
- Source may be moved closer to the detector, thereby enhancing sensitivity
- Expensive, complex add-ons needed on monitors with concurrent sampling to overcome sensitivity problem



# Semi-Continuous v. Continuous

- For customers requiring continuous monitoring, Met One can offer them the E-BAM or the ACE-BAM

# E-BAM



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# ACE-BAM



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# FEM Designation

- US-EPA established uniform Reference Methods for  $PM_{10}$  and  $PM_{2.5}$  gravimetric measurement.
- 24-Hour average for automated methods must closely match Reference Methods in order to be considered accurate



# Beta Gauge Advantages

- Beta attenuation technique is simpler, easier to use than other popular methods.
- Less expensive, lower cost of operation
- Filter replacement is predictable, less labor intensive
- Time proven technology: beta gauges have been in use for over 50 years.
- Beta attenuation has demonstrated superior accuracy compared to other popular methods.

# Beta Gauge Advantages

- No make up gas required
- Technology is “stable”.
- Filter replacement is needed only once every two months under routine operating conditions
  - Fewer site trips required
- Excellent accuracy compared to manual gravimetric technique

# Beta Gauge Advantages

- Seasonal “Correction Factors” are not needed.
- Geographical “Correction Factors” are not needed.
- It is not necessary to ever calibrate the unit in the field
- BAM provides excellent agreement with all reference standards

# BAM-1020 vs. TEOM Comparison

	<b>BAM-1020</b>	<b>TEOM 1400A</b>
<i>Complexity</i>	Very simple	Complex
<i>"Footprint"</i>	Smaller	Larger – especially with FDMS Option
<i>Accuracy</i>	Accurate under all climate conditions	Requires seasonal correction factors

# California Air Resources Board Data Summary

Site	Annual Regression Results & Data Capture June 2004 – May 2005				
	Slope	Intercept	r <sup>2</sup>	% Data Capture	n
Bakersfield Primary BAM	1.00	2.4	0.957	86	236
Bakersfield Collocated BAM	1.02	0.0	0.956	74	200
Chico Primary BAM	1.08	3.2	0.982	95	49
Chico Collocated BAM	1.05	2.3	0.989	98	50
Sacramento Primary BAM	1.06	2.1	0.971	99	301
Sacramento Collocated BAM	1.05	2.7	0.953	99	296
Calexico Primary BAM	1.21	1.6	0.936	98	96
Calexico Collocated BAM	1.23	1.5	0.893	98	97
Fresno BAM	1.04	3.6	0.955	86	232
Modesto BAM	1.08	1.1	0.980	99	113
Roseville BAM	1.12	3.7	0.930	80	44
Yuba City BAM	1.10	0.3	0.867	93	43
Visalia BAM	1.04	1.5	0.953	92	81
Overall BAM/FRM	1.03	2.4	0.949	92	1838

Table 1. BAM-1020/FRM Regression Results and BAM-1020 Data Capture.

Overall CARB Met One BAM-1020 Network vs. PM2.5 FRM  
June 2004 - May 2005

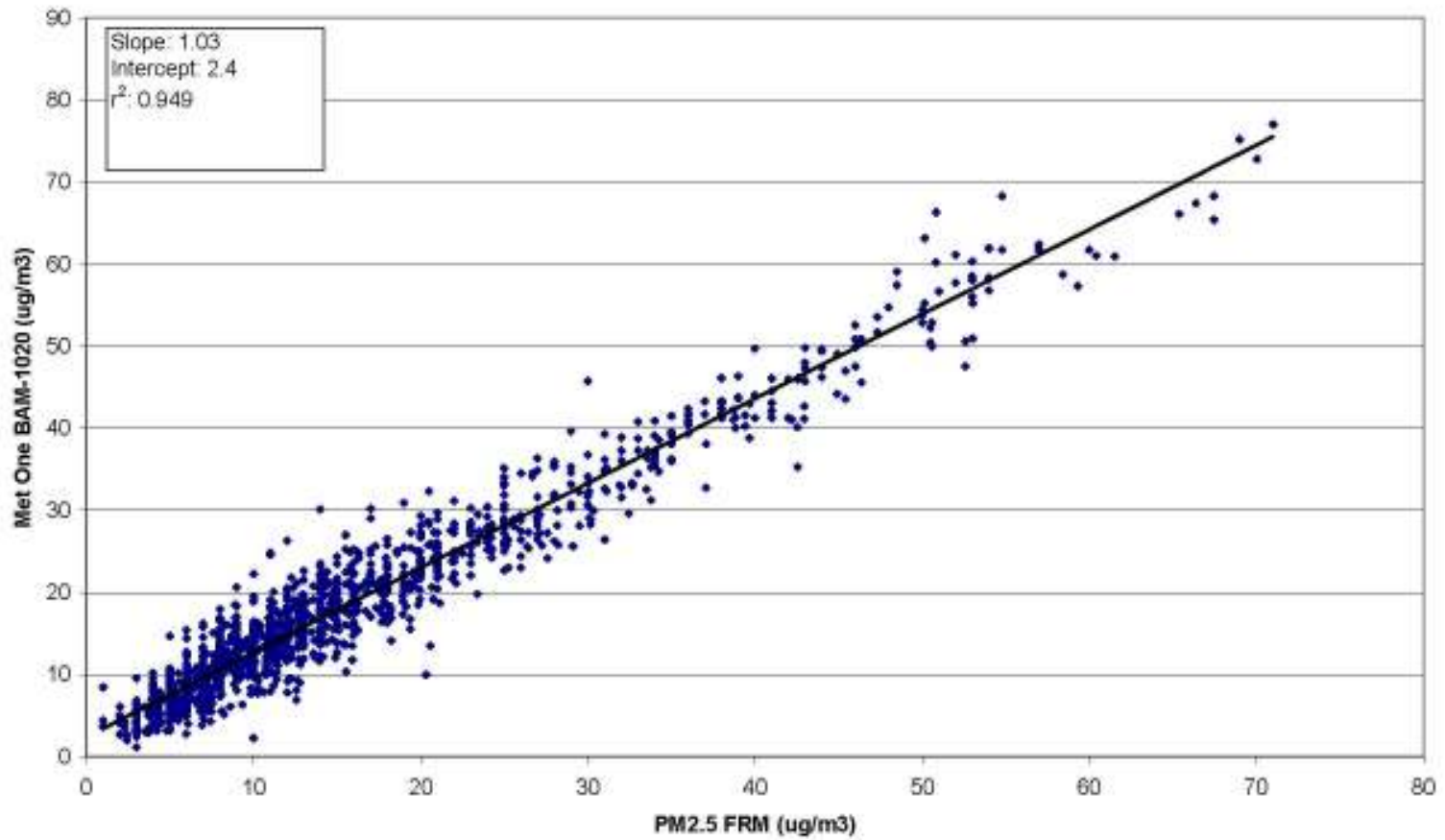


Figure 14. Overall BAM-1020 vs. FRM.





# Questions?

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