Air Resources Board

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TO: Kenneth R. Stroud, Chief
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FROM: Reggie Smith, Manager
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DATE: September 28, 2005

SUBJECT: OPERATION SUPPORT SECTION E-BAM EVALUATION

BACKGROUND

The following outlines the evaluation of the Met-One Instruments E-BAM conducted by the Operations Support Section (OSS).

The OSS purchased four E-BAM's in April 2003, with the intention to transfer the units to the Special Purpose Monitoring section after conducting a field evaluation of the samplers. Upon receiving the units in September 2003, staff installed the samplers on the Monitoring and Laboratory Division's (MLD's) Sacramento T-Street rooftop platform for evaluation.

During the initial phase of testing, regression analysis between the E-BAM and the PM 2.5 FRM resulted in low r^2 values (~ 0.6). Staff also discovered an E-BAM sampler malfunction. The samplers displayed intermittent zero hourly values during normal ambient sampling. Per conservations with Met-One, it was concluded that firmware and hardware modifications should be made on all units.

The four samplers were shipped to Met-One in January 2004 for upgrades and were returned to the OSS in April 2004. The samplers were reinstalled on the Sacramento T-Street rooftop platform.

The samplers were operated for several months and data was downloaded for evaluation in June 2004. Data analysis showed that the samplers were periodically recording zeros for the hourly average, even though the running average was reporting an increasing value. This was similar to the sampler malfunction discovered during the initial phase of testing. Staff contacted Met-One and were informed that Met-One would make a site visit to address the issue.

During July 2004, Met-One conducted a site visit to make on-site firmware changes. In addition, Met-One installed a modem on one E-BAM to allow for remote monitoring of the unit from Grants Pass, Oregon.

In September 2004, Dave Gobeli, of Met-One, informed OSS that Met-One engineering staff had discovered a flaw in the design of the E-BAM. This design flaw was due to the air gap between the source and detector of the E-BAM. The firmware did not account for ambient temperature variations during sampling. During sampling, as ambient temperatures increased, the density of the air between the source and detector decreased. This resulted in more Beta rays reaching the detector and caused higher mass calculations. For decreasing ambient temperatures the opposite was true.

In October 2004, Met-One visited the ARB to discuss E-BAM design and further upgrades. All units were again shipped back to Met-One for factory upgrades.

In January 2005, E-BAM's were returned from Met-One. Factory repairs included cleaning, pump replacement on one unit, new firmware and block modifications. At this time, OSS also received a draft of the U.S. EPA E-BAM Standard Operating Procedure (SOP) written under contract by Batelle. Since the U.S. EPA E-BAM SOP follows format of the Air Quality Surveillance Branch's (AQSB) SOP 400 for the BAM-1020, the OSS decided to adopt the U.S. EPA E-BAM SOP for its use.

In March 2005, E-BAM #1 experienced a pump failure and Met-One was contacted to send a replacement pump. E-BAM #2 was returned to Met-One to repair damage to the PMT resulting from a rainstorm. E-BAM # 4 was returned to Met-One to address flow problems.

In April 2005, E-BAM #1 was returned to service after a replacement pump was installed and the sampler was recalibrated.

E-BAM TO PM2.5 FRM DATA COMPARISONS

During the summer of 2005, OSS performed regression analysis on the E-BAM data collected between January and April 2005. Data results from each E-BAM were compared to the Sacramento T-Street PM2.5 FRM operated on a daily sampling schedule. Data results from E-BAM 1 and 3 were collected between January 21, 2005 and April 28, 2005. Data results for E-BAM 2 and 4 were collected between January 21, 2005 and February 13, 2005. The results of the regression analysis are shown in Table 1 which follows.

E-BAM	Slope	Intercept	r^2	n
1	1.05	3.09	0.986	34
2	0.94	0.37	0.894	22
3	0.93	1.68	0.972	89
4	1.07	0.05	0.984	23

Table 1: Regression results of E-BAM vs. PM2.5 FRM

Scatter plots of regression analysis are shown on attached graphs.

ADDITIONAL TESTING

Battery and Solar Panel Test

To determine operation of the samplers using battery and solar power, one sampler was operated in July 2004, using different battery/solar panel configurations. The table below details the results of that testing.

Battery/Solar Panel Configuration	Duration
One battery, no solar panel	~24 to 36 hours
Two batteries, no solar panel	~48 hours
One battery and solar panel	~ 3 days
Two Batteries and solar panel	~ 1 week +

Data Management

To evaluate the remote data retrieval capabilities of the E-BAM staff first installed a Motorola model I90 C cell phone to one of the samplers located on the Sacramento T-Street platform. The cell phone acts as a modem and using software provided by Met-One, data could be downloaded. However, this test was not conducted in a remote location.

In a separate but related study, the OSS participated in the U.S. EPA evaluation of E-BAM technology for wildfire smoke monitoring. This study utilized commercial satellite service to retrieve E-BAM data. OSS staff found this technology to be superior to cell phone/modem technology and recommends its use in conjunction with E-BAM deployment. The following information is provided to help implement commercial satellite data management.

Company: AIRSIS
6215 Ferris Square, Suite 120
San Diego, CA 92121
(858) 550-0567

Contact: Ken Lu, extension 124

Cost: Hardware (Satellite Modem Package ($1900.00))
AIRSIS Vision Service ($50.00 per month)
Satellite Account Set-up Fee ($40.00, one time charge)

Findings

A general evaluation of the samplers revealed the following:

1. Overall the samplers performed well for the intended uses by the AQSB (rapid response and special studies). When compared to the PM2.5 FRM, linear regressions yielded slopes from 0.93 to 1.07, intercepts from 0.05 to 3.09 and r^2 values from 0.894 to 0.986.

2. The sample tape lasts approximately two weeks when the sampler was configured to advance hourly. New modifications allowed for the advancement of tape every 24 hours or when a minimum pressure drop was reached. In this configuration, one roll of sample tape will last up to six months.

3. When the door to the sampler is open, the tape sensor does not sense the filter tape and causes the sampler to display “load tape message”. Staff believes this was due to the fact the tape sensor is an optical sensor and should not be a problem during routine operation.

4. The sampler uses a DC pump which has a short life span and requires replacement every four to six months. The DC pump can be replaced in the field but this is not recommended. Staff recommends that the AQSB instrument lab or Met-One factory personnel replace DC pumps when required. Met-One does offer an E-BAM with an AC pump option, which has a longer life span than the DC model. Staff recommends that the AQSB maintain a supply of DC pumps.

5. Due to frequent firmware updates and the time required to validate PM2.5 FRM filter data, the evaluation took longer than expected. Also, staff experienced long downtimes for the samplers due to various sampler malfunctions and/or events beyond staff control. Some of the instrument downtime was due to the continuous

operation of the samplers. OSS conducted evaluations by operating the E-BAM's continuously (like a BAM-1020) which is not the intended use of the E-EBAM. If samplers are operated at two to six week intervals, sampler downtime should be minimal.

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