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Environmental Protection  
Agency

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Planning And Standards  
Research Triangle Park, NC 27711

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Air

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# HOT MIX ASPHALT PLANTS

## RESPONSE to COMMENTS on TESTING PROGRAM for ASPHALT PLANTS C and D



**HOT MIX ASPHALT PLANTS**

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on TESTING PROGRAM for  
ASPHALT PLANTS C and D**

This document was prepared by:

Emissions Monitoring and Analysis Division  
Office of Air Quality Planning and Standards  
United States Environmental Protection Agency  
Research Triangle Park, NC

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U.S. ENVIRONMENTAL PROTECTION AGENCY  
Office of Air and Radiation  
Office of Air Quality Planning and Standards  
Research Triangle Park, North Carolina 27711

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## **DISCLAIMER**

The information in this document has been funded by the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency (EPA) under contract 68-D-98-027 to Midwest Research Institute and under contract 68-D-98-004 to Pacific Environmental Services, Inc. The EPA has made additions and revision to the information submitted by the contractors. This final report has been subjected to the Agency's review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

## Preface

This report was produced by the Source Measurement Technology Group of EPA's Emissions Measurement Center located in Research Triangle Park, NC. It is one of a series of twelve reports prepared to document an EPA emission test program to characterize emissions to the air from hot mix asphalt plants. These twelve reports and their associated EPA document numbers and publication dates are:

<b>Document Title</b>	<b>EPA Document Number</b>	<b>Publication Date</b>
Hot Mix Asphalt Plants Emission Assessment Report	EPA 454/R-00-019	
Hot Mix Asphalt Plants Kiln Dryer Stack Instrumental Methods Testing Asphalt Plant A, Cary, North Carolina	EPA 454/R-00-020	April 2000
Hot Mix Asphalt Plants Kiln Dryer Stack Manual Methods Testing Asphalt Plant A, Cary, North Carolina		
Volume 1 of 2	EPA 454/R-00-021a	April 2000
Volume 2 of 2	EPA 454/R-00-021b	April 2000
Hot Mix Asphalt Plants Kiln Dryer Stack Instrumental Methods Testing Asphalt Plant B, Clayton, North Carolina	EPA 454/R-00-022	April 2000
Hot Mix Asphalt Plants Kiln Dryer Stack Manual Methods Testing Asphalt Plant B, Clayton, North Carolina		
Volume 1 of 2	EPA 454/R-00-023a	April 2000
Volume 2 of 2	EPA 454/R-00-023b	April 2000
Hot Mix Asphalt Plants Truck Loading and Silo Filling Instrumental Methods Testing Asphalt Plant C, Los Angeles, California	EPA 454/R-00-024	May 2000
Hot Mix Asphalt Plants Truck Loading and Silo Filling Manual Methods Testing Asphalt Plant C, Los Angeles, California		
Volume 1 of 8	EPA 454/R-00-025a	May 2000
Volume 2 of 8	EPA 454/R-00-025b	May 2000
Volume 3 of 8	EPA 454/R-00-025c	May 2000
Volume 4 of 8	EPA 454/R-00-025d	May 2000
Volume 5 of 8	EPA 454/R-00-025e	May 2000
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Volume 7 of 8	EPA 454/R-00-025g	May 2000
Volume 8 of 8	EPA 454/R-00-025h	May 2000

<b>Document Title</b>	<b>EPA Document Number</b>	<b>Publication Date</b>
Hot Mix Asphalt Plants Technical Systems Audit of Testing at Asphalt Plant C Asphalt Plant C, Los Angeles, California	EPA 454/R-00-026	May 2000
Hot Mix Asphalt Plants Truck Loading Instrumental Methods Testing Asphalt Plant D, Barre, Massachusetts	EPA 454/R-00-027	May 2000
Hot Mix Asphalt Plants Truck Loading Manual Methods Testing Asphalt Plant D, Barre, Massachusetts	EPA 454/R-00-028	May 2000
Hot Mix Asphalt Plants Response to Comments on Testing Program for Asphalt Plants C and D	EPA 454/R-00-029	May 2000
Hot Mix Asphalt Plants Stakeholders Opinions Report	EPA 454/R-00-030	

These documents, including this Response to Comments document, are available for downloading, on CD-ROM and in paper.

Downloads can be made from:

<http://www.epa.gov/ttn/emc/asphalt.html>

Copies of the CD ROM can be requested by mail at:

Emission Measurement Center, MD-19  
US Environmental Protection Agency  
Research Triangle Park, NC 27711

Paper copies of the reports can be obtained from:

National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Phone orders 1-800-553-6847 or (703) 605-6000; FAX orders (703) 605-6900  
<http://www.ntis.gov/products/environment.htm>

## **Acknowledgments**

Many individuals contributed to the development of this report. Ron Myers of the Emission Measurement Center's Source Measurement Technology Group (SMTG), Scott Klamm with Midwest Research Institute (MRI) and Frank Phoenix of Pacific Environmental Services, Inc. (PES), are the primary authors of the report. Bob McConnell of EPA's Region I office, David

Mobley, Acting Director of EPA's Emissions Monitoring and Analysis Division, Bill Lamason, Mike Toney, Gary McAlister, and Candace Sorrell of EPA's Emission Measurement Center, Ron Ryan and Dennis Beauregard of EPA's Emission Factor and Inventory Group, Laura Autry of EPA's Air Quality Trends Analysis Group, John Hosenfield of MRI, and John Chehaske and Frank Meadows of PES participated in the review of comments and development of responses. We also acknowledge the contributions of numerous reviewers and advisors from PES, MRI and EPA.

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## Overview

Over the last several years, the US Environmental Protection Agency (EPA) has worked with a number of groups to better characterize truck loading emissions at hot mix asphalt plants. EPA has spoken with citizens, state and local health agencies, state and local air pollution control agencies, and industry associations. These different groups have provided input on the selection of facilities for emissions testing and the design of the test program, reviewed the individual site-specific test plans, and observed emissions testing. On June 14, 1999, draft reports documenting the test program and presenting the emissions from the tested sources were sent to these diverse groups. An Executive Summary Report was also included with the draft test reports. These groups were asked to review the reports and provide comments by September 15, 1999. On July 14, 1999, a mid-review period briefing was held in Boston, MA. This briefing provided an overview of the test program and allowed EPA to respond to questions regarding the reports.

Twenty-three comment letters were received in all, submitted by one state senator, five citizen associations, one industry association, one state public health department (two letters), and 14 individuals. The citizen comments came from seven states. This document includes a list of the commentors, a summary of the comments grouped by topic, responses to the comments and descriptions of planned revisions to the final reports. For continuity, the comment summaries will be followed by the EPA response.

## Summary of Changes to be Made

The comment letters received can be grouped into two general areas. The first area addresses the test methods and analyses used to arrive at an "as measured" emissions value. The second area concerns the interpretation of the data with respect to general usage for individual facilities or groups of facilities. Generally, only information specifically related to the test program that was conducted is presented in an emission test report. Little if any interpretation of the data is made except in relation to data quality issues. Since many of the comments that were received were related to interpreting the data, it has been determined that some additional analyses of the data will be performed and more interpretation of the data will be included in the test reports and the summary report. To effect this change, the revised name of the Executive Summary Report will be the Assessment of Emissions at Hot Mix Asphalt Plants. In the remainder of this document "Executive Summary Report" will mean the draft report which was sent to reviewers on June 14, 1999.

## Summary of Changes to be Made to Test Reports

The following changes will be made to the presentations of the emission test data in the test reports:

1. For Plant C (Instrumental Test Methods Report), the period used to quantify the THC emissions from the Silo Exhaust (SED in the draft report) will be revised to exclude periods where no asphalt was being loaded into Silo 2. (See Response 24 for details.)
2. For Plant C (Instrumental Test Methods Report), the method of calculating the THC mass emissions from the THC concentrations will be revised from a dry gas basis to a wet gas basis. (See Response 24 for details.)
3. For Plant C (Instrumental Test Methods Report), the calculation of the capture efficiency will be revised from the daily average to a statistically determined value (the lower 90% Confidence limit of the mean value) for each day. (See Response 55 for details.)
4. For Plant C (Manual Test Methods Report), the multiplier to determine the surface area from linear surface area for the corrugated ceiling will be revised from 1.084 to 1.217 to properly account for the total surface area. (See Response 34, item c, for details.)
5. For Plant D (Manual Test Methods Report), the deposition calculations will be revised to include capture hood plenum. (See Response 34, item f, for details.)
6. Information on the measurements of SO<sub>2</sub>, NO<sub>x</sub>, and CO emissions that were target analytes will be presented in the test report. Where the pollutants were below the analytical limit, the detection limits for the compounds will be presented. (See Response 50 for details.)
7. Information on the results of the run-by-run loss on heating by the Rolling Thin Film Oven Test (RTFOT) will be presented more prominently. (See Response 52 for details.)
8. Information on the results of the run-by-run temperature averages measured during the test programs will be presented more prominently. (See Response 53 for details.)
9. A number of editorial changes will be made. (See Responses 2, 8, 9, 39, 52 and 70)

## Summary of Changes to be Made to Emissions Analysis Report

The following additional analyses will be performed to extend the use of the data contained in the draft reports. Summaries of these additional analyses and conclusions will be presented in the Assessment of Emissions at Hot Mix Asphalt Plants report but not in the emission test reports.

1. An analysis of THC emissions (measured at Plant D during extended sampling periods) following normal loading operations was performed. A revised method to estimate emissions from transport truck beds following loadout will be presented. (See Response 15 for details.)
2. An analysis of emissions from the silo exhaust will be performed to allow for estimating emissions from asphalt storage tanks. (See Response 17 for details.)
3. The background adjustment calculation for Plant C will be revised. First, the emissions for each run will be adjusted for the run capture efficiency, then the measured truck emissions will be subtracted. (See Response 51 for details.)
4. The measured emissions for both tests will be adjusted to a consistent 0.5% loss-on-heating-value as measured by the RTFOT. Information will be included to allow adjustment of these measured emissions to RTFOT values measured by state departments of transportation. (See Response 52 for details.)
5. The measured emissions for both tests will be adjusted to a consistent 325°F. Information will be presented that will allow states to adjust these measured emissions to a value more consistent with the operations of facilities within their state. (See Response 52 for details.)

## List of Commentors

The following is a list of the individuals or organizations that provided comments on the draft test reports and the draft Executive Summary Report:

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## **Validity and Use of Reports**

### **1. Use of Reports for MACT Rules**

COMMENT: A number of commentors (Dahlberg, Dher, Ulbrich, Cantwell, Karr, Munzel, Perez, Kelly, Lynch, Toxics Action Center) request that the draft report be declared inconclusive because of their understanding that numerous technical errors and incorrect conclusions were made in the reports. They state that the reports should not be used as a basis of “opting out” HMA from a nationwide MACT emission standard. They further state that the MACT rule should be required. Lastly, they stated that the MACT rule should require industry-wide adoption of permanent enclosures, controls, and inherently lower emitting process technologies.

RESPONSE: As indicated throughout this response document, the draft report did not contain numerous technical errors or incorrect conclusions. The few technical and editorial errors that were identified will be corrected in the final report. In addition, a number of analyses have been performed to provide additional adjustments that result in values that are more easily compared and can accommodate operating differences between different facilities.

The Plants C and D reports are only one piece of information that will be used to consider the necessity for a MACT standard for these facilities. Other test data, engineering analyses and source category evaluations will be used to determine the need for such a standard.

### **2. Major Source Designation**

COMMENT: The commentor (Nowick) identifies a statement in the executive summary portion of the manual test method report for Plant C that states that the emissions measured clearly show that emissions from loading operations are well below the major source thresholds. The commentor points out that the test report presents emission factors and not total emissions.

He further states that major source thresholds are based on total emissions and cannot be based solely on the emission factor.

RESPONSE: The commentor is correct in that the major source thresholds are based upon the total facility emissions at the facilities permitted production capacity. The statement concerning major source thresholds will be removed from the PES Plant C test report.

### **3. Representativeness of Facilities Tested**

COMMENT: The commentor (Sierra Club) believes that the test facilities used in California and Massachusetts do not seem to be typical of the asphalt plants encountered in Michigan. They specifically note that the RAP (recycled asphalt pavement) usage in both the California plant and the Massachusetts plant was less than the maximum permitted amount allowed in Michigan (regular use of 30% RAP is not uncommon in their state). The commentor also stated that at the Massachusetts plant, only 142 tph were produced and that the more typical production rate in Michigan is over 350 tph.

RESPONSE: Information on the RAP usage at Plant C is presented in Appendix B1 of the PES test report. For the first day of testing at Plant C, no RAP was added to the mix. For the second, third, and fourth days of testing, the RAP usage averaged 28.0%, 23.4%, and 27.0%, respectively. These latter values compare well with the Michigan numbers supplied by the commentor. In addition, there were no significant differences in the emissions for the first day where no RAP was used versus the other days where RAP usage was over 23% of the mix. At Plant D, three mix types contained RAP: state binder with 10% RAP, modified top with 10% RAP, and state top with 10% RAP (as shown in Table 3.1 on page 3-7 of the PES Asphalt Plant D report). For the three days of testing at Plant D, these three mix types accounted for 86% of the total production. Detailed information on the RAP usage at Plant D is presented in individual load-out records in Appendix B of the PES test report.

As noted by the commentor, a production rate over 350 ton/hr is common for some facility types. Specifically, this is typical of many drum mix plants. While there are fewer drum mix plants than batch mix plants, the industry reports that drum mix plants produce the majority of asphalt. The operations of drum mix plants are more typical of Plant C. The production of Plant C was over 350 tons/hr.

Batch mix plants represent the other asphalt plant design. Generally, the maximum plant capacity of batch mix plants is less than drum mix plants, and batch mix plants are also used for lower production runs. Plant D is a more typical batch mix plant. At Plant D on days 1, 2, and 3, plant production averaged approximately 157 TPH, 134 TPH, and 140 TPH, respectively.

### **4. Is the Plant in Statistical Control?**

COMMENT: The commentor (Nadkarni) questions whether Plant C is in “statistical control” (that is, a process that is operating with only chance causes of variation). The commentor states that the plant is either operating under statistical control with respect to product



specifications or the product specifications are so loose that they can be met most of the time in spite of the plant being out of statistical control. The commentor bases his analysis of statistical control on the variations of THC concentrations and presents an analysis based upon a control chart example using two standard deviations as the control limits. The commentor presents some descriptive statistics for Plant D THC data. Later, the commentor suggests that unless an analysis is performed to determine the causes of the variations, any further calculations to determine the standard error of the estimates is inappropriate.

RESPONSE: During testing, Plant C produced a product that met the quality characteristics required by the customer. Within these criteria it can be assumed that the production was within statistical control for the key quality characteristics of the product. The commentor makes an inappropriate extension of statistical control by using the measurement of uncontrolled THC concentrations as an indication that the process is not in statistical control. The emissions of THC (or any other pollutant) from the tested processes are not a known indicator of any quality characteristic of the pavement produced. Therefore, the use of this measurement as an indicator of whether the production process is in statistical control is inappropriate.

The commentor infers that the lack of statistical control of THC emissions at Plant C invalidates the measurements of all pollutants. Many texts on statistical quality control indicate that a process that is operating in the presence of assignable and controllable causes is said to be out of statistical control. Generally, the assignable causes stem from three sources: improperly adjusted machines, operator error, or defective raw materials. (Reference: Chapter 4; *Introduction to Statistical Quality Control; Second Edition*; Douglas C. Montgomery; 1991).

In order to assign a cause to a variation, routine THC measurements must be made and related to production variables. There are no hot mix asphalt plants that routinely measure THC emissions from the processes tested. While it could be argued that almost everything at a facility is controllable, there should be some attempt to control the variation of the parameter prior to determining whether the process is in statistical control. There are no known hot mix asphalt plants that attempt to control short-term emissions from the processes tested. As a result, a discussion of statistical control is moot in the absence of measurements and an attempt to control the measured parameter. While there may be many causes for variations in the THC concentrations, the variations are an inherent part of the processes evaluated. A brief investigation of the variations of THC emissions and issues raised by the commentor may be in order.

The commentor said that it is common to use a control chart in statistical process control to identify trends when the process may not be operating within statistical control. The use of control charts is generally based upon the assumption that the information plotted on the control chart is normally distributed. The commentor also makes this assumption and uses plus and minus two standard deviations ( $2\sigma$ ) as upper and lower control limits. It is unclear why the commentor uses  $2\sigma$  as the control limits. Most control charts use plus or minus  $3\sigma$  as action limits for correcting a process that is “out of control” to insure that the process is not over

controlled. Some analysts suggest the use of  $2\sigma$  as a warning limit which would require some additional investigation prior to any action.

The commentor also indicates that one would expect 95% of the data to fall between the  $2\sigma$  control limits. For many processes, one of many indicators that the process has only chance causes of variation is the presence of normally distributed data. The existence of only chance variation can be evaluated by comparing the distribution of the THC data to the normal distribution curve. In evaluating the THC data, approximately 85% of the data are less than one standard deviation of the mean, approximately 98% are less than two standard deviations of the mean, and 99.5% are less than three standard deviations of the mean. This is typical for a normally distributed population. As a result, it is reasonable to expect that the variations were due to the periodic loading operation and chance cause rather than improperly adjusted machines, operator error, or defective raw materials.

With respect to the statement concerning the standard error of the estimate and the presentation of the  $2\sigma$  range of the Plant D THC data, it is assumed that the commentor is estimating the uncertainty of the mean. The commentor presented the mean estimate of 165 lb per 100,000 tons of product and a  $2\sigma$  range of 128 lb per 100,000 tons. He also presented this as  $165 \pm 78\%$ . While this may be an indication of the per-minute variation of the THC concentrations due to the loading of asphalt, it is not an estimate of the standard error of the mean estimate. To calculate the standard error of the mean estimate one is required to divide the standard deviation in emissions by the square root of the number of measurements. (Reference: *Statistical Methods; Eighth Edition*; George Snedecor and William G. Cochran; Iowa State University Press; Ames, IA; 1989) Since each of the individual THC runs consists of about 240 one-minute readings, the standard error would be 2.4 lb per 100,000 tons. Therefore, the  $2\sigma$  range would be  $165 \pm 4.8$  lb per 100,000 tons or, expressed as a percentage,  $165 \pm 2.9\%$ .

## 5. Effects of Asphalt Source and Refinery Processing

COMMENT: The commentor (Zeller) stated that the volatile chemical content varies with the asphalt cement supplier and even with each delivery from the same supplier. He states that asphalt from a refinery that includes hydrocracking and isomerization steps may contain more polyaromatic hydrocarbons than one that relies mainly on distillation. The commentor cites the range of loss on heating values determined during the Strategic Highway Research Program (SHRP) and states that tests were needed to eliminate the uncertainties caused by asphalt source and refinery conditions.

RESPONSE: While we recognize that the loss on heating (volatiles content) and chemical makeup of asphalt binders do vary, this variation is not likely to be due to processes performed downstream of the atmospheric and vacuum distillation columns. The processes cited by the commentor are performed on the material that evaporates from the distillation or vacuum distillation of the petroleum, and not on the asphalt material that remains at the bottom of the distillation columns. Therefore, these processes would not affect the polyaromatic content of asphalt. Additionally, almost 100 separate unblended asphalts were analyzed in the SHRP to characterize the physical properties of asphalt (Reference: *SHRP Materials Reference Library*:

*Asphalt Cements: A Concise Data Compilation*; David R. Jones, IV; SHRP-A-645; Strategic Highway Research Program; National Research Council; 1993). The asphalts used for asphalt binders are a number of asphalts from different crude stocks that are blended to achieve a product that is more consistent in the physical properties required for a given grade of asphalt binder. The resource constraints of the testing program precluded more emission tests at different times of the year and at different locations to establish either a relationship between emissions and the loss of asphalt heating or the variability of the emissions of individual chemical compounds. Nevertheless, methods are presented in Sections 52 and 53 that account for variations in the loss on heating of asphalt, and the information on the species referenced in Response 56 should provide an insight into the variabilities of the individual chemical compounds.

## **6. Effects of Maintenance**

COMMENT: The commentor (Yatzyshyn) states that facilities rarely operate at optimum conditions. The commentor stated that the testing should have been duplicated at various circumstances.

RESPONSE: We recognize that the production process may encounter operating conditions that affect emissions. In fact, as discussed in Response 29, the test of the dryer stack (a subordinate measurement during the test) at Plant C demonstrated a number of operating difficulties encountered by the plant. However, the primary focus of the emission tests was measurement of emissions from silo filling and load-out operations. The post-production emissions are caused by volatilization of a small portion of the asphalt binder as the paving asphalt falls through the air. The mechanical equipment involved in these operations include slide gates (which are either fully open or closed), scales, and bucket elevators. It is expected that less than optimum operation of this equipment would have a significant impact on the production capability of a facility. This less than optimum operation would result in emissions that are proportional to the reduced production capability of the facility but increased by the longer duration that partially loaded transport trucks are on site. Emissions from these operations are dependent on the physical properties of the asphalt (temperature, loss on heating). Both of these properties were measured during the test, and the methods to accommodate variations of these properties are presented in Responses 52 and 53.

## **7. Mission of the Test Program**

COMMENT: The commentor (Nadkarni) states that in many places in these reports, the original mission of the project and of the EPA seems to be lost or forgotten. He states that the mission was to measure currently unmeasured and unquantified emissions to the environment from asphalt production. He states that the emissions start from the instant the hot mix asphalt is loaded into silos and onto trucks and they continue until the asphalt is laid on the ground, is compacted, and cools down.

RESPONSE: The mission of the project was to quantify the more significant uncharacterized emissions sources at hot mix asphalt production facilities. Originally it was hypothesized that, compared to the already well characterized dryer drum units, emissions from

truck loading were more significant. EPA embarked on the test program to insure that emissions information used in the MACT program, the emissions inventory program, and the permits program encompassed the vast majority of emissions from the production facilities. While some of the information collected could be used to estimate offsite emissions, such extrapolation would be somewhat speculative and are beyond the primary goals of this study.

Before the final planning meeting for the test at Plant D, the stated objective by the citizens groups was to quantify emissions from silo filling and truck loadout. At several meetings and teleconferences, it was stated that these emissions were important since the facility is stationary and concentrates exposure for those individuals living nearby. During the final planning meeting, the issue was raised of emissions from the trucks after loadout. It was agreed that a few samples for THC would be collected to characterize the emissions from truck beds following loadout. During the test program, we collected five such samples. An emission rate of 0.17 lb/hr was presented in Table 2 of the Executive Summary Report as post-truck loading emissions that represent the period between the completion of truck loading and when the truck leaves the plant property. Developing less speculative estimates of emissions during transport and pavement laying would require more complex testing than was performed for this study. However, a revised methodology to estimate post-truck loading emissions is being recommended. The description of this methodology is presented in Response 15.

## Definitions

### 8. Definition and Use of the Term “Conservative”

COMMENT: A number of commentors (Nadkarni, Fillion, Ecology Center) requested clarification of the term “conservative” as used in the test reports. One commentor stated that the definition of the word depends upon an assumed perspective, the perspective is not stated, and the reports would gain clarity by using words such as “larger,” “greater,” “smaller,” or “lesser.” Another commentor suggested that the term mean “more protective of the public health.” Another commentor stated that the terms “conservative,” “high bias,” and “worst case” are judgments best left to the reader.

RESPONSE: As indicated by one commentor, the context in which the word “conservative” is used is one which would be more protective of the public health. The terms “high bias” and “worst case” provide a similar connotation. These terms are used when the collection of unbiased data is impractical or impossible. In these situations, a method is devised to collect data with minimal bias, providing information that will ultimately protect public health. For example, a difficult-to-obtain measurement that would influence the quantity of pollutant measured would be collected in a manner that causes the measured emissions of that pollutant to be greater than the actual emissions. Generally, the quantification of bias introduced is not possible in typical emission tests, and the qualifier is used to describe to the reader the potential for bias. A quantitative estimate some of the bias could be obtained with a method evaluation study. However, these type of studies are very expensive and beyond the scope of this study.

The term “conservative” in the reports will be revised to eliminate the potential misinterpretation of this term. In addition, the term “worst case” will be revised to better describe the potential bias that may be introduced. With respect to letting the reader judge whether a given condition has a bias: this makes the assumption that the reader is thoroughly familiar with test methods used, the conditions that existed, and what adjustments were made to allow the information to be obtained. Therefore, where methods are used that will introduce a bias, the reader will be informed.

## 9. General Definitions of Terms and Acronyms

COMMENT: Several commentors requested clarification of terms.

RESPONSE: For consistency, the following glossary of terms will be included at the beginning of each test report.

### Glossary of Terms

#### Plant C:

CEMS—Continuous Emissions Monitoring System  
CTS—Calibration Transfer Standard  
EMC—Emissions Measurement Center  
ESP—Electrostatic Precipitator  
FID—Flame Ionization Detector  
FTIR—Fourier Transform Infrared Spectroscopy  
HAP— Hazardous Air Pollutant  
MRI—Midwest Research Institute  
PES—Pacific Environmental Services  
PTE—Permanent Total Enclosure  
RAP—Recycled Asphalt  
SED—Silo Emissions Duct  
TED—Tunnel Emissions Duct  
THC—Total Hydrocarbons  
VOST—Volatile Organic Sampling Train

#### Plant D:

CAAP—Coalition Against the Asphalt Plant  
DQO—Data Quality Objective  
EFIG—Emission Factor and Inventory Group  
EMC—Emission Measurement Center  
ESD—Emission Standards Division  
FID—Flame Ionization Detector  
NDO—Natural Draft Opening  
OAQPS—Office of Air Quality Planning and Standards  
PES—Pacific Environmental Services  
RAP—Recycled Asphalt  
THC—Total Hydrocarbons  
TTE—Temporary Total Enclosure

## 10. ES Discussion of Sampling Techniques and THC Operation

COMMENT: Two commentors (Nadkarni and Lynch) make note that the description of the sampling apparatus is not clear, especially with respect to the use of particulate filters. Commentor Nadkarni states that the report incorrectly implies that all inorganic particulates were collected. Clarity of the overall sampling and analysis scheme is also requested, especially with respect to the THC, VOC, SVOC, and PAH measurements.

RESPONSE: The commentors conclusions are incorrect due to an apparent misunderstanding of the purpose of the filters for the different methods and sampling methods themselves. The methods used in the test program were described in each test report. Specifically, the following sections of the test reports describe the test methods:

Plant C Manual Testing (PES)	Volume I, Section 5 and Appendix F
Plant C Instrumental Testing (MRI)	Section 4
Plant D Manual Testing (PES)	Section 5 and Appendix G
Plant D Instrumental Testing (MRI)	Section 3

However, for clarity and to have all of the methods described in a single location, the methods will be described in this response. In addition, information on how the information developed from these methods fit together will be described.

Method 25A, operated by MRI, is a gas-phase measurement for total hydrocarbons. Sample lines are heated to prevent condensation of the source gas en route to the analyzer. The analyzer itself is a calibrated flame ionization detector (FID) and is not used to measure particulate matter in any way.

For the Plant C testing, sample gases were split from the same manifold to feed both the extractive FTIR (Method 320) and the THC analyzer. This setup used two in-line Balston particulate filters. The first filter is located near the probe tip for immediate removal of large particles. The second filter is located at the manifold and provides secondary filtration before gases are split to the various analyzers. The THC and FTIR are both used for gas-phase measurements, and the filtered particles are not included in the sample measurements.

For the Plant D testing, FTIR measurements were not part of the test program, allowing a somewhat simplified setup of the THC analyzer. A piece of glass wool was placed at the probe tip to filter larger particles, and secondary filtration was not necessary.

Either method of particle filtration is appropriate and within the defined limits of the method. A brief description of this principle is cited in Method 25A, Section 1.2 (Principle of Operation), which states “a gas sample is extracted from the source through a heated sample line, if necessary, and glass fiber filter to a flame ionization analyzer.”

As the commentors observed, the manual sampling trains operated by PES are also equipped with particulate filters. However, these methods are quite different from the THC and

FTIR methods described above, because particulate matter collected on the filter is saved and analyzed as part of the complete sample. PES used Method 315 at Plant C and Plant D to measure both inorganic and organic particulate. Method 315 measures and defines as particulate matter (PM) anything that is collected on a glass fiber filter heated at 250°F or in the chilled impinger water. Method 315 specifies the use of a glass fiber filter exhibiting at least 99.95% efficiency (i.e., less than 0.05% penetration) on 0.3 micron particles. The of 0.3 micron particles are used to evaluate filters because this size particulate is the most difficult to collect. In other words, more than 99.95% of all particles (organic and inorganic) are collected on the filter of the Method 315 sampling train. Organic material that is a vapor at the filter temperature is collected in chilled water in the impinger section of the Method 315 sampling train. This organic material is extracted from the water with methylene chloride. Inorganic and organic particulate together make up total PM. Organic particulate is defined in Method 315 as a PM subset and is any PM that is extractable with methylene chloride (i.e., MCEM or methylene chloride-extractable matter). Thus, any particles collected by these methods are included in the emissions totals.

Figure 1 presents a conceptual diagram of the pollutant definitions and the sampling scheme for the Plant C testing. The top of the figure shows volatiles on the left and proceeds through semivolatiles to nonvolatiles on the right. The major components, referred to as THC and PM, are on the next line, and show that THC (which is measured by Method 25a) begins with volatile compounds but ends in the semivolatile range (where compounds may remain in a gaseous state and will be collected in a Method 315 sample train). PM (measured by Method 315) picks up where THC leaves off and collects all particles and condensibles. It should be noted that there is a slight overlap in what is measured by Method 25a and Method 315. Neither Method 315 or Method 25a has the ability to determine the presence of individual species but does provide a measure of total mass. Other test methods were used at Plant C to determine individual hazardous air pollutant species present.

The methods below THC on the figure (FTIR, Method 18, VOST, Method 0010, and GC/MS) are aligned under the categories of Volatiles and Semivolatiles to provide a visual indication of where they fit. These methods identify and quantify specific target compounds (i.e., generally HAPs or pollutants of interest). Each of these methods is summarized below.

- a. Extractive FTIR (Method 320)—This method has the ability to identify and quantify organic and some inorganic gaseous compounds over the same operating range as the THC. The method simultaneously collects an infrared spectrum of all gaseous compounds present at concentrations from approximately 100 ppb to 1000 ppm. The method does not use any absorbant materials or separation systems, and thus provides a direct reading of the source gases. Mixtures of heavier hydrocarbons (semivolatiles) are difficult to identify due to overlapping of similar infrared bands.
- b. Concentrated FTIR—This technique concentrates sample gases on a Tenax absorbant trap direct from the source, which is analyzed by thermal desorption into the FTIR cell. Due to the expected low levels of certain targets (such as xylene), this technique was included

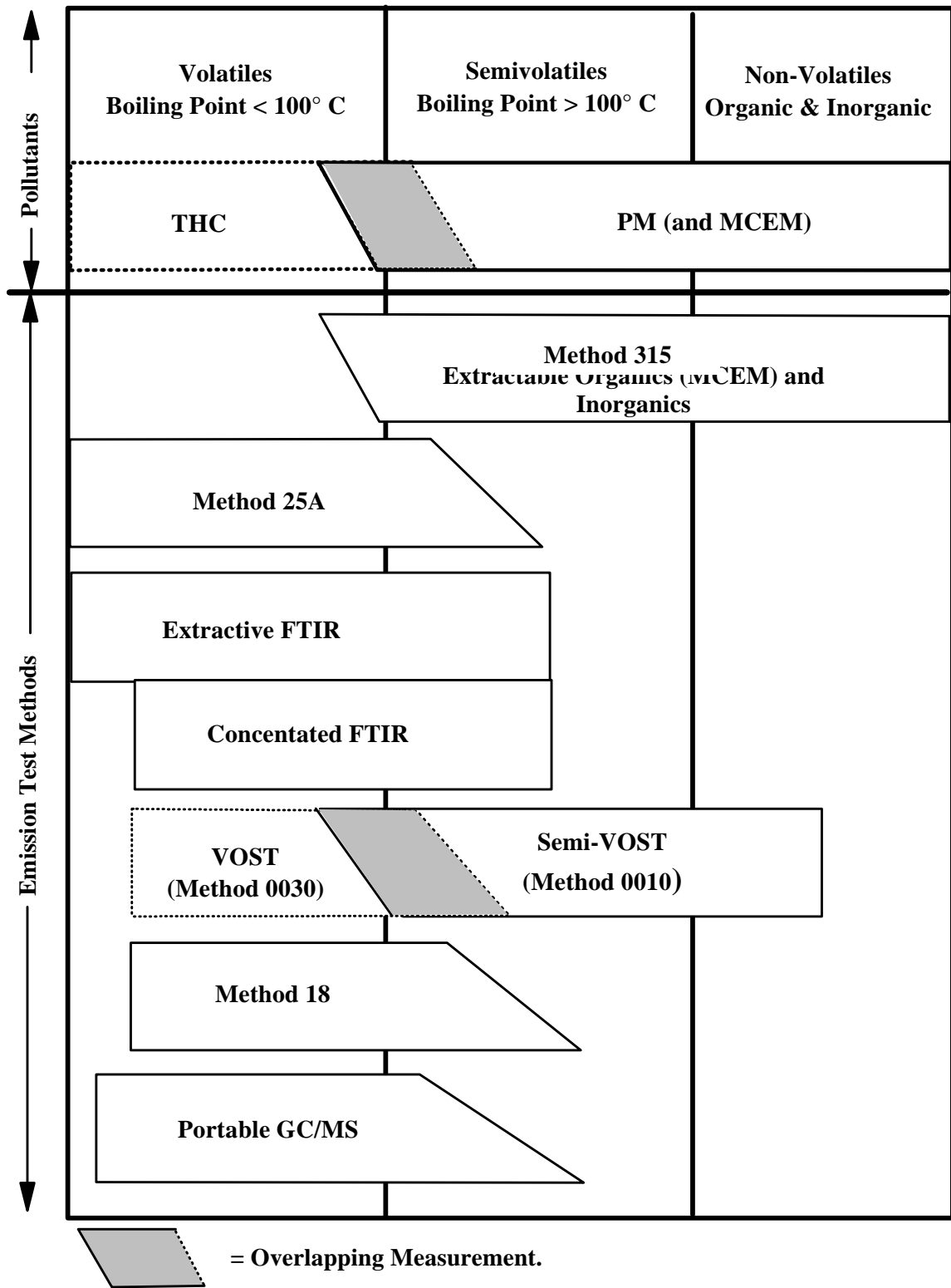


Figure 1. Conceptual Diagram of Pollutant and Test Method Definitions



to provide approximately 30 times better detection limits than direct FTIR. Light hydrocarbons, such as methane and ethane, are not retained by Tenax, and were not collected by this method.

- c. VOST (Method 0030)—This method uses a Tenax absorbant tube to concentrate sample gases. Tubes are shipped to the laboratory, where they are thermally desorbed for GC/MS analysis. As with the concentrated FTIR, light hydrocarbons are not retained by Tenax and cannot be seen with this method. The method is typically used to identify and quantify specific target HAPs in the range of 1 to 1000 ppb, and cannot be used for a broad screening of non-targeted compounds. Water reactive compounds (such as formaldehyde) or column reactive compounds (such as acids) cannot be seen with this method.
- d. Semi-VOST (Method 0010)—This method uses an XAD absorbant trap to concentrate sample gases and also collects PM on a filter upstream of the XAD trap. The filter and XAD are shipped to the laboratory for extraction of semivolatile compounds, and the extract is analyzed by GC/MS. This method is similar to VOST in that it is typically used to identify and quantify specific target HAPs and cannot be used for a broad screening of non-targeted compounds without special preparation, sample splitting, and analysis on multiple GC/MS columns. As shown in Figure 1, Method 0010, Method 18, and Method 0030 can all be used to measure some compounds that have boiling points near 100°C. PAHs are a sub-class of semivolatiles, and a portion of the extract is specifically set aside for PAH analysis.
- e. Method 18—With this method, source gases are collected on charcoal absorbent tubes (1,000 mg SKC Anasorb 747 activated-polymer tubes) and shipped off-site for analysis. The absorbent was extracted with carbon disulfide and analyzed by GC/FID. As with the concentrated FTIR, light hydrocarbons are not retained by charcoal and cannot be seen with this method. The method is used to identify and quantify volatile compounds and hydrocarbons in the approximate range of 1 to 1000 ppb. Heavier hydrocarbons and semivolatiles are not typically seen with this method due to condensation and/or difficulties with the GC column.
- f. Portable GC/MS—This method takes source gases immediately to a GC column coupled with an MS detector. A water knockout may be included with sources having a high moisture content. The instrument is used to identify and quantify specific target compounds in the approximate range of 1 to 1000 ppb. Light hydrocarbons, such as methane and ethane, are usually not targeted for analysis by this method. Similarly, heavy hydrocarbons and semivolatiles (other than those specifically targeted) also present difficulties due to column reactions or difficulty in identification.

Response 30 discusses in greater detail how emissions measured by these methods fit together into a so-called “mass balance.” In brief, THC and Method 315 provide measurements of total emissions but do not give any indication of individual components. FTIR (Method 320) provided measurements of the full range of vapor-phase components, from sub-ppm to high-ppm

concentrations. Finally, the manual methods (VOST, Method 18, Method 0010, and GC/MS) provided measurements of many specific target pollutants in the low-ppb and low-ppm ranges. These techniques together provide an excellent indication of total emissions from the asphalt load-out and silo filling process.

## **Suitability of Method 204 Criteria**

### **11. Inadequacy of Method 204 Criteria and TTE Operations**

COMMENT: The commentors (Nadkarni, Fillion, Toxics Action Center) are primarily concerned that the Plant D testing did not use a tracer gas. Two commentors assert that the plastic streamers at the top and bottom of the TTE showed air leaving the enclosure. Consequently (Nadkarni), winds potentially prevented 100% capture from being achieved by the TTE (without any measure of the true capture). Furthermore (Nadkarni), Method 204 does not provide any assurance that emissions captured by the TTE are actually drawn through the sampling systems and may have been lost or diluted when the TTE doors were opened for a new truck to enter.

RESPONSE: It is not clear what events the commentors are referring to when describing the streamer locations and ambient breezes causing fumes to escape the tunnel. EPA, MRI, and PES did not observe these events during the on-site testing, nor did the CAAP observer mention this situation during the test or at any time until the comment phase.

Paragraphs 3 and 4 of MRI's Plant D draft report, page 4-3, provide accurate TTE descriptions of the field events monitored by MRI. Airflow criteria of greater than 200 fpm were maintained during all velometer tests performed by MRI. Nine inches of additional open space across the top of each doorway were closed after Run 1 partially because the fan speed was reduced to increase the measured THC concentrations and partially as a precautionary measure in case higher winds occurred during Runs 2 and 3. The forecasted higher wind conditions did not occur until October 9, 1998. On this date, winds of 14 to 16 mph were recorded by the closest local National Weather Service Office compared to the 4 to 9 mph winds during the test period. Paragraphs 3 and 4 are correct in stating that these field modifications did not affect the total airflow or other operations of the TTE.

Contrary to one commentor's assertion, THC readings for Run 1 do not diminish as the test progresses, and the mass emissions agree quite well with mass emission averages for Runs 2 and 3. It is true that the measured concentration for Run 1 is somewhat lower than Runs 2 and 3, but this is explained by sample dilution from makeup air (paragraph 5 in MRI's Plant D draft report, page 4-3). Fan speed was reduced slightly for Runs 2 and 3 to minimize this effect. One can see from the emission rates (rather than concentrations) in Table 4-2 of the draft report that all three test runs show essentially the same result.

It might be useful to compare the Plant C and Plant D enclosures. With the simple addition of movable doors to enclose the load-out area completely, the Plant D TTE is otherwise quite similar to the Plant C tunnel. There, minimum average capture efficiencies of 60% to 70% were demonstrated under much stronger wind conditions, higher truck traffic, and with doorways open at both ends. Furthermore, MRI's preliminary tracer gas study at Plant C (May 1998) showed 100% capture with the exit doorway closed and a breeze blowing directly at the tunnel entrance door. With these data in mind, one would clearly expect capture at the Plant D TTE to be significantly higher than the 60% to 70% averages demonstrated at Plant C. Since the Plant D TTE met all design and operating criteria specified by Method 204, it is reasonable to assume that essentially 100% capture efficiency was maintained.

As noted by the commentor, Method 204 does not have design criteria for "dead spaces," channeling, or similar phenomena. The TTE design used at Plant D was built with natural draft openings across the top and bottom of each doorway. It was believed that this design would maintain good airflow near the ground at the doorways (i.e., low corners) and across the entire ceiling surface. Furthermore, asphalt fumes observed during load-out were hot and quickly rose to the ceiling, where they were swept into the exhaust system. Thus, it is reasonable to assume that dead spaces or channeling had minimal or no effect on the data.

The commentors also raise the issue that waiting only 15 sec after the last drop is not long enough to evacuate the enclosure and measure all of the captured emissions. The commentors identify this as additional evidence of the failure of Method 204 criteria. While it is true that 15 sec is insufficient time to evacuate the emissions in the enclosure, the commentors do not consider that emissions continue from the truck bed after loading, the emissions from one loading operation may be measured during subsequent loading periods, and that the doors to the enclosure were open for a very short time relative to the total loading time. These issues are discussed more fully in Response 15.

## **Capture Efficiency**

### **12. Tracer Gas Suitability for Condensable Emissions**

COMMENT: Commentor Nadkarni states that deposition plates were used to quantify emissions that did not reach the sampling ports. He further states that some of this material was deposited in the tunnel and some was pumped out of the tunnel by ambient breeze or by truck movement. He indicates that the tracer gas enabled an estimation of the VOC portion of this loss. He states that the citizens pointed out in the planning meetings that the tracer gas was a good proxy only for the non-condensable emissions but not for condensable emissions.

RESPONSE: It is recognized that some of the particulate emissions are removed in the collection hoods and ductwork prior to the sampling location. However, as pointed out in the planning meetings, the tracer gas is a good surrogate for small diameter particulate (as is generated in these processes) and vapors. Tracer gas is commonly used by many researchers as a

tracer for both vapors and particulate. As was noted in the meetings, this tracer is suitable only for small particulate (less than 10 micrometers in diameter), which behaves very much like vapors in air. The condensation phenomenon that creates the visible emissions (including both condensed water vapor and condensed organic material) from silo filling and truck loading, generates droplets that are smaller than one micrometer.

As mentioned above, SF<sub>6</sub> tracer gas is a good surrogate for particulate as well as vapor. The capture efficiency adjustment of emissions measured by Method 315 takes particulate into account. However, deposition plates were installed at Plant C to ensure measurement of emissions that did not reach the sampling ports. The combined capture efficiency adjustment and use of deposition plates resulted in double counts, not missed counts, of some particulates.

### **13. Capture Efficiency Varies over the Day**

COMMENT: The commentor (Nadkarni) expresses concern over using a single average capture efficiency of 68% since capture varied over the course of each day's test and appears to be linked to wind speed and direction.

RESPONSE: As discussed later in Response 60, some variation in THC concentrations at Plant C were observed in Run 1 possibly due to poor capture efficiency, but this is largely speculation since similar trends were not observed in Runs 2 and 3. The lack of variation in actual THC readings (and CO and VOST compounds as well as qualitative evaluations of CO<sub>2</sub>) during periods of poorer capture efficiency supports a conclusion that the SF<sub>6</sub> tests underestimate capture efficiency (i.e., provide a biased low estimate for capture of the actual emissions). With this information in mind, it does not make sense from a scientific or regulatory standpoint to adjust THC emissions due to variations in capture efficiency over brief periods.

The manual method samples for PM, MCEM, Method 18 VOHAPS, and SVOHAPS were 4-hr composite samples and therefore can only be matched with a 4-hr average capture efficiency. The VOST VOHAPS tests, however, consisted of three or four 20 to 30-min samples spread out over the 4-hr test period. A preliminary analysis of Runs 1, 2, and 3 indicates that the measured VOST VOHAP emissions did not decrease over the 4-hr test period as the SF<sub>6</sub> capture efficiency decreased. For example, 14 compounds were detected in multiple samples from VOST Run 1, performed on 7/24/98. Of these 14, 5 decreased over the 4-hr test period, 4 increased, and 5 showed no significant change. For Run 2, performed on 7/25/98, 2 compounds decreased over the test period, 7 increased, and 8 showed no significant change. For Run 3, performed on 7/27/98, 3 compounds decreased, 6 increased, and 3 showed no significant change. Run 4, on the other hand, performed on 7/26/98, showed a different pattern. Of the 14 compounds detected in more than one sample, 12 decreased over the 4-hr period, 2 increased, and 2 showed no significant change. Given these inconsistencies, and given the comments about THC concentrations mentioned earlier, we feel that matching VOST VOHAP emissions with time specific capture efficiencies would not add significant value to the data presented.

As explained in Response 55's discussion of capture efficiency adjustments, the final report will use the lower 90% confidence level of the average capture efficiency for each run.

#### 14. Planning Inaccuracies Supplied by EPA , plus MRI's Schragger Report

COMMENT: The commentor (Nadkarni) mentions several issues that appear to be observations rather than points of discussion. Three items concern assessments of the capture efficiency of the enclosures. One item concerns an initial assessment of the capture efficiency of the Plant C enclosure by MRI's Brian Schragger that was based upon the design considerations of the tunnel and exhaust system. Another item concerns an assessment of Plant C based upon visual observations. The last concern related to capture efficiency is the Method 204 (TTE design) guidelines for assuming total capture. Two items concern the ability of the manual sampling methods to collect and measure all emissions. One of these items notes that either all of the organic compounds are not HAPS or that the manual sampling does not measure all organic emissions.

RESPONSE: The capture efficiency assessment based upon the design of the tunnel was part of an initial evaluation of the July 1996 industry-sponsored emission test. The conclusion of the assessment was that the capture efficiency could not be assumed to be 100% since two of the criteria in Method 204 were not met. However, while it was stated that a precise method to estimate capture efficiency was not available, a capture efficiency estimate of between 70 and 90 percent was made based upon a comparison to the Method 204 criteria. (Reference: Letter with Subject *Review of NAPA Loadout Test Report* from Brian Schragger of Midwest Research Institute to Ron Myers of U.S. EPA dated January 31, 1998)

The capture efficiency assessment based on visual observations during the preliminary testing of Plant C was based not only on the appearance of visible emissions from the tunnel exit but also on observations of visible emissions collected by the exhaust system. John Hosenfeld of MRI, Frank Phoenix of PES, and Mike Toney and Ron Myers of EPA performed the preplanning site visits and did not observe visible emissions attributable to load-out leaving the tunnel.

Observations during the emissions test were similar to those performed during the preplanning visits. The commentor is correct in that some visible emissions were observed at the downwind end of the tunnel. However, the vast majority of the visible emissions were drawn into the ventilation system. As was observed during the preplanning visits, visible emissions at the tunnel exit were partly the result of asphalt emissions from the beds of trucks that were exiting the tunnel. These visible emissions increased somewhat during conditions of high winds and were probably due to lower capture efficiency. It is apparent that daily atmospheric conditions have an impact on visible emissions leaving the tunnel.

The EPA's concern for obtaining good quality data led to a capture efficiency study performed by MRI at the Plant C site in May 1998. The capture efficiency study involved a series of smoke releases, several measured SF<sub>6</sub> releases, visual observations, and SF<sub>6</sub> capture measurements by extractive FTIR. Release location, truck location, and opening/closing of doorways were also considerations. Test results showed that acceptable capture could be achieved under normal plant operating conditions and expected winds. These results were presented at the Boston meeting of May 20-21, 1998, when plans for the full-scale testing at

Plant C were finalized. Results from the May capture efficiency tests were also summarized and submitted to EPA in a letter report dated July 20, 1998.

As indicted by the commentor, the issues of the sufficiency of EPA Method 204 criteria and the collection and analysis of the manual sampling methods were addressed in separate comments. Responses can be found with the summaries of those comments in Responses 10 and 11.

## **Post Loadout Emissions**

### **15. THC Emissions During Extended Period Tests**

COMMENT: Several commentors (Nadkarni, Fillion, Toxics Action Center, Yatzyshyn, Lynch) expressed concern over the determination of static emission rates (e.g., trucks sitting in the yard) based on the Plant D extended period tests. As a related issue, the same commentors were also concerned that holding the trucks for 15 sec following the final drop was not long enough, and that some fraction of the emission was missed. Additional clarification on both of these issues was requested.

RESPONSE: The commentors concern relates to the presentation of an emission rate of 0.17 lb/hr for post load-out emissions may not properly quantify these emissions. During the emission testing at Plant D, there were eight periods where loaded trucks were held in the enclosure and THC emissions measured for extended periods. The extended period test data presented in Figure 2 show that emissions are not constant. However, the data also indicate that not all emissions measured during extended period testing are post load-out emissions. Normally, about fifteen seconds following the last batch drop, the doors to the enclosure would have been opened briefly to allow the loaded truck to leave and be replaced with an empty truck. As discussed earlier in Response 11, the TTE design met all necessary criteria to assume essentially 100% capture. However, to achieve this capture efficiency, some of the emissions that occurred during a given loading operation were captured during subsequent loading operations. That is there were residual emissions in the tunnel from the previous load out. Some of these residual emissions were also measured during the extended sampling periods to quantify the post load-out emissions. Because of the one minute averaging times for THC and the variations within this period that trucks were released, it is impossible to eliminate any the overlap between measured emissions attributable to load-out operations and emissions that occur following load-out. As a result, the full extended period data was used to revise the post load-out emissions estimate. To differentiate these emissions from the load out emissions and to improve the terminology, the term “yard emissions” is used to describe these emissions.

### **Yard Emissions**

Table 4-4 of the MRI Plant D draft report presented data from several extended period tests in an attempt to determine a static emission rate. The average emission rate at the end of the

(Test 2, extended period 13:33-13:38)

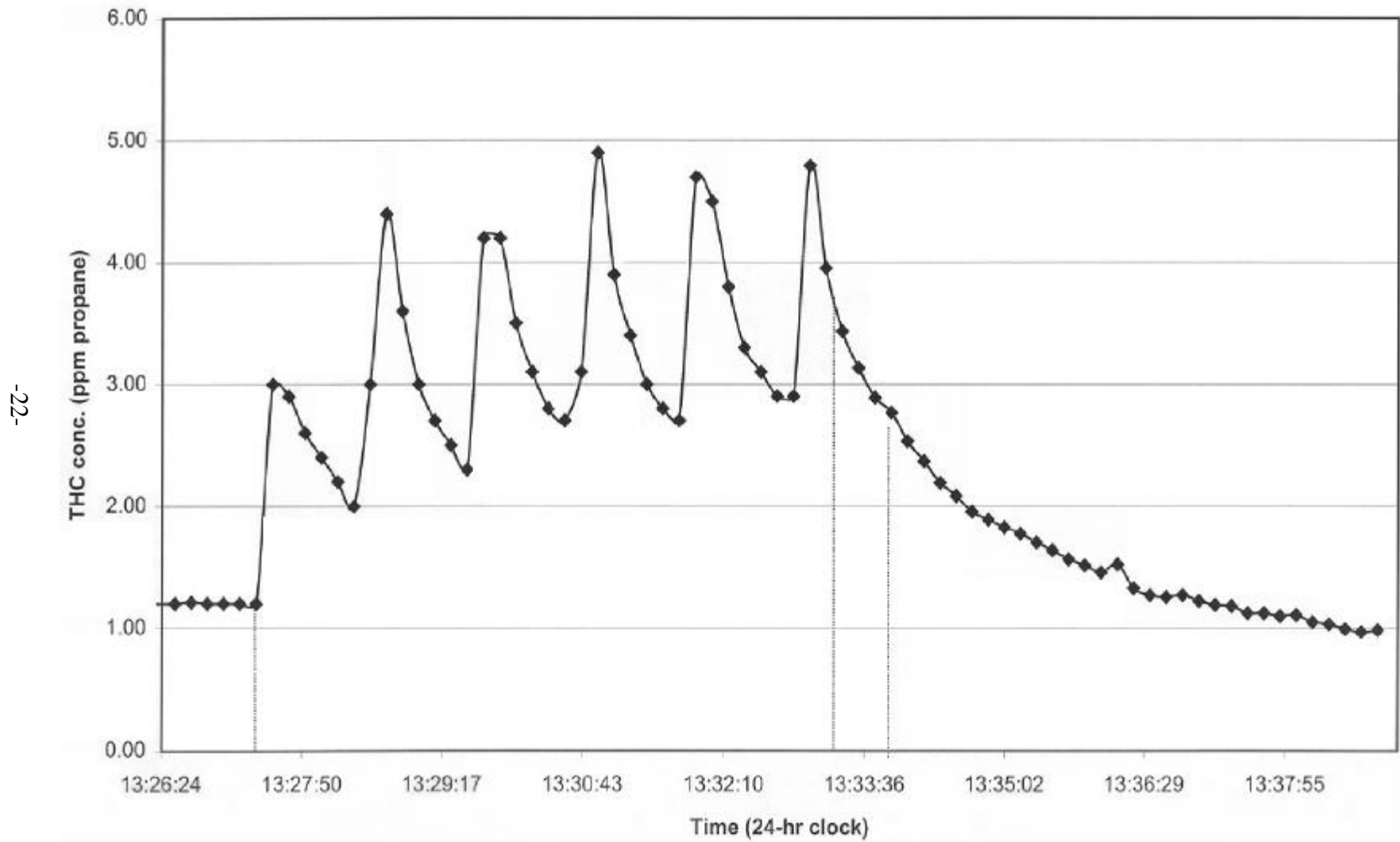


Figure 2. "Extended Sampling Period Emissions"  
(Test 2, extended period 13:33 - 13:38)

extended period tests for those tests greater than 4-min was used in the Executive Summary report as the “Post Truck Loading” emissions rate. The rate presented was 0.17 lb/hr (equivalent to 77 grams/hr) of THC. This static emission rate has been poorly defined by all parties involved in the project but is generally considered to represent emissions from loaded trucks sitting in the yard or in transit to a paving site. Thus, it is important to note that the yard emissions described below double-count emissions already included in the 15-sec period following the final drop, and thus bias these emissions high. Additionally, these emissions include those emissions retained in the tunnel and are described above.

Figure 3 shows time plots of the extended period test results. Note that the 3-min extended period test data were dropped from consideration since all other test data are from 5 to 7 min in duration. Additionally, it is apparent that the six data sets demonstrate a consistent downward trend. Several curve fits in Lotus and Excel were attempted on this data set, but the downward trend of the data presented problems for these programs.

Successive emission rates for each data set were added to obtain cumulative emissions over time. Figure 4 shows the cumulative emission (total grams) versus time after loading for each of these sampling periods. For the scale shown, much of the data appear to be nearly linear, although some of the data and the previously noted tail-off indicate that a nonlinear function may be more valid. Both linear and nonlinear functions were investigated. Table 1 summarizes the best curve fits for the linear and nonlinear functions. All three of these functions are plotted on Figure 4 with the data sets and are described in the following paragraphs.

**Table 1. Yard Emissions Summary**

	Linear function	Nonlinear (quadratic)	Nonlinear (power)
Equation	$1.75 * T + 0.96$	$-0.025 * T^2 + 1.96 * T + 0.64$	$2.45 * T^{0.855}$
r-squared	0.927	0.928	0.951
Time = 5 min	9.7 grams	9.8 grams	9.7 grams
Time = 8 min	15.0 grams	14.7 grams	14.5 grams
Time = 10 min	18.5 grams	17.7 grams	17.5 grams
For an 8-min period:			
Run 1 (37 trucks)	554 grams	543 grams	536 grams
Run 2 (35 trucks)	524 grams	515 grams	507 grams
Run 3 (34 trucks)	509 grams	500 grams	493 grams

Note that these equations may not hold beyond 5 to 7 min for several reasons. First, no data are available past eight minutes and, as with all extrapolations, estimates beyond the available data are highly speculative. Second, as described in Response 53, emissions are highly dependent on temperature. The asphalt will cool and the emission rate will be further reduced. It is expected that these equations will provide emission estimates that are biased higher with increasing time. Because of the consistent downward trend in the data, we believe that the linear equation is an upper-bound estimate of emissions. The power function equation is believed to provide the least biased emissions estimate within the constraints of the data. However, the



### Extended Period Tests (1 min. averaging)

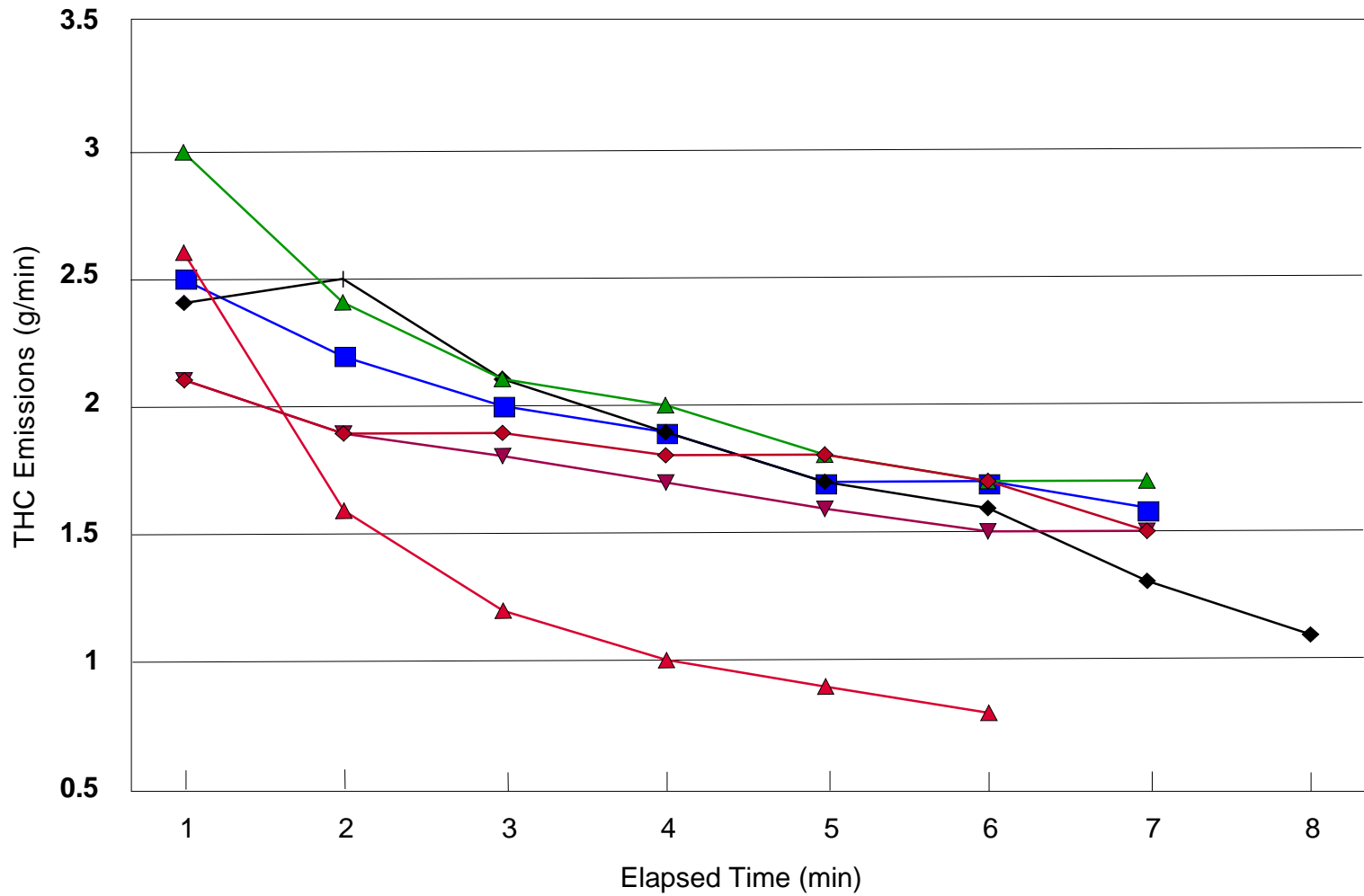


Figure 3. Extended Period Tests (1 min averaging)

### Cumulative Emissions vs. Time After Loadout

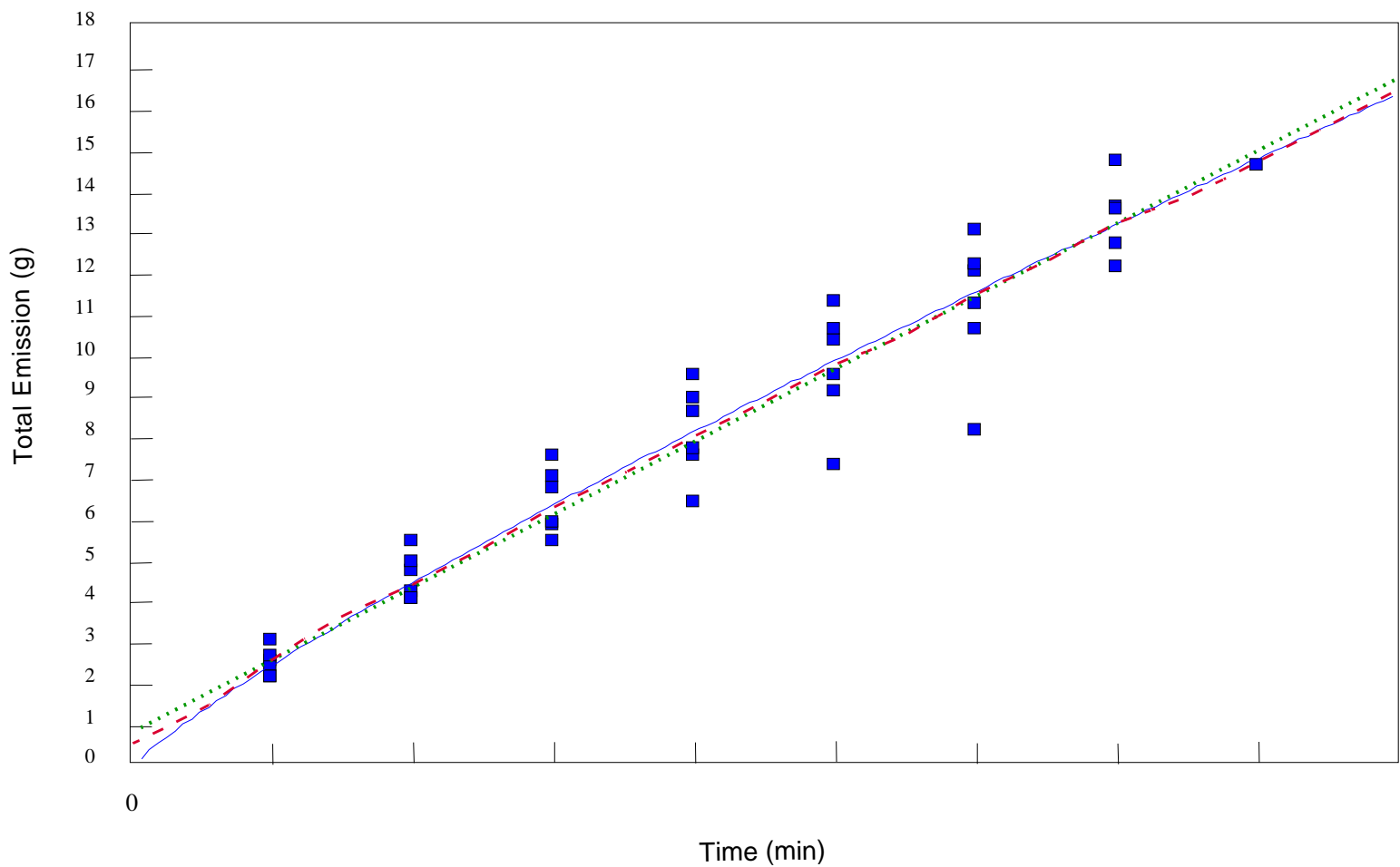


Figure 4. Cumulative Emissions vs. Time After Loadout

linear and power equations can be used to show a range of the upper-bound estimate of yard emissions. Cumulative emissions were calculated at the 5-, 8-, and 10-min points and are included in the table below. These times should be typical of the times that trucks are in the vicinity of the production and loading operations. The table also includes a summary of total yard emissions from each test run, using the actual number of trucks for each test. “R-squared” is a mathematical term used to numerically define how well the curve fits the data, and a value greater than 0.9 is considered good. The three equations below were the three best-fitting equations generated.

Table 2 summarizes all of the emissions from the Plant D testing. These emissions include the measured emissions presented in the draft Plant D report, and post-loadout emissions based on the power function with an assumed 8-min period for the yard emissions. As noted previously, some of the emissions used to estimate total yard emissions were measured during the test program.

**Table 2. Summary of Plant D Emissions**

Emission Type	Run 1 (grams)	Run 2 (grams)	Run 3 (grams)
Measured	546	632	662
Yard (@ 8 min)	536	507	493

## 16. Effects of Truck Lines Leaving the Plant

COMMENT: The commentor (Yatzyshyn) states that trucks lining up to leave the plant would be a significant source of fugitive emissions. The commentor also stated that the number of trucks in relation to production will also change the emissions.

RESPONSE: The only delays that occur following truck loading are the periodic delays to make temperature measurements or to obtain a sample for quality assurances purposes. During the test program, these delays were generally less than 2 to 3 min. However, it was common at the two tests to have a number of trucks waiting to be loaded with asphalt. Measuring emissions from diesel exhaust was not an objective of this test; these are better estimated by other methods.

## Storage Tank Emissions

### 17. Asphalt Cement Storage Tank Emissions

COMMENT: The commentor (Fillion) stated that emission from the filter on the asphalt storage tank was noticed throughout the testing. In addition, he noted that there was discoloration of the tank skin just below the filter. He indicated that the emissions continued steadily throughout the test.

RESPONSE: Methodologies are available to estimate emissions from heated organic liquid storage tanks (see Organic Liquid Storage Tanks in Chapter 7 of AP-42 <http://www.epa.gov/ttn/chief/ap42c7.html> and the TANKS software <http://www.epa.gov/ttn/chief/tanks.html>). The emissions from these types of tanks depend on the contents of the tank, the volume of gas vented, and the operating temperature range of the liquid in the tank. Emissions during the filling of these tanks (working loss) are governed by the saturation concentration of the liquid stored in the tank and the volume of gas displaced by the addition of liquid to the tank. Emissions during other periods (breathing loss) are governed by the saturation concentration of the liquid stored in the tank and the changes in the volume of the gas caused by temperature variations. However, vapor pressure information on paving asphalt is not available to allow the use of the TANKS program without additional information.

As was presented during the July 15, 1999 stakeholders briefing, we believe that information is available in the test report for Plant C to infer emissions during the filling of the asphalt storage tank and, by extension, the vapor pressure characteristics of paving asphalt at the typical operating temperatures. The derivation is based upon the assumption that emissions from the storage tanks and the silo vent are saturated and are at the maximum concentration possible for the temperature maintained. As a result, organic compound emissions (THC, MCEM, VOHAPS, and SVOHAPS) occur at the same concentrations as the maximum measured from the silo vent. Knowledge of the mass (volume) of asphalt transferred into the storage tank can be used to determine the volume of gas and, therefore, mass emissions from the storage tank during filling operations. With this information, an aliphatic hydrocarbon exhibiting equivalent working loss emissions can be added to the chemical compounds in the TANKS database. Following this, the breathing loss emissions can then be estimated. As indicated in Response 28, an upper-bound estimate of the maximum THC concentration of 2,000 ppm can be made. This value is equivalent to 0.000228 lb/ft<sup>3</sup>. It is estimated that 6,000 tons of asphalt binder is used in the production of 100,000 tons of virgin asphalt pavement. At a density of 69 lb/ft<sup>3</sup>, the volume of gas displaced from the storage tank by this asphalt binder is 173,913 cubic feet. As a result, the asphalt storage tank emissions during filling would be 40 lb/100,000 tons of asphalt production. The closest aliphatic hydrocarbons that would generate these emissions are pentacosane (C<sub>25</sub>H<sub>52</sub>) and hexacosane (C<sub>26</sub>H<sub>54</sub>), which produce 48 and 30 lbs of emissions, as determined by the TANKS program using Antoine's equation (below).

$$\text{Log } P = (-0.05223 A) / T + B$$

where:

log (P) is the logarithm (base 10) of the vapor pressure (P).

P = vapor pressure in mmHg

T = temperature for vapor pressure determination in °K.

The constants for pentacosane and hexacosane (using °K) are 87081.6 and 90385.7, for "A" and 9.734 and 9.8998 for "B" (Reference: *Handbook of Chemistry and Physics*; 54th Edition; CRC Press; June 1973). Using this information and an assumed temperature range of 20°F, it is estimated from the TANKS program that the annual breathing losses would be 4

lb/100,000 tons of asphalt production. Information on the derivation of these numbers will be included in the Assessment of Emissions at Hot Mix Asphalt Plants report.

## **Measurements—Sampling**

### **18. Sample Probe Cleanup Procedures**

COMMENT: The commentor (Fillion) expresses concern that the Method 315 probes were not sufficiently cleaned. Commentor 16 said, “The methodology for 315 dictates that acetone will be used to flush the deposits from all walls of the glass tubes by pouring the acetone down the tube while the tube is rotated 360°. . . In the second day of the test I observed technicians consistently washing only slightly over 180° of the probes.”

RESPONSE: At both Plants C and D the Method 315 probes were thoroughly cleaned as prescribed in the method. To start, rinse reagent was poured down the probe and drained into the sample container as the probe was rotated first 180° clockwise, returned to the initial position, and then turned 180° counterclockwise. This satisfies the requirements of the method. The probe was then brushed down its full length and back up its full length 3 times with a probe brush as additional rinse reagent was poured into and drained down the probe and into the sample container. Next, the probe was rinsed again with rinse reagent into the sample container while the probe was rotated first 180° clockwise, returned to its original position, and then turned 180° counterclockwise. The probe was then visually inspected along the entire inside surface to confirm that it was clean. Also note that at both Plant C and D Mike Toney and Ron Myers of EPA observed these procedures, and the PES Project QA Coordinator, Dennis P. Holzschuh, was on-site and observed and documented these probe cleanup procedures. This documentation is included in Appendix F of the Plant D report and in Volume 3, Appendix D, of the Plant C report. At Plant C, the Research Triangle Institute independent auditor, Dr. R. K. M. Jayanty observed and documented these cleanup procedures. This documentation is included in a letter report dated September 29, 1998 from Dr. R. K. M. Jayanty of Research Triangle Institute to Lara Autry of U. S. Environmental Protection Agency.

### **19. Collection of Large Diameter Particulate**

COMMENT: Commentor Fillion states that in the PES Plant D report (page 3-9), the consultants are concerned about the interference in accurately measuring asphalt fume due to the capture of large diameter material, referred to as “small dust.” This particulate material was noticed on both the screens that covered the hood openings, attributed to the pug mill paddles, and on the filters of the Method 315 trains. The commentor observes that the report states, “In addition to the fine particulate typical of asphalt fume emissions there was particulate of a size that was readily visible as individual grains of material. It is estimated that the size of the individual grains was about 0.1 millimeters in diameter.” The commentor concludes that the presumption that such visible particles are not a part of asphalt fume is one of the series of assumptions that lessen the total amount of asphalt fume.

RESPONSE: In Section 3.5 of the Plant D report, it is noted that on-site observations indicated that the ventilation system picked up some “small dust” kicked up by the pug mill paddles. Notations within emission test reports of this type are not unusual. Appearances of the material sampled which deviate from the familiar or customary are noted to identify potential variations that may affect the interpretation of the data. Typical comments may include variations in the color of material collected, differences in the visible quantity of material collected and the presence of loose material. The CAAP representative (Dr. Nadkarni) observed this sample and concurred that the loose particulate appeared to be about 0.1 mm in diameter and that the sample appeared different from the other samples collected. In Section 2.1 it is noted that the emissions presented may be biased high as a result of this “small dust.” Note, however, that no correction was made to lessen the total amount of asphalt fume, and the data presented for Plant D include the “small dust.”

## **20. Coordination at Massachusetts Test**

COMMENT: Commentor Fillion states that in the PES Plant D report (pages 3-3 and following), the coordination between the control room and field technicians for starting and stopping Method 315 relied on the visual evidence of exhaust from the fan stack. After the last load, the Method 315 testing continued for 15 to 20 sec and then stopped when visual observations indicated that load-out emission had stopped. However, CAAP’s representatives report that there was never a stopping of visible emissions from the exhaust tunnel, though there were clear variations in the quantity of moisture. Additionally, the plume was for the most part colorless, not white as indicated in the PES report (page 3-6). The white color was apparent only in the early morning during the colder part of the test period.

RESPONSE: Throughout each day, it was possible to observe and distinguish between periods of visual emissions during load-out and periods of no visual emission between load-outs. In the morning the distinction was more obvious, but the distinction was discernable throughout the day. The PES project manager was in the Plant D control room for the entire test program and observed this pattern from no visual emissions, to visual emissions, to no visual emissions over 700 times. A typical truck load-out, of which there were more than 100, consisted of seven drops over a 7- to 8-min period. Testing began before the first drop began and continued until approximately 15 to 20 sec after the last drop when the seventh and final visual plume dissipated.

As noted, the project manager was in the control room with the operator of the facility during the testing at Plant D. Detailed information on the beginning and end of each loading operation was obtained by the project manager from the control room operator. This information was radioed to the operators of the test equipment and the people in the tunnel that operated the doors and vent for the truck exhaust.

## **21. Sampling Periods Missed**

COMMENT: The commentor Fillion states that some asphalt dumping episodes were not measured because of coordination difficulties with the control room. The THC calculations appear to account for these difficulties (i.e., time log of doorway operations), while the PM and

MCEM measurements do not. The commentor believes that testing continued while the doors were open, allowing the ambient breeze to carry away some emissions.

RESPONSE: Testing was performed at Plant D only when the doors were closed and load-out was occurring. No testing was performed when coordination difficulties resulted in uncaptured emissions. Also note that the asphalt loaded during these missed periods was excluded from emission calculations.

## **22. THC Indicates Lingering Emissions & Corrections Needed**

COMMENT: Commentor Fillion states that data over the time period of 1006 to 1018 (Plant D, Run 3) show increasing emissions during times of non-activity. This event should be explained. The commentor suggests scaling the data to account for time periods between loading.

RESPONSE: The data referred to by the commentor are plotted on Figure 4-4 on page 4-10 of the Plant D draft report and are from a specific 15-min interval used to verify the THC data logging rate. During the 15-min period, THC data logging was increased to one reading/sec (rather than the usual 1-min averaging) to provide better time resolution. Figure 4-4 shows the 1-sec data along with 10-sec and 1-min averaging. It is clear from the 1-sec data that loadout operations were under way during this period and that the emission tails off after each asphalt drop. Times recorded by the logger do not exactly match the main log in Appendix E because the logger had to be reset (to perform 1-sec logging) for this specific 15-min period.

Scaling the data to account for time periods between loading is not appropriate and was largely covered under Response 15 (Capture Efficiency and Yard Emissions). Scaling the data by a simple ratio of time periods assumes that the emissions between loading operations remain at the same average concentration as the measured emission, and does not tail off over time. Time plots presented earlier show that this is clearly not the case. Note that the integration of the entire tail-off integral (Response 15 under "Capture Efficiency") resulted in a factor of 1.33 to 1.42 and represents an extremely high estimate for the reasons discussed there. The Capture Efficiency Adjustment Factor of 1.06 to 1.10 discussed in Response 15 has been shown to be a better estimate of potential measurement discrepancies.

## **23. Measurement of Duct Velocity**

COMMENT: The commentor (Nowick) points out the discrepancies in the PES report referencing the use of Method 1 and Method 1A at the SED at Plant C. The commentor also notes that the Method 1A criteria for 8 diameters downstream and 2 diameters downstream were not met.

RESPONSE: Method 1A was followed at the SED with one exception: an S-type pitot tube instead of a standard pitot tube was used to measure velocity pressure. This exception was approved by the EPA prior to the testing. The substitution of an S-type pitot tube for a standard pitot tube was allowed since a standard pitot tube would not fit through the sampling port and

would not measure the velocity at the sampling point. With respect to the sampling location, EPA Method 1A allows sampling with as little as 2 diameters downstream and one-half diameter upstream. The sampling location at the SED was within the allowable range.

## **24. Analysis of Silo Filling Operations at Plant C**

COMMENT: Commentor Nadkarni requested that additional text describing the THC readings observed at the Plant C SED location be provided. THC calculations for this location should be described in greater detail. The commentor specifically notes the different concentrations within and between the three runs. The commentor suggests that a problem with the sample line caused the variation.

RESPONSE: As noted by the commentor, the SED testing was intended to measure emissions during times of silo filling, when the silo is vented. When the silo is not being filled, no silo headspace is being displaced, and airflow through the SED is zero. For periods of no airflow, measured headspace concentrations are meaningless because the resultant emission would remain zero (i.e., emissions equals concentration times flow rate). Thus, only THC concentrations measured during time periods of silo filling are relevant to determining silo emissions, and other time periods should be ignored. Note that this especially applies to Run 2, discussed below, where concentrations of 1 to 10 ppm THC were logged for over an hour from the exhaust duct from the silo when no silo filling took place, and were incorrectly included in the daily average.

During Run 1, MRI operated a single THC, and the analyzer alternated measurements between the TED and SED. Measurements were collected concurrently with the FTIR, and SED sampling was performed only during periods of silo filling, which typically was 30 to 60 min in length. Thus, the two time periods mentioned reflect two separate time periods of silo filling: one from 0720 to 0805, and one from 0936 to 1030. The data show that emissions levels averaged (to quote the commentor) about 710 ppm for the first period, and about 460 ppm for the second. There were no observed changes in the test conditions to account for these variations. These data are not affected by capture efficiency, and the observed differences are likely due to random scatter.

During Runs 2 and 3, MRI operated two THC analyzers and thus was able to dedicate one of the analyzers to the SED location for the entire test run. The time plot of Run 2 (Appendix E, MRI Plant C draft report) shows these data, and the commentor correctly observed an initial hump around 0900, with emissions then tailing off to a low level. The time period from 0845 to 0925 corresponds to the actual time of silo filling and provides the only data of interest for Run 2. Averages were calculated incorrectly using data from the entire day. The THC Emissions Summary (Table 3-7 of the Plant C draft report) will be corrected.

During Run 3, silo filling occurred over an extended period relative to the other tests. (Two periods of 1 to 2 hr each were monitored by MRI, as opposed to the usual 15- to 60-min silo filling episodes). The moisture content of the SED exhaust gas changed from 14% on 7/24/98 to 23% on 7/25/98, 60% on 7/27/98, and 45% on 7/28/98 as the moisture content in the



RAP varied. Also, the load-in rates varied from day to day. These variations could account for many of the variations in THC concentrations observed. MRI monitored continuously throughout the test day, except for two time periods where instrument checks were performed (approximately 0737 to 0750 and 0930 to 1010). Emissions during Run 3 were of a much higher concentration than Runs 1 and 2 and exceeded the instrument span (1000 ppm) for a time period of about 10 min at 0723 and 4 min at 0840. These THC concentrations observed were significantly higher than the 600 to 800 ppm maximum concentrations seen in Runs 1 and 2, and it was not possible to recalibrate the instrument in order to bring these readings on-scale. Following the high excursion at about 0850, THC concentrations returned to the more typical levels of about 500 ppm and remained there for the rest of the test. Duct airflow (Table 3-3 of the Plant C Draft Report) is also low for Run 3 by a factor of nearly 2, which helps explain the high concentrations observed. (The acfm was relatively constant, but scfm varied with the change in moisture content mentioned above.)

During this review of the silo emissions data it was noticed that emissions were calculated using the dry-gas flows rather than the actual gas flows. Since the THC instrument measures emission concentration on a wet basis it was incorrect to calculate the emissions on a dry-gas basis. In the final report, the silo emissions will be calculated on a wet-gas basis. As a result of both of these corrections, the Run 2 corrected emission rate of 1.8 lb/hr is now similar to the 2.1 and 2.3 lb/hr measured in Runs 1 and 3, respectively. Therefore, the revised emission factors for silo filling are 530, 650, and 420 lb/100,000 tons for Runs 1, 2, and 3, for an average of 533 lb/100,000 tons. Note also that Run 3 may have a low bias due to the high excursions just discussed. However, as estimated in Response 28, the maximum bias due to this 10-min excursion is estimated at 3.6% and does not affect the emissions after rounding to two significant figures. Additionally, although Run 3 may be biased low, it does have the highest emissions. Since the exclusion of this run would result in an even lower bias in the emissions, this run will be included and a statement that an estimate of 3.6% bias due to this excursion will be included. Because of the differences in the production rates during Silo 2 loading, the variations in the emission factor are reduced from those presented in the draft report.

## **Measurements—Analytical**

### **25. THC Plugging of the Nozzles and Hydrocarbon Deposition**

**COMMENT:** Several commentors (Nadkarni, Ecology Center, Eberhard) expressed concern that not all the fugitive emissions reached the THC instrument, and that the THC data may be biased due to plugging of the nozzles.

**RESPONSE:** The commentors may have misinterpreted sample activities during Plant C testing. During Run 1 of the TED/SED testing, a single THC analyzer was in operation and was switched back and forth between the two sampling locations simultaneously with the FTIR. Operational problems prohibited the second THC analyzer from operating concurrently. For Runs 2 and 3, however, an additional analyzer was acquired (rented), and THC data were

simultaneously collected at the TED and SED. Table 3-2 of the Plant C report summarizes operating times of the THC analyzer at each location.

It is not clear what the commentors are referring to by “plugging of the nozzles.” High moisture and THC levels at the SED during Run 3 caused some difficulties in keeping the flame lit, and the analyzer was briefly taken off-line twice to check the instrument. Except for these two short periods, THC operations proceeded normally. Proper flows were maintained at all times, and all calibration checks were within acceptable limits. The flame problems mentioned above are not abnormal for this type of instrument and did not cause a low bias to the data. RTI provided a brief description of these events in their audit report and hypothesized that the problems were caused by “clogging of the FID burner tip.” However, these issues were not discussed with MRI at the test site by either the RTI auditors or the CAAP representative. Additionally, while RTI commented on the situation, this finding was classified as “Unlikely to Have an Effect on Data Quality.”

## **26. Calibration Checks on THC for Plant C, and Calibration with Propane vs. Other Calibration Gases**

COMMENT: The commentor (Nadkarni) expresses concern that zero/span error and instrument drift may be a significant portion of the measured background. Furthermore, the commentor is concerned that the analyzer span was maintained at 100 ppm despite lower readings during the testing. Finally, there is concern that the THC analyzer was calibrated with propane but was not recalibrated for other compounds likely to be present.

RESPONSE: The commentor expresses a valid concern that the instrument drift may be greater than the reported background emissions. Calibration data are presented in Appendix E of the MRI Plant C draft report and show the measured zero drift to be 1.3 ppm, 2.0 ppm, 2.0 ppm, and 0.1 ppm for Runs 1, 2, 3, and 4, respectively. All these tests met the calibration criteria of 3% of instrument span, or 3 ppm, since the instrument was spanned with 100 ppm propane. It is unlikely that instrument drift affected the background run since the Run 4 drift was only 0.1 ppm.

Instrument span was maintained at 100 ppm throughout the test series for several reasons. First, the instrument was spanned at 100 ppm to provide a typical operating range for a source with emissions of unknown magnitude. Instrument linearity was checked using gas mixtures of 25 ppm, 50 ppm, and 90 ppm according to the procedures outlined in Method 25A, thus assuring accuracy across the full 100-ppm span.

Following Run 1 (high value of 26 ppm), MRI had an opportunity to recalibrate the analyzer at a lower span value. Method 25A, Section 2.2 (Span Value) recommends that the instrument operator “...use a span value equivalent to 1.5 to 2.5 times the expected concentration.” For 26 ppm, a span value 2.5 times greater would be 65 ppm. It was decided that maintaining a 100-ppm span was the best course of action in view of (1) the need to maintain run-to-run operating consistency and (2) the uncertainty of measuring emissions from a source suspected to have higher THC levels. Runs 2 and 3 had high concentrations of 33 ppm and 17

ppm, respectively. The THC analyzer met all linearity criteria at the 25-, 50-, and 90-ppm calibration levels, and the data are considered valid across the full 100-ppm span.

Method 25A uses a flame ionization detector (FID) to measure hydrocarbon levels during combustion of the sample gas. The commentor is correct that different hydrocarbons can have a high or low signal, and the FID response is essentially based on the molecular structure of the hydrocarbon. For most sources tested, Method 25A reports a conservative estimate of “total VOCs,” since the FID detector responds to both methane and ethane (i.e., they will be included in the “total hydrocarbon” count). In addition, neither methane or ethane is classified as a HAP compound nor as a VOC for determinations related to the Ozone National Ambient Air Quality Standard.

FID detectors have been in use for many years by a wide variety of industries, and published response factors exist for many hydrocarbon compounds. “Response Factors for Gas Chromatographic Analyses” by W. A. Dietz (*Journal of Gas Chromatography*, February 1967, pages 68-71) is one such source and lists response factors for many individual compounds or families of compounds. Typical response factors for aliphatic, aromatic, and cyclic hydrocarbons range from 0.97 to 1.03, meaning that one could expect an inaccuracy of about 3% when measuring these species. Non-hydrocarbon species such as alcohols and aldehydes tend to have much poorer responses (0.23 to 0.85) but were effectively quantitated by other techniques in the test program (EPA Method 18, EPA Method 0030, and EPA Method 320). They were detected at levels that are relatively low compared to the aliphatic and aromatic hydrocarbons. Propane was used as a calibration gas for the THC analyzer and has a published response factor of 0.98. In addition, when converting from the measured ppm value to a mass emissions basis, using the molecular weight of propane provides a conservative (higher) mass emission compared with the cyclic and higher molecular weight aliphatic compounds that are actually being measured.

Method 25A does not provide procedures for correcting data due to response factors of individual species (since they are not identified by the method), and it is generally accepted that response factors for multi-component mixtures such as asphalt fumes will average out to approximately 1.00. For gas sources where a few clearly identified components make up significant portions of the mixture, it may be possible to obtain better accuracy by applying individual response factor corrections and individual molecular weights in calculating mass emissions. For the asphalt fumes encountered at Plant C, however, this level of detail is not needed since the response factors for propane and hydrocarbon mixtures are nearly the same and using the molecular weight of propane provides a high bias.

## **27. Analytical Interferences on Silo Samples**

COMMENT: The commentor Fillion states that the Executive Summary in the PES CA report (Vol. 1, sec. 2.1, page 2-6) acknowledges a problem with non-targeted hydrocarbons interfering with the analysis of target HAPs at the SED. Yet those non-targeted hydrocarbons did not interfere with the Tunnel Exhaust Duct (TED) measurements. Is there an explanation of why those non-targeted hydrocarbons did not affect one area while they did the other?

RESPONSE: The non-target hydrocarbons, present in the SED at levels well above 500 ppm, were present only at much lower concentrations (less than 10 ppm) in the TED. The high concentrations created interference problems; the low concentrations did not. The difference in these non-target hydrocarbon concentrations is evident in the THC data presented in the MRI report.

## **28. THC Reads 999.5 or Greater. How Did MRI Average These?**

COMMENT: The commentor (Napadensky) asks for clarification on how readings beyond the instrument maximum of 999.5 ppm were treated.

RESPONSE: Values greater than 999.5 ppm THC were logged as 999.5 ppm and represent the maximum reading of the instrument. These values were included in the average for the entire test period. In previous discussion from Response 24, revised mass emissions for Runs 1, 2, and 3 show 2.1, 1.8, and 2.3 lb/hr, respectively. Since the Run 3 average contains “pegged” values at 999.5 ppm rather than an actual reading at a higher concentration, Run 3 may have a low bias, and data from Runs 1 and 2 are more useful in characterizing these emissions. The usefulness of the Run 3 data can be evaluated in two ways. The first is based on the consideration of the effects if these data are excluded from use entirely because of the excursions above the instrument’s capabilities. As can be seen, the exclusion of the data would result in an average value that may bias the data more than the bias introduced due to the inability of the instrument to measure the higher value. The second method to evaluate the usefulness of this data is to estimate the bias of using this data with the excursions. An analysis of the potential bias follows.

Two episodes of “pegged” THC readings occurred during Run 3. One was for a 10-min period from 0723 to 0733, and one was a 4-min period from 0841 to 0845. Two other episodes occurred and lasted 1 min. Using the slope of the lines on either side of the “pegged” readings, an estimate of the “unmeasured” emission was determined graphically from the Run 3 THC time plot (Figure 5). A maximum concentration of about 1800 ppm is estimated for the 0723 to 0733 time period. This estimate is considered to be an upper-bound estimate for the following reasons:

1. Data from Run 1 and 2 also show fairly steep curves on both sides of a plateau that is below the 1000 ppm maximum reading of the instrument. Figure 6 shows data from Run 2 typical of both runs. As can be seen, there is a very steep curve that plateaus at about 500 ppm. Extrapolating this curve shows a peak value near 2000 ppm, a situation not shown by the actual data for this Run
2. Despite the steep curves seen in Run 3, several on-scale readings were observed immediately before and after the “pegged” readings, indicating that the true peak was likely just beyond the instrument span of 1000 ppm. Specifically, these readings were 856 ppm at 0722, 811 ppm at 0734, 994 at 0840, and 982 ppm at 0845.

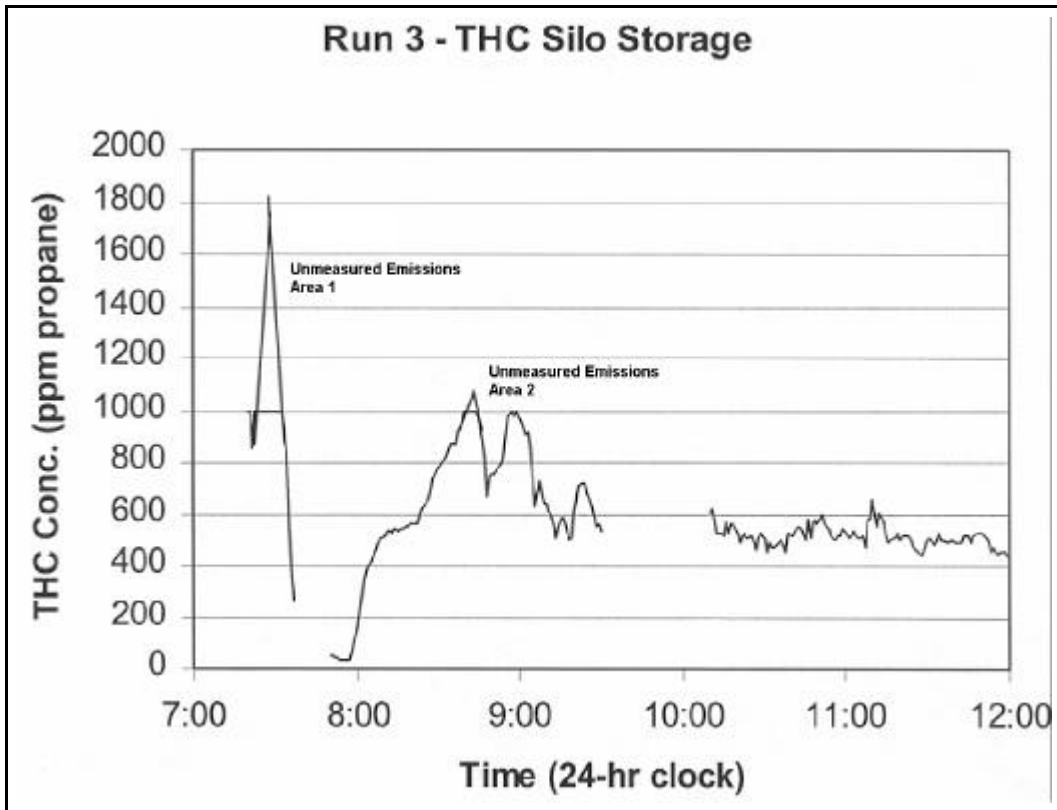


Figure 5. Unmeasured THC Silo Storage Emissions, Run 3

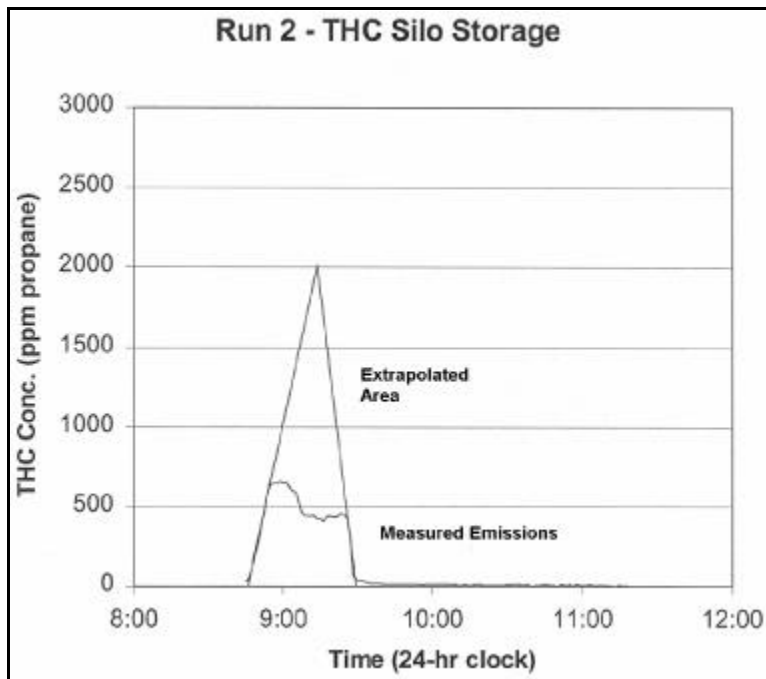


Figure 6. THC Silo Storage Emissions, Run 2.

Integration of the area under the curve (“measured” emission) and the two triangular areas marked on the plot at “Area 1” (10-min interval) and “Area 2” (4-min interval) allows us to estimate the “unmeasured” emission. Table 3 shows the results of these integrations.

Note that this analysis is included as a way to determine the usefulness of the Run 3 THC data. The reported data are not corrected in any way. As the table indicates, Run 3 data may be biased low by about 3.66%. Therefore, adjusting the Run 3 data would result in an emission rate of 2.4 lb/hr. Averaging this with the Run 1 and 2 data would result in an emission rate of 2.09 lb/hr compared to the original 2.07 lb/hr. Since both of these values would round to 2.1 lb/hr, the bias would be insignificant.

**Table 3. Plant C, SED, Run 3 Unmeasured THC Emissions**

	Base (min)	Height (ppm)	Area (ppm-min)	% of total
Area 1	10	1000	5000	3.6
Area 2	4	40	80	0.1
“Measured” Area	NA	NA	135122	96.4
Total Area	NA	NA	140202	100.1

NA Not applicable.

## 29. CO Emissions on Fig 3-2, 3-3, Tables 3-4, 3-5, Add Footnotes

COMMENT: The commentor (Acott) believes that CO data from the Plant C process stack testing is suspect due to process problems and should be explained and/or footnoted.

RESPONSE: As noted in Section 3.1.1 of the MRI draft report, there were several operational problems encountered during the dryer stack testing. The commentor may be correct in assuming that process problems contributed to the CO fluctuations observed. Should the commentor have additional detailed information that supplements the text in Section 3.1.1, this information can be added to the final test report. The tables and graphs mentioned by the commentor will include a short statement on the operational difficulties and a reference to Section 3.1.1 for more detail. It should be noted that the emission factors measured during this test (0.0041 and 0.017 lb/ton) are in the lower range of available site-specific emission factors (0.011 to 0.6 lb/ton) used to develop the CO emission factor of 0.15 lb/ton presented in the current draft AP-42 section for hot mix asphalt plants.

## Measurements — Mass Balance

### 30. Detailed THC Analysis and Closing the Mass Balance

COMMENT: Commentors Nadkarni and Ecology Center note that discussion of the THC results is lacking and that the mass balance numbers do not add up. One commentor (Nadkarni)

also requests justification for using one set of numbers over another, and specifically cites rejection of Method 18 data versus the GC/MS or FTIR data.

RESPONSE: Detailed discussions of the THC results are included in Response 5 for Plant C and in Response 18 for Plant D. A brief discussion of the overall mass balance is included below. Note that the Plant C testing was intended to be an emissions characterization study and was not designed as a mass balance study. A mass balance study is more complex (in terms of sampling, analysis, and data evaluation) than the testing at Plant C. While a mass balance study provides information on the major components of the emissions and can provide additional information on emissions, it does not necessarily improve the reliability or accuracy of emission measurements and significantly increases sampling and analysis costs. However, in this response, we have addressed the commentors issues of mass balance between THC and the suite of VOHAP methods used in the Plant C test.

The summary of test methods (Figure 1), presented as part of Response 10, above, should lend some clarity to the mass balance. The commentor is correct in that the sum of the individual HAP compounds reported in the Executive Summary do not match the THC values. THC values do, in fact, represent total vapor phase hydrocarbons (as seen by an FID calibrated to a propane standard). Other measurement methods, however, were chosen to measure specific pollutants such as HAPs and PAHs, and thus represent discrete fractions of the total hydrocarbon count. Note that there is occasional overlap of the test methods—where two methods are measuring the same compounds—which may result in some double-counting. Response factor variations exist for each identified species due to the different detector types (FID, GC/MS, or GC/FID) associated with each method. These variations may also contribute to inconsistencies in the mass balance. Finally, the Method 320 (FTIR) results did not completely speciate the organic compounds referred to as “toluene” and “hexane” in the test report. While these two HAP compounds represent the best least-squares spectral fit (using EPA reference spectra available at the time of analysis), the mixture was very complex and composed of primarily aliphatic hydrocarbons. This is the principal reason that the emissions listed as “toluene” and “hexane” in the test report were not used as emissions of these specific compounds.

To reduce the confusion caused by using the closest HAP spectral fit for this mixture (i.e., toluene and hexane reference spectra), this response and the final report will use two new terms. The term “hydrocarbon mixture A” describes the compounds having spectral similarities to toluene, and the term “hydrocarbon mixture B” describes those with spectral similarities to hexane. The VOST analyses were generally more reliable than the Method 18 analyses, so they were preferentially used as measures of the emissions. Still, the Method 18 data cannot be discredited. Therefore, the Method 18 data will be averaged with the VOST data to quantify emissions.

The remainder of this section discusses in detail the FTIR analysis and the mass balance presented in Table 4. Technical issues related to the THC sampling are discussed in greater detail in Response 26.

As described earlier in Response 10, the THC analyzer and the extractive FTIR results provided the only measurements which estimate all of the vapor phase emissions. The remaining methods (Method 18, VOST, Method 0010, and portable GC/MS) provided measurements of specific targets within the general volatile and semivolatile classes of compounds. As noted by the commentors, the specific targets do not add up to anywhere near the reported THC values (Nadkarni mentions 6 lb out of 134 lb, as one example). A more detailed examination of the FTIR data and how they fit into the overall sampling and analysis scheme provides some clarity.

The FTIR spectral analysis indicates a mixture of primarily aliphatic compounds (likely C5 to C9 range). As stated above, using the EPA library of HAP reference spectra, the best spectral fit for the organic mixture was toluene and hexane. It is highly probable that with additional reference spectra, more individual non-HAP hydrocarbons could be measured in this complex mixture, and the reported toluene and hexane concentrations would be lower. At the time the original analysis was performed, the EPA spectral library contained only spectra of the HAPs hexane and isooctane in this class of compounds, and additional reference spectra were not available. Since then, however, MRI has measured reference spectra of 10 additional hydrocarbons and used these new spectra to speciate mixtures at six other sources. This work is potentially applicable to the Plant C spectra, and based on MRI's experience with spectral analysis, indicates the most likely components of the Plant C mixture are C5 to C9 non-cyclic compounds. Some cyclic hydrocarbons were investigated in the original analysis, and it is unlikely that these represent significant components of the hydrocarbon mixture. Because other methods provided valid analyses for the specific compounds of toluene, hexane, and isooctane, the additional confirmatory spectral analyses of the FTIR data are not warranted.

Table 4 summarizes the FTIR results presented in the Plant C draft report for the three sampling locations (Process Stack, SED, and TED). The table shows the reported emission rates for each individual compound identified by FTIR, the hydrocarbon mixtures quantitated using reference spectra for toluene and hexane, and the total emission rates. The table also includes the THC mass emissions measured at each sampling location (from Table 3-7 of the Plant C draft report), allowing a direct comparison of THC and FTIR measurements.

For the TED location, FTIR and THC measurements show virtually the same mass emission of about 0.50 lb/hr. FTIR results show that the major components of the emission are methane and hydrocarbon mixture B, with trace hits for hydrocarbon mixture A, ethylene, and formaldehyde. These compounds were detected at concentrations of 0.20 to 10 ppm in the source gas stream and are much more concentrated than the individual compounds targeted by the VOST, Method 18, Method 0010, and GC/MS. Thus, it is reasonable to expect that the overall mass balance basically works, and one can conclude that the majority of the emission is composed of aliphatic hydrocarbons rather than HAPs.

For the SED location, there is some discrepancy between the FTIR and THC measurements, but the mass balance still shows generally good agreement at about 1.7 to 3.0 lb/hr. Greater discrepancies may be expected since the concentrations observed at the SED varied over a much wider range than the TED. The FTIR results show that the major components of the emission are methane, hydrocarbon mixtures A and B, ethylene, and



**Table 4. Mass Balance Calculations  
(Based on THC and Extractive FTIR Measurements)**

	Run 1 (lb/hr)	Run 2 (lb/hr)	Run 3 (lb/hr)
<b>TED location</b>			
FTIR results			
Methane	0.084	0.079	0.082
Hydrocarbon Mixture A <sup>a</sup>	0	0.0044	0
Hydrocarbon Mixture B <sup>a</sup>	0.45	0.38	0.42
Ethylene	0.0051	0	0.0061
Formaldehyde	0	0	0.0011
FTIR total emission	0.54	0.47	0.51
THC emission	0.52	0.54	0.53
<b>SED location</b>			
FTIR results			
Methane	0.024	0.0033	0
Hydrocarbon Mixture A <sup>a</sup>	1.07	0.062	1.41
Hydrocarbon Mixture B <sup>a</sup>	1.7	1.65	1.29
Ethylene	0.0088	0.00057	0.052
Formaldehyde	0.051	0.0080	0
Isooctane	0.16	0.0091	0
FTIR total emission	3.03	1.74	2.76
THC emission	2.10	1.79	2.29
<b>Process Stack</b>			
FTIR results			
Propane	0.71	0	
Methane	2.66	4.85	
FTIR total emission	3.36	4.85	
THC emission	3.30	3.65	

<sup>a</sup> Together, “hydrocarbon mixture A” and “hydrocarbon mixture B” represent the best least-squares spectral fit for a non-aromatic hydrocarbon mixture. Mixture A was quantitated using reference spectra for toluene, and Mixture B was quantitated using reference spectra for hexane. See text for further details of this analysis.

formaldehyde. Isooctane was also observed in Runs 1 and 2. One can conclude that the majority of the emission is composed of aliphatic and aromatic hydrocarbons, rather than HAPs, since the manual methods again reported low levels of the specific target HAPs.

Process stack results have also been included in the table and show good agreement between the THC and FTIR results. One can see that the process stack emission is mostly methane.

In two other studies for other projects (not on asphalt plants), MRI has performed mass balance closures between THC and individual species (see references below). These studies compared THC measurements to the sum of individually targeted pollutants and provide a point of reference for large-scale emissions studies. Both of these studies were performed for EPA's Office of Solid Waste and attempted to quantitate all of the individual pollutants comprising THC measurements from hazardous waste combustors. These two studies used many of the same sampling and analysis methods used for the Plant C testing, with the notable exceptions of the online GC/MS and FTIR (Method 320).

One of these studies, the 1987 Total Mass Emissions (TME) study, showed mass balance "closure" (versus THC readings) ranging from 50% to 90%. Another study, that for Products of Incomplete Combustion (PIC), showed a range of 88% to 90%. That is, THC readings agreed to within 10% to 50% and 10% to 12% versus the summed components for the TME and the PIC study, respectively. Furthermore, these two studies showed that a high degree of mass balance closure is only achieved when major gas-phase components such as methane or non-target hydrocarbons are specifically quantitated. Other studies that are cited in other parts of this response to comments show similar results. Specifically, the 1997 report *Sources of Fine Organic Aerosol, Hot Asphalt Roofing Tar Pot Furnaces* could not resolve 84% of the organics, and only 50% of the resolved organics could be identified.

In conclusion, the FTIR measurements collected at Plant C contribute significantly to closing the mass balance (by indicating the presence of certain major hydrocarbon components) and have also served to identify key HAPs, such as formaldehyde, which were present at ppb to ppm levels. The remaining test methods (VOST, Method 0010, Method 18, and GC/MS) have quantified other targeted HAPs, most of which are present at ppb levels and make up a relatively small portion of the total emission. Finally, although the Plant C testing was never intended to provide a mass balance, the crude mass balances shown in the table compare well with two previous MRI mass balance studies on hazardous waste incinerators. To expect greater accuracy of the Plant C mass balance is beyond the scope of the test design and budget.

References cited above are:

1. "Total Mass Emissions from a Hazardous Waste Incinerator" ("TME"); Midwest Research Institute; June 1987; under contract to Acurex Corporation; EPA/OSW.
2. "Products of Incomplete Combustion Emission Test" ("PIC study"); Draft Report; Midwest Research Institute and A.T. Kearney, Inc.; April 1997; under contract to EPA/OSW.

### **31. Composition of Organic Particulate**

COMMENT: The commentor (Eberhard) notes that for Plant C, the PM seems to be 100% organic, discounting the background inorganic matter. She notes that if the adjusted OPM is 3.95 lb/100,000 tons, the PAH is 0.37 and the SVOHAP is 0.328, though the remaining bulk of the OPM is unknown. In addition, she questions whether the PAH and SVOHAP values are low or whether other material is involved.

RESPONSE: MCEM, or as the commentor refers to it, organic particulate matter or OPM, is a subset of PM. The TED background diesel emissions were subtracted from the TED normal operations emissions using the draft report method to adjust for background emissions. The PM emissions equaled the MCEM emissions, indicating that all the PM was MCEM. Note that a different calculation to adjust for the background concentrations is now being used, PM may no longer be equal to MCEM but is still likely to be most if not all of the PM. PAHs and SVOHAPS are a subset of MCEM. The fact that the PAH and SVOHAP results are about 18% of the MCEM total indicates that 82% of the MCEM is something other than the 19 target PAHs and the 87 target SVOHAPS. It does not mean that the PAH and SVOHAP results are low. It should be noted that other references cited in this response to comments more fully characterize the resolvable and identifiable portions of asphalt emissions. In the reference *Sources of Fine Organic Aerosol, Hot Asphalt Roofing Tar Pot Furnaces*, 73% of the organic mass was n-alkanes (aliphatic hydrocarbons), and only 7.9% of the identifiable organic mass (which was about 3.9% of the extractable mass) was composed of PAH compounds. The PAH percentage measured during the EPA test was comparable with this value. The 19 PAHs and 87 SVOHAPS are specific organic compounds that Congress has identified as potentially hazardous. There are many organic compounds that EPA has not identified as hazardous, and these compounds make up the majority of OPM present in the TED.

## **Measurements—Deposition**

### **32. Calculation Formulas to Determine Deposition in Tunnel**

COMMENT: Commentors Nadkarni and Fillion state that the formulas used for reducing organic particulate deposition on plates to actual deposition and emission rates are absent.

RESPONSE: The deposition calculations are presented for both Plants C and D. For Plant C the calculations are described in Volume 1, Section 5, pages 5-7 through 5-11 and presented in detail in spreadsheet form in Volume 1, Appendix A, pages 206 through 209. Deposition calculations for Plant D are described Section 5.5, 5.6, and 5.7 on pages 5-3 and 5-5 and presented in detail in spreadsheet form in Appendix D.

### **33. Development of Deposition Calculations.**

COMMENT: Commentor Fillion states that during the final review of the test protocol (Spring 1998), significant critiques were made of the deposition formulae. The EPA contractor asserted that the formulae would be reconstructed and provided for review prior to actual testing.

RESPONSE: Following the Spring meeting, EPA, PES, and the CAAP evaluated several modifications to the deposition calculations for the TED. A final decision was made in a meeting on-site just prior to the testing. EPA, PES, and CAAP met at Plant C and observed first-hand the TED and the issues surrounding the deposition estimates. At the meeting, the final



decision on how to handle TED deposition calculations was made and agreed to by all parties present, including Ravi Nadkarni, the CAAP representative.

### **34. Deposition Calculations**

#### **COMMENTS:**

- a. Commentor Fillion states that the qualitative descriptions found in Vol. 1, (pages 5-7 through 7-10) are not sufficiently detailed to ascertain the final deposition calculations without accepting on faith certain data. For example, there are no measurements given that demonstrate the differing areas accorded to the 6 boxes in the plenum's "tuning fork" (Vol.1, page 207).
- b. Commentor Fillion questions the statements in the PES test report where collecting boxes were identified as "contaminated" but no further description given on how that was determined. He further states that if it is not fully addressed, this will be perceived to bias the deposition to the low end.
- c. Commentor Fillion states that a multiplier of 1.084 was used to account for the corrugation of the sheet metal used to create the preexisting tunnel. The commentor suggests that a multiplier of 2 would be more accurate based upon pictures of the tunnel supplied by EPA. The commentor questions how the 1.084 multiplier was arrived at.
- d. Commentor Fillion states that no effort is made to account for deposition on tunnel side walls at either CA or MA, or to account for deposition on the several steel structural beams which are inside the tunnel in CA.
- e. Commentor Fillion states that the PES Report on MA (Appendix D) makes a number of assertions with no quantitative data to substantiate these numbers. This report suggests that the two elbows impaction areas, which are not defined with measurements or even a description, are the only impaction areas.
- f. Commentor Fillion states "Does the plenum have any impaction areas? Its design would suggest that is the case. Ignoring those impaction areas could bias the deposition factor low. Do non-impaction areas include the balance of the tuning fork and areas of elbows not considered impaction area? Where are the measurements of the tuning fork and other aspects of the ductwork to confirm the tabulation of 205.18 sq. in. of non-impaction area?"
- g. Commentor Fillion states "At the CA facility, there were three sample plates attached to the ceiling downstream of Silo 5, a distance of 66 feet (MRI report for CA, page 2-5). However, no plates were attached to represent the area between Silo 2 and Silo 5, which represents a distance of 42 feet. This length is two-thirds the length of the sampled area and includes many extra surfaces—the three tuning forks—upon which asphalt fume might depose."

## RESPONSES:

- a. The calculation was based on the ratio of areas calculation as described in Volume 1, Section 5, pages 5-7 through 5-11 and presented in detail in spreadsheet form in Volume 1, Appendix A, pages 206 through 209. In reference to the example cited by the commentor, the box pipe dimensions are presented on page 207. Note 1 states “six pieces of box pipe, 6" long by 3" OD, and 2.75" ID were installed in Silo 2 exhaust plenum.”
- b. The determination to exclude the contaminated samples from the data summary was not made to bias the plenum deposition to the low end. The determination was made by the PES Project Manager with approval of both the EPA Work Assignment Manager and the EPA Project Manager based on on-site observations during the box plate sample recovery. The extraneous material was asphalt transferred from the capture hood to the back sides of box pipes WS and ES. This material was observed during the sample recovery process, and it was decided to exclude the results from box pipes WS and ES from the data summary. Note, however, that deposition calculations were performed both including and excluding the contaminated samples (see Volume 1, Appendix A, page 207). Had the contaminated samples been included in the data summary, the results, in the opinion of the PES Project Manager, would be biased high. Nonetheless, both sets of data were included on page 207 to afford the reader the opportunity to include the contaminated samples if desired. If one includes the results from the contaminated samples in the Table 2.1 presentation on page 2-2 of the Plant C report, the PM and MCEM emissions increase by approximately 5%.
- c. The correction factor (i.e., multiplier) used to account for the corrugation of the sheet metal ceiling was reviewed. Based upon this review, the correction factor of 1.084 was in error. The revised correction factor of 1.217 will be incorporated into the calculation of the ceiling deposition on page 208 of Volume 1. This correction factor is based upon the corrugated shape of the sheet metal. The shape of the sheet metal can be described as two parallel lengths connected by segments at 45° angles (or a shape similar to “”). To have a correction factor of 2.0, the profile would need to be one of two parallel lengths connected by segments at 90° angles (or a shape similar to “”).
- d. At the last meeting in Boston prior to the Plant C test, a decision was made and agreed to by all parties present to measure deposition on the ceiling downstream of Silo 5 only. This consensus decision was made based on a discussion led by the PES Project Manager. In the discussion, he shared his observations from inside the TED that indicated that deposition inside the tunnel was minimal and primarily on the centerline portion of the ceiling downstream of Silo 5.
- e. There were only the two elbow impaction areas in the TTE Exhaust Duct (TTE). The first elbow served to transition the TTE from its original horizontal position coming off the exhaust plenum to a vertical position heading down to ground. The second elbow served to transition the TTE from the vertical position to a horizontal position heading to the exhaust fan. The TTE exhaust duct and its two elbows are pictured in Section 3.0 of the Asphalt Plant D report in Figures 3.2 and 3.3. Impaction and non-impaction surface area dimensions and calculations are presented in Appendix D of the Plant D report.

- f. While it was decided in the meeting in Boston prior to the Plant D test to estimate the deposition in the TTE exhaust duct only, the plenum does have impaction areas, and ignoring the plenum areas does bias the deposition estimate low. The deposition estimate from the TTE exhaust duct will be included in the calculation of the total deposition in the exhaust system.
- g. At the last meeting in Boston prior to the Plant C test, a decision was made and agreed to by all parties present to measure deposition on the ceiling downstream of Silo 5 only. This unanimous decision was made based on a discussion led by the PES Project Manager. In the discussion, he shared his observations from inside the TED that indicated that deposition inside the tunnel was minimal and primarily on the ceiling downstream of Silo 5. Observations during the field study confirmed these earlier observations.

### **35. Low Biases in Deposition Calculations**

COMMENT: The commentor Fillion identifies several areas where deposition calculations may be biased low.

RESPONSE: It was made clear early on that the deposition measurements were unusual and would be at best an approximation. Inherent in any approximation are biases, often both high and low. The commentor has identified several places where the approximations may be low. The commentor does not address places where the estimates may be high. For example in Table 2.34 on page 2-83 of Volume 1 of the Plant C report, footnote No. 2 states “PM deposition estimates for the TED, Ceiling, and Exhaust Plenum have a high bias due to ambient dust generated daily at start-up.” Another area where the data may be biased high concerns the location of the ceiling deposition plates inside the tunnel. At Plant C all of the three ceiling deposition plates were centered between the walls. This was the area of the tunnel that had the highest visible indication of asphalt deposition. It is believed that this deposition was the result of the asphalt fumes from the fully loaded truck beds pulling out of the tunnel. As a result, the deposition plates collected material that is most representative of the central portion of the tunnel exit. The deposition determined by these plates was applied over the entire ceiling area downstream of Silo 5. Since the deposition measurement was made in the area where there was the most visible deposition and applied to areas where there was little or no visible deposition, this measurement is biased high. It should also be noted that the capture efficiency adjustments accommodate not only the emissions that escaped capture by the hood system and deposited inside the tunnel but also those that escaped capture by the hoods and exited the doorways. It is believed that overall, the deposition calculations used for deposition measurements biased the capture-efficiency-adjusted emissions high.

### **36. Offgassing of Deposition Plates**

COMMENT: Commentor Fillion states that there is ample evidence in the reports that emissions continued to be measurable even when trucks were not in the loadout zone. He states that this could be a matter of residual emissions not captured by the exhaust system which are

later emitted from those surfaces. He states that at both locations, CA and MA, the deposition sample plates were on location for several days. Thus, the accumulated deposition measured does not account for substances that “emitted” from those sample surfaces during the +15 hr that those plants were not in operation (evening and nighttime). Therefore, it appears that the deposition numbers could be biased low, with no way of estimating that bias from results from this test.

RESPONSE: It is not clear what measurements of residual emissions the commentor is describing. As discussed in Response 22, the emissions that the commentor appears to be using as evidence of residual emissions were in fact emissions during truck loading. It is true that when either of the facilities was operating, ten or more minutes were required for the THC concentrations to return to near-background concentrations. While a very small portion of this residual concentration may be due to the deposits of asphalt that collect on the structure surrounding the loadout chute and are kept hot by the silos. To a lesser extent, this could also include the nearby surfaces of the capture hoods. A more significant source of the residual emissions was noted by another commentor. That is, the residual concentrations may be the result of “channeling” of the air flows in the tunnel. In reality, this “channeling” may be incomplete mixing of the makeup air with the air in the tunnel. It can be shown that with perfect mixing, the concentration within an enclosure is reduced by slightly over 60% as a result of one complete air change. Also, three air changes will reduce the concentration by about 95%. It should be noted that for both Plant C and Plant D, the per-minute ventilation rate (CFM) was about 80% of the volume of the tunnel, and three air changes would require almost four minutes. With incomplete mixing, more time would be required to return the concentrations to near-background conditions.

The organic material deposited on the plates is similar to the asphalt-like substance near the loadout chute. This material evaporates at temperatures of about 300°F and condenses when cooled. The maximum daytime ambient temperatures in California were in the 90s, while evenings were in the 70s. In Massachusetts, the temperatures were in the 50s during the day and 30s at night. The vapor pressure of organic material is not directly proportional to the temperature but has an exponential relationship. As a result, at ambient temperatures the organic material on the plates would have a relatively low vapor pressure. The relative weight loss for the deposited asphalt material can be estimated using the equations presented in Response 53, Temperature Effects. It should be noted that the RTFOT is a 5-hr test and, therefore, an estimate of hourly weight loss would likely be one-fifth of the loss for the RTFOT. The fundamental physical phenomenon is best described by the Clausius-Claperon equation, where the natural log of the vapor pressure is a linear function of the absolute temperature (Reference: *Experimental Physical Chemistry*; F. Daniels, J. W. Williams, P. Bender, R. Alberty and C. Cornwell; McGraw-Hill; 1962).

Table 5 presents the loss on heating for 300° and 325°F and the estimated loss that would occur at the above range of temperatures encountered during the emission tests. The two rows identified as “California Asphalt” and “Massachusetts Asphalt” use the equations presented in Response 53. The two rows identified as “California Asphalt Volatiles” and “Massachusetts Asphalt Volatiles” use an adjustment of the equations in Response 53 that establishes the second

constant in the equations at values that produce 100% weight loss at 325°F (-13.53 for California and -16.67 for Massachusetts). The two rows for California and Massachusetts provide a range of potential evaporation of the asphalt deposited within the enclosures at the two facilities. It should be noted that these values are highly uncertain and assume that the loss on heating is due to volatiles already contained in the asphalt rather than the cracking of the asphalt molecules due to high temperature.

**Table 5. Evaporation of Asphalt at Different Temperatures**

	Loss on Heating (% by RTFOT)		Estimated Daily Loss at Indicated Temperature (Percent by Weight)			
	300°F	325°F	100°F	90°F	80°F	70°F
<b>California</b>						
Asphalt	0.182	0.314	0.0084	0.0067	0.0053	0.0042
Asphalt Volatiles		100	2.65	2.1	1.67	1.33
<b>Massachusetts</b>						
Asphalt	0.101	0.213	0.00070	0.00053	0.00041	0.00031
Asphalt Volatiles		100	0.36	0.28	0.21	0.16

Based upon the values in Table 5 under the Estimated Loss at Indicated Temperature columns, the range of weight loss that would be experienced on the deposition plates for the testing period would be between 5% and 11% for the four days the California deposition plates were installed and between 0.5% and 1% for three days that the Massachusetts deposition plates were in place. These values assume that all of the deposition occurred on the first day of testing rather than about equally each day. The highest value assumes that the ambient temperatures were at the maximum temperature for the entire 24-hr day. Therefore, the likely evaporation from the deposition plates is one-half of the midrange value presented and is a relatively small amount. It should be noted that the California facility operated two 10-hr shifts per day. There were no loading operations during one 24 hr period (Sunday when the background run was conducted) and one 8-hr period (when electrical power was restricted in the area).

As stated in a number of other sections, capture efficiency adjustments correct for those particulate emissions that escape by the exhaust system. Therefore, the tunnel deposition adjustments were not needed for Plant C because they represent measurement of emissions that are already counted. Estimated evaporation loss for Plant D are very small and are indiscernible from other variations in the data. Therefore, adjustments to the deposition estimates were not made for Plant D.

### 37. Replacement of Deposition Plates

COMMENT: The commentor Yatzyshyn notes that the collection plates were strategically placed for optimum collection. He suggests that the plates should have been replaced after each “drop into a truck.” The integrity of the collection plates could have been



compromised due to oils and particulate, which would not allow for additional accumulation. He concludes that this would render the test invalid.

RESPONSE: Three ceiling test plates were installed on July 23, 1999, and removed on July 26, 1999. While the test plates were in place, 20,666 tons of asphalt were loaded into transport trucks. The total catch on all three plates was 49.9 milligrams of PM, or 0.0024 milligrams per ton. Had the plates been replaced after each truck (average load-out per truck was 23 tons), the catch per plate would have been below the detection limit of the 0.1 milligram analytical balance (i.e.,  $0.0024 \times 23/3$  plates = 0.018 milligrams). There is no reason to expect that plate accumulation would be different for a new plate compared to a plate with some accumulation. In addition, a truck was loaded every 1 to 2 min at Plant C and every 5 to 8 min at Plant D. The replacement of the plates would require approximately 30 min. This would significantly restrict plant operations.

### **38. Recovery of Deposition Samples**

COMMENT: The commentor (Condon) stated that their technical staff expressed concern that some of the large particles could collect disproportionately at the elbow junctions of the Plant D exhaust system and that the total particulate estimates may be low if these sections of the air collection duct are not considered. She stated that it was their understanding that the elbows would be constructed to be removable so that the relative concentrations of particulates could be determined in each section of the duct (i.e., elbows vs. linear portions).

RESPONSE: The elbows were indeed removed and cleaned before and after the testing. The particles deposited on the impaction zones were recovered and analyzed separately from the particles deposited on the non-impaction zones. These procedures are described in Appendix D of the Plant D report. It should be noted that the larger particulate is inorganic material. The organic emissions are the result of condensation phenomena. Particulate formed as a result of condensation phenomena are primarily sub-micrometer in size, behave much like a gas and do not preferentially deposit at elbows.

### **39. Semivolatile Organics Deposited near Loadout Area**

COMMENT: The commentor (Nadkarni) states that there is evidence that the semivolatile organics did not condense and deposit near the point of emission. The suggested evidence is that the quantity of organic material collected on the plates within the tunnel was greater further away from the loadout area. The commentor hypothesized that the fume near Silo 5 was too hot to deposit the SVOCs.

RESPONSE: It is unclear how the commentor arrived at this conclusion since information on the sequence of the collector plates was not presented in the test report. The greatest mass of organic material was on plate 1, which was closest to Silo 5. The second plate in the sequence was plate 3, which had the next greatest mass of organic material. The revised test report will include information on which collector plates were placed in which areas of the tunnel. The commentor's statement may also be interpreted to mean that the test methods may

not have collected these organic emissions that were too hot to deposit. However, both vaporous and solid semivolatile organics are collected in the EPA Method 315 and SW-846 Method 0010 sampling train. In the Method 315 train, the vaporous organics are cooled and collected in the impingers, which are maintained in an ice bath. The vaporous organics are collected, cooled, and adsorbed in the adsorbent resin trap of the Method 0010 train. A schematic of the Method 0010 train is presented in Volume 1, Figure 5.3, page 5-8 of the Plant C report.

#### **40. Long Term Effects of Residue in Ductwork**

COMMENT: The commentor (Yatzyshyn) notes that over time, the inside of the ductwork will be covered with residue. He questions whether this will affect emissions in the long run.

RESPONSE: The PES Project Manager went inside the TED at Plant C both before and after the test program and observed only a minimum amount of residue inside the duct. The residue observed represented 3 years and approximately 3,000,000 tons of hot mix asphalt production at the plant. It is not expected that this residue has any short- or long-term effect on emissions.

### **Measurements—Background**

#### **41. Problems with the Background Run at Plant C**

COMMENT: Further details were requested by commentor Nadkarni on the Plant C, Run 4, background test. The commentor was particularly interested in an explanation of the higher background levels observed during the second half of the test.

RESPONSE: As shown in the Plant C draft report, higher winds and poorer capture efficiency were observed during the second half of the background test (Run 4). These conditions also arose during Runs 1, 2, and 3. During much of the loading operations of Runs 1, 2, and 3, one or more trucks were lined up to enter the tunnel, partially blocking the wind.

For the background test, only two trucks were available for testing, requiring one truck to circle the plant from the tunnel exit to tunnel entrance while the other remained in the loadout position. This action created long periods when the tunnel doorway was not blocked by an awaiting truck. As the winds increased during the day and capture efficiency decreased, the truck drivers were encouraged to circle the plant as quickly as possible, reducing the time the doorway was unblocked. For all four of the test runs, trucks blocking the tunnel entrance were parked at the same location. In addition, for Runs 1, 2, and 3, one or more trucks were parked at the entrance for a greater percentage of the time than for the background test.

Slightly higher winds during the background tests may have caused some additional truck exhaust to enter the tunnel during the second half of the test. While it is uncertain whether the

best representation of truck exhaust emissions are the average, first half or second half THC concentrations measured during the background run, it was agreed that the lower concentrations measured during the first half of the background run would be used to adjust for the diesel engine emissions. This adjustment assures the the background corrected THC emissions for load out are not under counted.

For further discussion of capture efficiency and adjustment of background readings, see Sections 13, 51, and 55.

## **Measurements—Temperature**

### **42. Calibration of Thermometers**

COMMENT: The commentor Nadkarni stated that “much was made of the temperature measurements taken with a kitchen meat thermometer” (and its errors) that he had brought to the test of Plant C. The commentor questions why the kitchen thermometer results achieve so much prominence? He stated that he checked its calibration afterwards with boiling water and again on September 13, 1999, and it reads correctly now.

RESPONSE: Two instruments were used to measure temperature of the asphalt in the transport trucks directly after loadout: a PES thermocouple (TC) and a CAAP dial thermometer. Both instruments were calibrated in boiling water on-site on July 28, 1998, after the last test. The calibration-adjusted readings on average are within 2% of each other, with the dial thermometer adjusted reading being 2% higher than the TC. The dial thermometer was generally inserted into the asphalt first and was therefore in the asphalt longer. The TC was generally inserted second and, in some cases, was not in the asphalt long enough to reach a stable temperature. It was therefore felt that the dial thermometer readings were more reliable. Both sets of data appear in the PES Plant C report, Volume 2, Appendix B, on page 92. Because the dial thermometer reached a stable temperature quicker than the thermocouple, corrected data from the dial thermometer was presented in Table 3.3 of the PES Plant C report.

## **Measurements—Test Method Validation**

### **43. Discussion on Statement in Audit Report on the Use of Validated Methods and Use of Bench-Scale Testing**

COMMENT: One commentor (Fillion) states that if bench testing had been performed as requested by the citizens, confidence in the test results and their relevance would be more likely. The commentor references the statement made in the *Technical Systems Audit of PES Emissions Testing at Hot Mix Asphalt Plant C* that says the “VOST and Modified Method 5 methods have not been validated for all chemical compounds of interest in the asphalt plant emissions.” The commentor further states that bench testing would begin to address some of the questions

regarding the accuracy of the data presented. The commentor states that EPA used circular logic in explaining that the methods used were the best methods available and that validation is expensive and seldom done on the first test of a source.

RESPONSE: It is unclear how bench-scale testing would have addressed the few testing issues that were encountered during the test program. The test methods that were used have been validated for a number of pollutants at some sources and are routinely and successfully used at many other sources. Some of these same test methods were used to quantify the emissions from the dryer stack at hot mix asphalt plants. However, their successful use requires some prior knowledge of the conditions that will exist during the emission test. For the most part, the industry test and the analyses that were performed during the pretest survey provided this knowledge.

An example of one of the issues encountered at Plant C was created during the final planning stages for the test. While the revised sampling locations for the silo exhaust were preferred to the locations originally selected, this change created another obstacle. During the pretest survey, samples were collected in the silo duct system just prior to connecting to the tunnel duct system. As pointed out by the citizens, this location created a number of obstacles in properly measuring these emissions. The emission concentrations from the silo were significantly different than we had estimated based upon the pretest survey testing and the assumed operation of the silo damper system. Bench scale testing would not have revealed this situation nor provided information that could have been used to adapt to these changes. Additionally, while bench-scale testing may complement validation it can not substitute for field validation of these methods.

Methods are validated for specific pollutants at specific emission sources, and any validation would generally not be transferable to another source. Validating a method requires testing the source under the conditions for which the method is being validated. For example, at asphalt plants, the dryer stack, the silo exhaust, and the tunnel exhaust might for each process be considered separate sources. Therefore, the method may require separate validation testing. Generally, because of cost, EPA only validates methods that will be used to demonstrate compliance with an emission standard. While three manual method sample trains were run at different times to quantify emissions during the asphalt tests, method validation could require six sets of four collocated sample trains, or as many as 24 total samples. As a result, the cost of the test program would be significant, and the information obtained would be only marginally improved. We believe that even where additional procedures were required to obtain the reported data, the information is sufficient to make a reasonable assessment of the emissions from these sources.

## Measurements—Accuracy

### 44. Accuracy of Reported Emissions

COMMENT: The commentor (Eberhard) states that there should be some indication of the accuracy of the numbers. She also indicates that, where appropriate, the range of values should be reported in addition to the averages. She notes that almost all data are reported to three significant figures and questions whether this is the accuracy obtained.

RESPONSE: While we did not collect information that could be used to determine the precision and bias (accuracy) of the values measured during these tests, the selection of the test methods and the execution of the test programs give us confidence that the data collected are comparable in precision and bias to many other high-quality air emissions samples. All of the test reports include information in the quality assurance sections and the appendices related to the accuracy of the individual components of the sampling system (pitot tubes, volume meters, thermometers, etc.). Additionally, the analytical laboratories' case narrative reports include quality assurance information. Information to estimate accuracy is included as detection limit and quantitation limit information. As discussed in Response 43, determining the accuracy and precision during a test (as is done during validation testing) is significantly more expensive than the performance of a single emissions test as was conducted at Plant C or D.

While presenting the range of data in addition to the average may provide some useful information for large data sets such as those obtained for the THC data, it is unclear what value would be added for data sets of three values. In addition, discerning this information from three values is much simpler. As a result this type of information will not be presented in the test reports for the manual sampling methods.

### 45. FTIR Uncertainties Calculation

COMMENT: Appendix C shows uncertainties in the FTIR data tables. How were these uncertainties calculated?

RESPONSE: Uncertainty determinations are a normal part of the FTIR data analysis and involve fairly detailed computerized calculations outlined in Method 320 and the FTIR Protocol. Both of these were attached to the Plant C Site Specific Test Plan and are available from EPA. Copies of these methods are not usually attached to the final report but can be produced at the request of EPA.

Uncertainty is calculated by a least-squares fit of the reference spectra versus the sample spectra, and calculates the error band for each target species. In general, uncertainties greater than the reported concentration indicate the values detected may not be valid; uncertainties less than the reported value confirm the presence of the target compound.

The entire EPA spectral library was used for analysis of the FTIR spectra. For simplicity of reporting, Appendix C includes only those compounds whose presence was confirmed. Target compounds with high uncertainties (i.e., potential hits) were treated as non-detects and also included in Appendix C.

#### **46. Accuracy of Tables, Significant Figures, Nomenclature of ND, Etc.**

COMMENT: The commentor (Eberhard) questions whether the two or three significant figures are indicative of the accuracy of the values presented. Additionally, she suggests we use standard terms rather than dashes in various places where a value is not presented.

RESPONSE: Where appropriate and where continuous measurements were made, the information presented included averages and maximum and minimum values in both the Plant C and D draft reports. For the manual methods, generally only three values were collected because of time and resource constraints. It is unclear which significant figures the commentor is questioning. In most cases MRI reported values to two significant figures. This corresponds to the accuracy of MRI's instrumentation and is appropriate. For the manual methods, normally three significant figures are presented. This is the general accuracy of the analytical measurements used to calculate the final value and not the accuracy of that value. As discussed in Responses 42 and 43, the determination of precision and bias is more complicated and expensive than the test program conducted at Plants C and D. However, the final reports will be reviewed for consistency in the use of significant digits, nomenclature for non-detects (ND), not measured, etc.

## **Measurements—Production**

#### **47. MRI Plant D Process Description Page 2-1**

COMMENT: The commentor (Fillion) cites MRI's Plant D draft report, which lists a nominal production capacity of 150 tons/hr. Two other references are also cited which list its capacity as 255 tons/hr and 600,000 tons/yr. Clarification of these plant descriptions is requested.

RESPONSE: The commentor is correct in that the plant is approved for 255 tons/hr of production. However, this value is included in the air permit as the maximum potential production and is based on a production rate of 1 batch/min for 60 min. In practice, these rates are rarely achieved, and 200 to 210 tons/hr is a more realistic rate for a *full* production day. MRI's nominal value of 150 tons/hr is typical for a *normal* production day.

The annual rate of 600,000 tons/yr also represents the maximum potential production and is based on 24-hr/day, 365-days/yr operations. Seasonal restrictions and city-restricted operating hours (5 days/wk, 10 hr/day maximum) prohibit these conditions from being achieved. A typical annual production for the facility is 100,000 tons. The Plant D final report will include information on the hourly production capacity stated in the air permit as well as information on the typical hourly and annual production achieved by the facility. (Plant information obtained from the Vice President of Engineering and Production for Plant D.)

#### **48. Composition of Asphalts Produced**

COMMENT: Commentors Nadkarni, Fillion, and Lynch state that the asphalt content of the various mixes produced (i.e., the ratio of asphalt to crushed stone) has not been mentioned in the reports.

RESPONSE: A thorough presentation of these data is included in the PES reports for both Plants C and D. For Plant C, the rate of all materials fed (including the aggregate, RAP, liquid asphalt, and total mix) are presented in Volume 2, Appendix B, beginning on page 5. For Plant D, the quantity of asphalt cement, RAP, and each grade of aggregate used for each load-out is presented in Appendix B. To more clearly present this information, the various mix designs produced during the Plant D test will be included in the Appendix.

#### **49. Release Agent Use**

COMMENT: The commentor (Acott) observed that there was no mention of the release agent used during the tests or the quantity used. They noted that since this substance is an organic and volatile, it would constitute a partial source of VOCs as compared to the HMA.

RESPONSE: Samples of the release agent were taken at Plant C, but the volume of release agent used was never quantified nor were the samples analyzed. It is possible, as the commentor suggests, that some small portion of the VOCs present in the TED were from the release agent. It should be noted that the release agent used was an emulsified material substantially diluted with water.

### **Measurements—Missed Pollutants**

#### **50. SO<sub>2</sub>, NO<sub>x</sub>, CO, and H<sub>2</sub>S Measurements by FTIR**

COMMENT: Commentors Nadkarni, Acott, and Peterman state that SO<sub>2</sub>, NO<sub>x</sub>, and CO measurements by EPA Method 320 (FTIR) are referred to in the test plan, but results were not presented in the Plant C summary tables. Commentor Nadkarni also mentions CO<sub>2</sub> and H<sub>2</sub>S measurements.

RESPONSE: SO<sub>2</sub>, NO<sub>x</sub>, and CO measurements were part of the Plant C emissions test program specified in MRI's test plan. Analysis for these components showed the presence of CO in the process stack (dryer), SED, and TED, and was reported on Tables 3-4, 3-5, and 3-6 of the MRI Plant C draft report. SO<sub>2</sub> and NO<sub>x</sub> were not observed in any of the samples. Detection limits for these compounds are shown in Table 6, below, and will be included in the Plant C final report detection limit tables in Appendix C.

**Table 6. Detection Limits for SO<sub>2</sub> and NO<sub>x</sub> Compounds**

Compound	Loadout MDL (ppm)	Silo & Stack MDL (ppm)
SO <sub>2</sub>	0.36	2.94
NO	1.21	4.38
NO <sub>2</sub>	0.20	0.63
N <sub>2</sub> O	0.024	0.187

The CO<sub>2</sub> measurements mentioned by Nadkarni apparently refer to diesel exhaust. Since CO<sub>2</sub> is neither a criteria pollutant nor a HAP pollutant, it was not a targeted compound, and MRI made no reference to CO<sub>2</sub> measurements in the Plant C test plan. Note that for non-combustion sources such as the asphalt emissions from the TED and SED, oxygen and carbon dioxide levels are nearly the same as ambient air. It should be noted that CO<sub>2</sub> was seen in the TED FTIR spectra but was not quantified. The spectra for CO<sub>2</sub> were subtracted from the samples in order to measure the target analytes. A qualitative inspection of selected samples revealed that the CO<sub>2</sub> concentrations were consistent throughout each individual run and also among the four test runs.

Commentor Nadkarni raised the additional question of sulfide emissions, specifically hydrogen sulfide, at the Plant C facility. Note that with the SO<sub>2</sub> information presented above and the original quantitation limits presented in Appendix C of the draft report, neither SO<sub>2</sub> or carbonyl sulfide (COS) were detected. It is MRI's experience that SO<sub>2</sub> and COS are frequently observed at sources emitting sulfide compounds. Both of these compounds also have reasonably good detection limits (e.g., well below 1 ppm for COS).

Hydrogen sulfide (H<sub>2</sub>S) was not observed in any of the samples, but has a weak infrared spectrum, and the lowest detectable level of H<sub>2</sub>S is probably no better than 100 ppm for the extractive FTIR measurements. Carbonyl disulfide (CS<sub>2</sub>) has a much stronger infrared spectrum than H<sub>2</sub>S, but the strongest spectral features are overlapped with water vapor bands. Thus, the detectible range for CS<sub>2</sub> is estimated at 100 ppm in the high-moisture samples (process stack and silo) but would be lower in the tunnel.

The Tenax (concentrated) samples shed more light on the possible presence of sulfide compounds. COS, H<sub>2</sub>S, and SO<sub>2</sub> are too volatile to be quantitatively retained on the Tenax. However, if these compounds are present in the emissions source, some concentration still occurs, and traces of COS and SO<sub>2</sub> are frequently observed in the desorbed samples. MRI did not see any traces of sulfide compounds in the Plant C Tenax samples, demonstrating that the



detection limits mentioned above are significantly higher than any concentrations that may have been present for these compounds.

Other sulfides, such as dimethyl sulfide (CH<sub>3</sub>)<sub>2</sub>S and dimethyl disulfide (CH<sub>3</sub>)<sub>2</sub>S<sub>2</sub>, have been measured by direct FTIR at other sulfide-emitting sources. Both dimethyl sulfide and dimethyl disulfide adhere to Tenax, so both compounds have been measured by the concentrated FTIR techniques at other facilities. Neither the direct FTIR nor the sample-concentration FTIR measurements at Plant C indicated the presence of sulfide emissions. Detection limits for dimethyl sulfide and dimethyl disulfide are estimated to be below 1 ppm.

## Adjustments—Background

### 51. Background Adjustments

COMMENT: The commentors (Nadkarni, Fillion, Eberhard, Toxics Action Center and Ecology Center) raise issues related to the background emissions adjustment. These issues include the effects of the adjustment, the exclusion of the measured stone dust emissions, and the comparison with other diesel exhaust emissions tests. Dr. Nadkarni provides an illustration that 72% of the measured MCEM emissions from production have been made to “disappear by this adjustment.” In addition, he notes that the background adjustment is a major adjustment to each raw measurement. He states that there were five VOHAPS where the adjustment exceeded the emissions during production operations. Dr. Nadkarni further indicates that significant adjustments of high molecular weight compounds are made when one would not expect these compounds in diesel exhaust. One commentor (Fillion) states that there is an intention to discard the stone dust captured by the emission testing. Additionally, since the asphalt fume adheres to the stone dust, they should be reported together. Comments by the Toxics Action Center also state that the stone dust in the asphalt emissions should be included. Comments by Eberhard and the Toxics Action Center address the observed background and question how it compares to other measured emissions of diesel exhaust. They note the circumvention of emissions controls by many diesel manufacturers and question whether the emissions controls of the trucks used were operating correctly.

RESPONSE: While some of these comments may not appear to be related, the process of using background concentrations to adjust the emissions concentrations measured during the production periods creates the appearance that inorganic emissions are discounted and that background emissions are inflated. The purpose of the background adjustment is to separate and eliminate some of the multiple counting of fugitive dust and truck emissions that are estimated more comprehensively by other methods. As indicated by comments from Mr. Fillion, there are methods of estimating emissions from other sources such as fugitive dust, that would also be a concern at hot mix asphalt plants. Methods for estimating fugitive dust emissions from paved and unpaved roads are available in AP-42 and are more specific for these sources. (Reference: *Section 13.2.1 Paved Roads; October 1997 and Section 13.2.2, Unpaved Roads; September 1998; EPA AP-42; [www.epa.gov/ttn/chief/ap42c13.html](http://www.epa.gov/ttn/chief/ap42c13.html)*). They can accommodate parameters

which were not measured during either test. In addition, in the mobile sources portion of AP-42, there are methods for estimating emissions from heavy duty diesel trucks. The emissions estimate for fugitive dust depends on the type of road (paved vs. unpaved), the average weight of vehicles, and the amount of material on the surface of the road. The emissions estimate for heavy duty diesel trucks depends on the class of vehicle, date of manufacture, speed, and mileage. Segregating these two emission sources will not only allow for improved emissions estimation methods but is important to emission factor development in that it will accommodate future improvements in emission estimation methods and control technology. One example of improvements in the near future is the recent emission control technology advances that significantly reduce emissions of NO<sub>x</sub>, VOC, and PM from diesel engines.

Although some emission factors exist for these sources, the emission factors do not currently encompass all of the pollutants measured at Plant C and do not encompass the same operating conditions as those at the plant. While Dr. Nadkarni indicated in a separate comment that there is no such thing as ambient asphalt fume, the components of asphalt fume are not unique and are emitted by many other sources. Diesel emissions are known to be major contributors to ambient air concentrations of particulate, THC, CO, NO<sub>x</sub> and PM (Reference: *Emission Control Potential for Heavy-Duty Diesel Engines*; EPA 420-F-95-009b; June 1996; [www.epa.gov/oms/noxfact2.htm](http://www.epa.gov/oms/noxfact2.htm)).

The AP-42 section ([www.epa.gov/oms/consumer/f98014.htm](http://www.epa.gov/oms/consumer/f98014.htm)) on mobile sources includes an estimate of tailpipe emissions for heavy duty diesel emissions during idling. Emission rates in grams per minute for VOC (a component of THC), CO, NO<sub>x</sub> and PM are presented in Table 7. A more complicated method ([www.epa.gov/oms/ap42.htm](http://www.epa.gov/oms/ap42.htm)) is available to estimate emissions when the vehicle is moving. Table 7 also includes THC, methane, formaldehyde, CO, and NO<sub>x</sub> emission rates for a truck traveling 5 mph. As for all vehicles, diesel emission rates are increased during acceleration. However, a reasonable estimator for emissions during mild acceleration is not available. The NO<sub>x</sub> emissions presented are based on the results of Federal Test Certification data and do not include an adjustment for the noted circumvention of the NO<sub>x</sub> emissions limit that was recently discovered (Reference: Diesel Engine Settlement Information; PR DOJ, EPA Announce One Billion Dollar Settlement with Diesel Engine Industry for Clean Air Violations; US EPA Headquarters Press Release; Washington, DC; 10/22/98; <http://es.epa.gov/oeca/ore/aed/diesel>). Additionally, the non-tailpipe THC emissions from evaporation of diesel fuel are not included. Because of the prevalence of the circumvention of the NO<sub>x</sub> emission limits, it is probable that all trucks at this facility had NO<sub>x</sub> emissions that were higher than the above values. Although we could not quantify the NO<sub>x</sub> emissions from the tunnel, the background emission testing provides a direct measure of the trucks is not necessary. The uncorrected emissions measured during the background run was 0.66 g/min for THC, 1.2 g/min for CO, and 0.54 g/min for PM. Except for PM, these agree very well with the estimated emissions from AP-42. It should be noted that the fugitive PM emissions are not accounted for in the above comparison.

**Table 7. Emission Rates for Heavy Duty Diesel Trucks and Background Emissions Measured at Plant C.**

Criteria Pollutant	Diesel at Idle (g/min)	Diesel at 5 mph (g/min)	Measured Background (g/min)
THC	NA*	0.34	0.66
Methane	NA*	0.1	0.61
VOC	0.208	0.24	0.05
Formaldehyde	NA*	0.18	BDL
CO	1.57	2.2	1.2
NO <sub>x</sub>	0.917	1.06	BDL
PM	0.043	NA*	0.54

\* Emission rate information was not available.

Diesel emissions also contain significant amounts of volatile HAPs and PAHs. A 1993 motor vehicle air toxics study (EPA 420-R-93-005) discussed some of these emissions. With respect to Dr. Nadkarni's statement that one would not expect diesel exhaust to contain high molecular weight compounds such as anthracene and phenanthrene, this document provides a brief characterization of diesel particulate (see document [airtox1c.pdf](#) that is Chapters 8-16 at [www.epa.gov/oms/toxics.htm](http://www.epa.gov/oms/toxics.htm)). Specifically, it states:

At temperatures below 500° C, the particles become coated with adsorbed and condensed high molecular weight organic compounds. Typically, about 25% of the particle consists of extractable organics, although different vehicles may have extractable fractions of 5-90%, depending on operating conditions. These compounds include open-chain hydrocarbons of 14-35 carbon atoms, alkyl-substituted benzenes, and derivatives of the polycyclic aromatic hydrocarbons (PAH) such as ketones, carboxyaldehydes, acid anhydrides, hydroxy compounds, quinones, nitrates, and carboxylic acids (Johnson, 1988). There are also heterocyclic compounds containing sulfur, nitrogen, and oxygen atoms within the aromatic ring. Inorganic compounds also are present and include sulfur dioxide, nitrogen dioxide, and sulfuric acid (NRC, 1982).

Additionally, general profiles for diesel exhaust in the Speciate database (Reference: <http://www.epa.gov/ttn/chief/software.html#speciate>) show organic compounds from C1 to C43. The largest percentage of the higher molecular weight compounds are in the C10 to C17 range, with each of the compound classes being 3% to 4.5% of the total hydrocarbon emissions. As a result, emissions of each of these classes would be about 0.09 g/min. While many different compounds are probably in the C10 to C17 range, two recent articles provide a detailed chemical speciation of diesel emissions during federal certification test runs. (*Composition of Light-Duty Motor Vehicle Exhaust Particulate Matter in Denver, Colorado Area*; Environmental Science and Technology; Cadle et.al. May 15, 1999, pp 2328 - 2339 and *Measurement of Emissions from*

*Air Pollution Sources. 2. C1 through C30 Organic Compounds from Medium Duty Diesel Trucks*; Environmental Science and Technology; Schauer, Kleeman, Cass and Simoneit; May 15, 1999; pp 1578-1587.)

The test data supporting these two articles measured anthracene and phenanthrene as components of diesel exhaust in addition to many other PAHs. The equivalent emission rate derived from these articles are estimated at between 0.000027 and 0.00004 g/min for anthracene and 0.00016 g/min for phenanthrene. The anthracene and phenanthrene emissions measured during the background runs were 0.000014 and 0.00026 g/min, respectively. Other compounds that were quantified during the background run are also quantified for diesel exhaust in these articles. Table 8 is a listing of the emission rates for these compounds that were common between the background test and one or more of these articles. For all but four compounds, the emission rate during the background run was lower than presented in the articles. For these four compounds, the emission rate was within a factor of two of the rates presented in the articles. More background run compounds do not compare more favorably to the emission rates presented in the articles because the Federal Test Procedure begins with a cold start and the acceleration requirements are greater than the truck accelerations used during the test.

These data provide sufficient evidence that diesel emissions are the source of the background concentrations measured and that the adjustments made are reasonable. It should be noted that these adjustments were not required at Plant D since diesel exhaust was evacuated from the tunnel separately and not measured. As stated previously, adjustments for background conditions recognize that within the tunnel there were additional emission sources other than asphalt. Therefore, by adjusting for the background concentrations, emissions that are better estimated separately and more comprehensively are excluded and are not double-counted.

A number of methods to adjust for these background concentrations are possible. The most correct method to adjust for emissions measured during background operations would be to separately adjust each run for the measured capture efficiency and then subtract these adjusted background emissions from the adjusted emissions measured during production operations. This procedure used in preparation of the draft reports produced negative values for both the PM and MCEM and many other HAP compounds. As a result, an approach that provides a high bias relative to the most correct method mentioned above and did not result in as many negative values was used to accommodate background emissions. The as-measured background concentrations were used in adjusting the as-measured average emissions during production. Then the average capture efficiency was used as an adjustment to arrive at the emissions. This resulted in no inorganic PM (stone dust) but measurable emissions of MCEM and all but four specific compounds. These results agreed with Dr. Nadkarni's previous hypothesis that particulate emissions were the result of condensation of asphalt fumes.

**Table 8. Comparison of Diesel Exhaust Emission Rates with Background Concentrations**

Compound	Emissions Rate mg/min		
	Schauer et.al. <sup>1</sup>	Cadle et.al. <sup>2</sup>	Background Run
Acetone	25		1.4
Benzene	3.5		1.06
Toluene	4.55		1.55
Ethyl benzene	5.37		0.197
m,p Xylene	2.66		0.55
o Xylene	0.95		0.24
Formaldehyde	26		8.3
Acenaphthalene	0.08		0.0017
Acenaphthene	0.02		0.03
Anthracene	0.027	0.40	0.014
Benz(a)anthracene	0.012	0.0057	0.00096
Benz(a)pyrene		0.0046	BRL <sup>3</sup>
Benzo(ghi)perylene		0.0096	0.00048
Crysene		0.0096	0.020
Fluorene	0.05		0.1
Fluoranthene	0.13	0.06	0.02
2-Methylnaphtalene	0.70		0.17
Naphthalene	0.71	3.49	BRL
Phenanthrene	0.16		0.26
Pyrene	0.18	0.074	0.038

<sup>1</sup> *Measurement of Emissions from Air Pollution Sources. 2. C1 through C30 Organic Compounds from Medium Duty Diesel Trucks*; Environmental Science and Technology; Schauer, Kleeman, Cass and Simoneit; May 15, 1999; pp 1578-1587.

<sup>2</sup> *Composition of Light-Duty Motor Vehicle Exhaust Particulate Matter in Denver, Colorado Area*; Environmental Science and Technology; Cadle et.al. May 15, 1999, pp 2328-2339.

<sup>3</sup> BRL - Below reportable levels.

However, in retrospect, this method of adjustment also allows for a potential over adjustment of some individual runs. This happens when the background concentration exceeds one or more individual run values and provides an additional unintended adjustment to the remaining runs that exceeded the background concentration. As a result, the method for adjusting for the background concentrations is being revised to one that provides for a slightly higher but still acceptable bias of the load out emissions. Each separate run will be adjusted for capture efficiency, and then the as-measured background concentration will be subtracted. Values will be treated as zero if the background concentration exceeds the capture-efficiency-adjusted run concentration. This process, while not the most correct method, provides for the most biased high estimate of load out emissions that also makes some accommodations for the background emissions from truck operations.

As a result, in the Assessment of Emissions at Hot Mix Asphalt Plants report, the particulate matter emission factors for truck loading will be revised from 3.95 to 10.4 lb/100,000 tons, and the organic particulate will be revised from 3.95 to 7.08 lb/100,000 tons. It should be noted that these revised values do not include any adjustments for other parameters noted elsewhere. Additionally, isooctane and trichlorofluoromethane will have some emissions estimated because of this revised method to adjust for background concentrations. In addition, the particulate matter emissions from Table 3, rather than the organic particulate emissions, will be used for silo filling emissions. Less significant changes will occur for most of the other specific compounds.

## **Adjustments—Volatiles Content and Temperature**

### **52. Effects of Volatiles Content**

COMMENT: The emission test and volatiles content data from the Plant C and D tests will be used at other facilities by local permitting agencies to derive emission factors. The commentors (Nadkarni, Fillion, Toxics Action Center, Nowick, Eberhard, Lynch, Zeller, Ecology Center) raise issues related to the “volatiles content” of the asphalt binders at both Plants C and D.

Dr. Nadkarni provided historical information related to the citizens’ request that EPA require the facilities tested to obtain asphalt binder close to the maximum specification limits of 1% loss on heating. EPA responded that it could not require the plants to locate, purchase, and use binder with this property without incurring a minimum liability of \$180,000 for the potential production of pavement that did not meet specifications. This commentor also provided information relating to the past grading system for asphalt binders and the newer “Superpave” grading system being adopted by many federal and state transportation projects. State Senator Lynch provided the *1995 Massachusetts Highway Department Standard Specifications for Highways and Bridges*, which includes information on the requirements for viscosity-graded asphalt binders used for paving material and mineral aggregate, mineral filler, and bituminous binder mix formulas for pavements. Commentors Fillion and Nadkarni cite information

presented in the test reports on the volatile content of asphalt samples obtained during the pretest surveys and during the test. They implied that a 22% to 33% decrease in volatiles content is evidence that this change was not coincidental.

Many commentors stated that the volatiles content of the asphalt binders used during the tests should be included in the reports. While most commentors stated that the volatiles content of the asphalts used during the tests were low, one commentor (Eberhard) suggested that the reports include information concerning the representativeness of the volatiles content of the asphalt binders used. Another commentor (Toxics Action Center et.al.) stated that comparing results from tests performed on different dates and from the different locations is difficult without the use of a consistent volatiles content. Many commentors recommended that the emissions be adjusted to reflect an asphalt binder at the maximum specification limit of 1% volatiles. One commentor states that the test data in the reports should be increased by a factor of 6 for Plant C and by a factor of 8 for Plant D to reflect the maximum volatile content of 1%. The commentor stated that the reports should include a note that data represent a maximum volatiles content of 1% to afford clarity to all. Dr. Nadkarni presents run-by-run ranked THC and volatile content data for plant D and indicates that this is additional proof of the need to control the volatile content to the maximum allowed. One commentor (Nadkarni) stated that industry uses various additives that are light compounds; these increase the volatiles content.

RESPONSE: As stated by EPA during the planning meetings for these two emission tests, the industry cannot be forced to obtain and use a raw material in their product without the Agency incurring a liability to compensate the facility for their increased expenses. We only estimated the cost of the material produced and did not estimate the additional cost to remove the off-specification pavement and dispose of it properly. As a result, the additional cost would be much greater than the \$180,000 cited by the commentor. As presented in an EPA memo from Ron Myers to Bob McConnell dated March 18, 1998 which transmitting the Plant C test plans and was provided to the stakeholders an estimate of \$200,000 was provided. This estimate was based upon a \$25 per ton cost of asphalt at the production facility and includes a note that the estimate does not reflect the potential cost of disposing of the asphalt.

Two commentors presumed that the reduction of the volatiles content used during the test versus what was collected during pretest visits to the plants was not a coincidence. The 22% change in the loss on heating of the asphalt used at Plant C was well within the statistical variation of the asphalt used during the test. During the emission test, 13 samples were obtained and analyzed. One of the 13 samples exceeded the loss-on-heating value obtained during the pretest visit. Two additional samples were within 10% of the loss on heating value of the sample obtained during the pretest visit. Variations in loss on heating over longer periods of time are likely to be more substantial than was observed during the week of the test. As a result, there is a high chance that these samples are from the same loss-on-heating population and the change is due to coincidence. For plant D, only three samples were obtained, and a similar analysis is not possible. However, the loss-on-heating results by the rolling film test of 44 samples collected in 1999 by the Massachusetts Highway Department were obtained. As indicated in Table 9, a 33% change in the loss on heating is less than 60% of one standard deviation. As a result, a 33% decrease is well within the normal variabilities of Massachusetts asphalts and would be expected

to occur about 27% of the time. Again, as for Plant C, it is likely that the reduced loss-on-heating results are coincidental.

While the loss on heating value of the asphalt was shown in the PES report, this information was missing from the Executive Summary Report and the MRI reports. Since some people may use only the Assessment of Emissions at Hot Mix Asphalt Plants report or the MRI reports, the information on the rolling thin film oven tests will be included in these reports. Within the MRI and PES test reports, the as-measured run data and as-measured averages will not be adjusted in order to preserve the data as it was collected. However, data presented in the Assessment of Emissions at Hot Mix Asphalt Plants report will be adjusted to an average (or “standard”) loss-on-heating value of 0.5% to reflect the highest average value obtained from selected state transportation departments. Since this value is greater than the 99.99 upper confidence level of the data from Minnesota (which has the highest average and standard deviation), it provides for more than an adequate margin of safety. The ratio of 0.5 to the individual run’s loss-on-heating value will be used to achieve a consistent value for each facility. The adjustment will be based upon the rolling film loss test data in the PES test reports. Table 9 includes the run-by-run RTFOT loss-on-heating data and the resulting adjustment factor that will be made to the background-adjusted emissions data.

**Table 9. Loss on Heating (RTFOT) Values and Adjustment Factors to –0.5% Loss on Heating**

Date	Loss on Heating (%)	Volatiles Adjustment Factor	Date	Loss on Heating (%)	Volatiles Adjustment Factor
California Test Data			Massachusetts Test Data		
07/24/98	-0.369	1.355	10/05/99	-0.216	2.315
07/25/98	-0.311	1.608	10/06/99	-0.206	2.427
07/27/98	-0.286	1.748	10/07/99	-0.218	2.294
07/28/98	-0.296	1.689			
Average	-0.316	1.600	Average	-0.213	2.360

A methodology will be presented in the Assessment of Emissions at Hot Mix Asphalt Plants report to allow for adjustment to a common loss-on-heating value so that a comparison between the two facilities can be made. It will be noted that this adjustment is highly uncertain but is assumed to be directionally correct since the basic physical processes that the asphalt binder experiences in the production of hot mix asphalt and during the rolling thin film test are similar. Additionally, text will be included that suggests that further adjustments to the emissions may be made (by dividing the emissions by -0.5 and multiplying by the state department of transportation loss-on-heating data) to accommodate measured loss on heating results for the state or location where a facility is located.

It is not appropriate to adjust all test data to the maximum loss on heating value contained in the state or AASHTO specifications for asphalt binders used for hot mix asphalt. Available data on unblended asphalt binders provided to the citizens by EPA during the planning for these



tests showed that less than 3% of these asphalts have this maximum loss-on-heating value by the thin film oven test (*Properties of Asphalt Cements*; V. P. Puzinauskas; Research Report N. 80-2; Asphalt Institute; November 1980; and *SHRP Materials Reference Library: Asphalt Cements: A Concise Data Compilation*; David R. Jones IV; Report SHRP-A-645; Strategic Highway Research Program; National Academy of Sciences; May 1993). In addition, most if not all asphalt binders used are blended with other asphalts and additives to achieve a specified performance characteristic. Many state transportation departments test most asphalts used within their state for loss on heating in preparation for the other tests performed to evaluate the quality of the asphalt binders. The use of this loss-on-heating information would be more appropriate than using the maximum specification for loss on heating. As indicated by Dr. Nadkarni, states are transitioning to performance-graded asphalts. These tests provide improved information about the long-term suitability of performance-graded asphalts as binders for roads that experience different operating conditions. In addition, the determination of loss on heating has been revised to provide more consistent results and will be used by all states in the future. As stated previously, some data for calendar year 1999 have been recently obtained from Massachusetts, Connecticut, North Carolina, Michigan and Minnesota. Each of the state transportation department laboratory employees who provided these data said that they analyze asphalts used or projected for use without further blending or modifications. Information on the rolling thin film tests for Plant C and D and for selected states where data from 1999 were obtained are presented in Table 10. Also included are the number of samples tested and the standard deviation of the loss-on-heating values.

**Table 10. Rolling Thin Film Oven Results from Selected States**

State	Number of Samples	Average loss on heating (ASTM (percent mass change)	Standard Deviation
Massachusetts	44	-0.232	0.124
Plant D - MA	3	-0.237	0.030
Connecticut	29	-0.355	0.147
North Carolina	226	-0.227	0.160
Michigan	32	-0.272	0.173
Minnesota	438	-0.440	0.289
Plant C - CA	13	-0.330	0.040

With respect to the comment that most additives to asphalt are low molecular weight compounds that increase the volatiles content, it is not known how each additive may affect the loss on heating of the resulting mixture. However, it is not logical that the addition of a low molecular weight compound would improve the life of an asphalt pavement nor the other characteristics that are desired in asphalt pavement. The State of Michigan submitted data that included one asphalt that had been modified with a polymer and the same asphalt that was

unmodified. The polymer-modified asphalt had a loss on heating of -0.25 compared to -0.51 for the unmodified asphalt. While this is only one piece of information, conversations with each of the above state laboratories indicate that the asphalts they analyze are essentially the same as delivered to, and used by, the hot mix asphalt plants during production.

It is highly recommended that any adjustments for the loss on heating be an appropriate statistical calculation of a representative sampling of asphalts used in the location in question. Selection of the appropriate statistical calculation should also be based upon the pollutants and health endpoints being evaluated. As stated previously, adjustment of the data based upon the maximum loss-on-heating value allowed by some general specification is not appropriate, nor is the selection of the maximum loss-on-heating value obtained for any one sample.

### **53. Temperature Effects**

COMMENT: The commentors (Yatzyshyn, Nadkarni, Zeller, Nowick, Ecology Center) state that the temperature of the asphalt affects the emissions. One commentor states that the minimum temperature at which asphalt paving is allowed to be laid is 275°F. The commentor notes that during colder weather the loadout temperature must be increased to maintain an acceptable paving temperature. The commentor further states that the significant difference in the loadout temperature would affect the emissions and flaw the current test. One commentor (Zeller) indicates that temperature affects the emissions and the individual compounds contained in the emissions. He states that some additives used in asphalt require higher temperatures to be effective, with some required temperatures being as high as 420° to 450°F. He stated that he saw no provision for determining these unknowns in the test reports. He asked how EPA accounted for volatile species differences caused by temperature.

RESPONSE: The statements by the commentors that temperature has an effect on the emissions are valid. Supplemental laboratory analyses performed on the asphalt binder obtained during the emissions test can be used to estimate the relative significance of this temperature effect. The analyses for loss on heating performed on the asphalts used during the tests included temperatures 25°F above and below the ASTM reference temperature of 325°F. The results of these analyses are presented in Table 11. As indicated by these tests, the loss on heating can change almost by a factor of 2 with these changes in temperature. The industry has stated that good paving practices dictate that loadout temperatures in excess of 325°F should be avoided. The industry indicates that higher temperatures are avoided due to issues related to long term viability of the pavement, difficulty in handling the hot pavement at the job site and production economics. As requested by the citizens, both facilities were requested to increase the loadout temperature as much as possible. The loadout temperatures measured during testing are presented in Table 3.3 of the PES Plant C report and Appendix B of the PES Plant D report. As testing was conducted with higher load out temperatures than routine industry practice, the results of these tests may be somewhat higher than would be expected under routine plant operation. The potential result of the higher load out temperatures can be estimated from data derived from the loss-on-heating analyses performed at different temperatures.

If one were to assume that the loss-on-heating test is an indicator of relative emissions from the asphalt, then these data can be used to accommodate variations in the temperature of the asphalt. As stated previously, the fundamental physical phenomenon is described by the Clausius-Claperon equation, which states that there is a linear relationship between the natural log of the vapor pressure and the inverse of the absolute temperature (Reference: *Experimental Physical Chemistry*; F. Daniels, J. W. Williams, P. Bender, R. Alberty, and C. Cornwell; McGraw-Hill; 1962). Many engineering tests and manuals (*Handbook of Chemistry and Physics*; 45th Edition; CRC Press; June 1973) provide Antoine's equation constants describing this linear relationship for many compounds. Using the above data the constants describing this relationship for the asphalts used during the tests can be empirically developed. Using the actual Plant C and D data, we can relate temperature to the loss on heating by using the following two equations, where t equals temperature (°F):

California Asphalt:       $Loss = -e^{((t + 460)*0.0231 - 19.28)}$

Massachusetts Asphalt:       $Loss = -e^{((t + 460)*0.0271 - 22.93)}$

**Table 11. Rolling Film Thickness Loss on Heating Data**

Temperature (deg F)	Date	Loss on Heating (% by RTFOT)	Date	Loss on Heating (% by RTFOT)
California Test Data			Massachusetts Test Data	
300	07/24/98	-0.216	10/05/98	-0.089
	07/25/98	-0.200	10/06/98	-0.105
	07/27/98	-0.142	10/07/98	-0.109
	07/28/98	-0.171		
325	07/24/98	-0.369	10/05/98	-0.216
	07/25/98	-0.311	10/06/98	-0.206
	07/27/98	-0.286	10/07/98	-0.218
	07/28/98	-0.292		
350	07/24/98	-0.686	10/05/98	-0.400
	07/25/98	-0.611	10/06/98	-0.395
	07/27/98	-0.498	10/07/98	-0.380
	07/28/98	-0.510		

Data presented in the Assessment of Emissions at Hot Mix Asphalt Plants report will be adjusted to the desired maximum loadout temperature of 325°F using the above equations. The resulting run-by-run multipliers that will be used to adjust the emissions are presented in Table 12.

**Table 12. Loadout Temperature and Adjustment Factors for 325°F**

Date	Mix/Loadout Temperature	Temperature Adjustment Factor	Date	Loadout Temperature	Temperature Adjustment Factor
California Test Data			Massachusetts Test Data		
07/24/98	326/321	1.097	10/05/99	307	1.629
07/25/98	325/316	1.231	10/06/99	325	1.0
07/27/98	322/291	2.193	10/07/99	327	0.947
07/28/98	335/	1.00			
Average	327/309	1.380	Average	320	1.192

Dividing the calculated loss on heating at different temperatures by the loss on heating at 325°F, results in a set of adjustment ratios. Table 13 presents these adjustment factors for asphalt samples obtained at both the Massachusetts and the California test locations. Averaging both of these adjustment factors creates a set of factors that is of more general use. These adjustment factors can be used to arrive at an emissions estimate for facilities that have a demonstrated loadout temperature different from the temperature used to normalize the test data. Table 13 presents the average temperature adjustment factor that will be included in the Assessment of Emissions at Hot Mix Asphalt Plants report. Users can use it to make adjustment to the average loadout temperatures demonstrated by actual measurements performed at a facility.

**Table 13. Adjustment Factors from 325°F to Indicated Temperature**

Temp (deg F)	Calif Data	Mass Data	Average
270	0.281	0.224	0.253
275	0.315	0.257	0.286
280	0.354	0.294	0.324
285	0.397	0.337	0.367
290	0.446	0.386	0.416
295	0.500	0.442	0.471
300	0.561	0.507	0.534
305	0.630	0.581	0.605
310	0.707	0.665	0.686
315	0.794	0.762	0.778
320	0.891	0.873	0.882
325	1.000	1.000	1.000
330	1.122	1.146	1.134

It is possible that the relative amount of the individual species emitted will change with the temperature. Higher temperatures will probably cause increased emissions of compounds emitted at lower temperatures and additional emissions of higher molecular weight compounds. As noted earlier, the facilities tested were requested to operate at the highest temperature consistent with good paving operations. As stated previously, the industry considers 325°F as this maximum targeted temperature. The daily average loadout temperatures documented during

the tests ranged from 291° to 327°F and averaged 314°F. Therefore, it is expected that the emissions of heavier molecular weight compounds were higher than might be expected at most plants under routine conditions.

It is not expected that facilities will use temperatures significantly above the industry's good operating practices maximum temperature of 325°F. In addition, additives like those cited by the commentor are added by the facility producing the asphalts or the asphalt distribution terminal and not by the hot mix asphalt plant. Therefore, the above adjustment factors should be sufficient for the majority of hot mix asphalt facilities.

## **Adjustments—Production**

### **54. Different Multiplier for Size of Plant**

COMMENT: The commentor (Yatzyshyn) states that the size of the plant should be weighted. The commentor stated that an hourly production combined with a time of operation would not factor into a simple multiplier. The commentor also stated that different facilities may have a different number of silos.

RESPONSE: The emission factors presented in the Executive Summary Report were scalable to facilities of different sizes and different operating schedules. To estimate emissions for a desired period, the only information required is the production for that period. In a like manner, silo emissions are also scalable to production. The quantity of hot mix asphalt processed through the production area equals what is loaded into the silos, and which is also loaded into the transport trucks. Therefore, emissions for each process can be estimated using only the production information.

## **Adjustments—Capture Efficiency**

### **55. Use Lowest of the Low Capture Efficiency**

COMMENT: The commentor (Eberhard) states that she had assumed the capture efficiency would be large and constant, and notes that apparently this was not the case. She recommends that if the capture efficiency shows large variation, the lowest of a low value should be used, not the average. She also questions whether the actual capture efficiency can be better matched with the corresponding sampling period.

RESPONSE: EPA Guidelines for Determining Capture Efficiency (located at URL <http://www.epa.gov/ttn/emc/guidlnd.html>, under document <http://www.epa.gov/ttn/emc/guidlnd/gd-035.pdf>) addresses the incorporation of variability in the calculation of capture efficiency. This guideline specifies that the lower 90% confidence interval of the average be the method to calculate capture efficiency. The use of the lowest capture

efficiency does not address the periods where capture efficiency is near 100%. As discussed elsewhere, it is believed that the injection of the tracer gas used to determine the capture efficiency provides a biased low indication of the true capture efficiency achieved by the ventilation system at Plant C. However, without designing a more complicated tracer gas system that mimics asphalt fume better, and retesting the facility, we cannot tell how low the capture efficiency is biased. In the calculations in the draft reports, the statistical method prescribed by the guideline document was not used. In the revision of the reports for Plant C, the method specified in the guideline document will be used for each run, and these values will be used to adjust the as-measured data. As stated above, this method requires the adjustment of the measured data using the lower 90% confidence level of the average capture efficiency. That is calculated by multiplying the standard deviation of the individually measured capture efficiencies by the  $t_{0.90}$  statistic value for the number of measurements and dividing by the square root of the number of measurements made. This result is subtracted from the average capture efficiency.

## Extension of Speciation Data

### 56. Scaling of Specific Compounds to Other Plants

COMMENT: The commentors (Krueger, Condon) state that the reports provide substantial and useful information and address some important data gaps in the relative contributions of various parts of the production process. While the commentors recognize that EPA resources precluded the speciation of emissions at the Massachusetts facility as was done at the California facility, they question whether specified information from the California facility is applicable to the Massachusetts facility because of different modes of operation and different materials.

RESPONSE: As indicated by the commentors, substantial useful information has been developed during these two tests. While this test program speciated certain compounds from only one facility, speciation information for asphalt is available in other studies. Two such studies were provided to the citizens groups previously. (*Evaluation of Emissions from Paving Asphalts*; EPA 600/R-94-135; US Environmental Protection Agency; Research Triangle Park, NC; August 1994; and *Evaluation of VOC Emissions from Heated Roofing Asphalt*; EPA 600/2-91-061; US Environmental Protection Agency; Research Triangle Park, NC; November 1991) The paving asphalt study included detailed speciation as was performed at the California facility. In addition, more detailed speciation data were obtained during the pretest survey visit to Plant C. Another study was published that characterized the organic compounds in asphalt roofing tar fumes (*Sources of Fine Organic Aerosol. Hot Asphalt Roofing Tar Pot Fumes*; Rogge, Hildemann, Mazurek and Cass; Environmental Science & Technology; Vol 31, No 10, pages 2726-2730). While roofing asphalt may be somewhat different from paving asphalt, it provides valuable confirmatory information for some specific pollutants and information that is otherwise unavailable. Since the cited studies were laboratory bench-scale tests, it was not possible to accurately estimate the mass emissions from asphalt plants with these studies. Because the relative ratios of compounds to the whole class of pollutant (e.g. PM) can

be calculated for these tests, these studies can now be used to provide additional useful information. By using the ratios between the measured pollutants of one or more key pollutants, information on the variability in these ratios can be used to improve the assessment of health impacts. Comparisons between different tests can be made by looking at the ratio of specific compounds to the extractable organic material. For example, the PAH to MCEM ratios for the current test were about 2% compared to the above study, where the ratios were about 4%.

## **Comparisons—Between Silo and Loadout Emissions**

### **57. Differences in Emissions Indicate Incomplete Sampling of Tunnel Emissions**

COMMENT: The commentor (Nadkarni) states that one would have expected the silo emissions to be less than the loadout emissions since the silo discharges vapor-saturated air with no wind or mixing to decrease the degree of saturation. He indicates that decreasing the degree of saturation should increase the amount of THC that would be volatilized. He states that since all emissions from the silo exited past the sampling location and the sample did not have much of a chance to cool off, a good sample was collected and the opposite is the case for the tunnel exhaust. It is his conclusion that the difference in the measured emissions indicates problems with incomplete sampling of the tunnel exhaust.

RESPONSE: While the commentor's argument supporting the hypothesis may appear reasonable, it is not supported by the data collected during the Plant C test which is valid. As presented elsewhere in this document, the sampling for the silo and the tunnel emissions (when combined with the capture efficiency adjustment and deposition calculations) was representative and complete. The data show that the physical processes affecting THC emissions are more complex than the commentor's hypothesis is based upon. While the physical processes affecting THC emissions may not be fully understood, variations in two critical parameters affecting emissions (asphalt volatilities and load out temperatures) will be included in the methodology used in procedures for estimating emissions for HMA plants.

## **Comparisons with Stack Emissions**

### **58. Executive Summary Tables 1 and 2 Comparisons of Stack and Fugitive Emissions**

COMMENT: The commentor (Nadkarni) believes that the comparison of stack emissions and fugitive emissions in the Executive Summary tables is not appropriate. He suggests that the comparison should be made on the weight of fuel burned versus the weight of volatiles in the asphalt. The commentor suggests that the weight of fuel burned for drying the crushed stone is about 300 times the weight of volatiles in the asphalt, some of which will be emitted during silo storage and loadout. The commentor also states that presenting these data without interpretation easily misleads the reader.

RESPONSE: The tables present emissions in terms of the facilities' production. The tables are primarily meant to give the reader a complete picture of the emissions from a facility with that level of production. The emissions can also be directly scaled to facilities with greater or lesser production. In addition, if the reader wishes, a direct comparison of the various major emission sources at a hot mix asphalt plant can be made. This portrayal would also allow someone to properly assign the release characteristics to the emission sources as part of a dispersion analysis to estimate ground level concentrations of the pollutants. By comparing emissions per unit of fuel usage for the stack emissions with emissions per unit of asphalt volatiles for the asphalt fugitive emissions, we gain little meaningful information—information that would be confusing to most readers. The ratio of THC stack emissions to fuel usage provides an additional indicator of combustion efficiency. This physical process is completely different from the process that governs the release of emissions from the asphalt product.

## **Comparisons with Previous Data**

### **59. Comparison of 1996 Data to 1998 Data**

COMMENT: The commentors (Nadkarni and Ecology Center) requested that comparisons be performed with previous analysis of THC data obtained by Method 25A for Plant C. The data collected at plant C in September 1997 by EPA and by the industry in July 1996 were cited as the additional data that should be analyzed. There were two reasons provided for analyzing the additional data. One was that Method 25A was the only link among all the data at Plant C and Plant D. The other was that the same sampling setup was used to measure tracer gas concentrations via FTIR to adjust all of the data for capture efficiency. The commentor requested a full explanation of the reason for not analyzing and reconciling the results from different plants. The commentor presented THC emissions measured during the July 1996 industry tests for comparison to the most recent EPA test. The commentor stated that an adjustment for the volatile content was not possible since this information was not recorded.

RESPONSE: It was not in the scope of the testing project to reanalyze the previously collected data, nor had anyone requested that the data from these different tests be compared and reconciled. It should be noted that the July 1996 industry tests were performed at a combined TED/SED test location. In contrast, the EPA testing established sampling locations at both the loadout tunnel (TED) and the silo exhaust (SED) to isolate these two sources and eliminate as much as possible the removal of silo emissions due to condensation in the ductwork .

As indicated by the commentor, the emission testing accomplished by industry had uncorrected average THC emissions of 307 lbs/100,000 tons for truck loading tests and 701 lb/100,000 tons for the combined silo and truck loading tests. The most appropriate comparison for these data would be with the unadjusted average THC emissions measured in the most recent EPA test. The most recent test results for THC emissions are 110 lb/100,000 tons for truck loading and 377 lb/100,000 tons for the sum of silo filling and truck loading. While a difference



of a factor of 2 or 3 may appear significant, emission tests accomplished at different times under different situations can have differences of this magnitude without a clear identifiable reason.

Other than a change in testing locations, several other differences could cause these differences.

1. It is not clear how effectively the dampers in the silo ductwork prevent the emissions from silos reaching the tunnel duct during the industry test.
2. It should be noted that the ductwork from the silos to the tunnel duct was coated with a thin film of condensed material that may have contributed to the emissions measured during the industry test. This thin film was also present in the tunnel duct upstream of the industry test location. The film appeared to be material condensed from the silo emissions and was a tar-like substance not unlike the original asphalt. This condensed material was not present in the duct for the most recent EPA tests.
3. The industry tests were of a shorter duration than the EPA test; therefore, the industry test may have sampled during a relatively high THC concentration period, which was seen as a variation in the EPA test.

Although the commentor stated that Method 25A is the only link among all the data at Plant C and Plant D, particulate data were collected during all of the tests. For particulate emissions, Method 315, Method 5, and CARB Method 5 are generally equivalent. The particulate measured during the industry test indicated PM emissions of 0.33 lb/hr. Assuming a loadout rate of 450 tons/hr, emissions were about 73 lb/100,000 tons loaded. The most recent EPA test measured uncorrected PM emissions of 56 lb/100,000 tons, and the EPA presurvey test measured PM emissions of 55 lb/100,000 tons. These three emissions can be considered comparable.

## **Trends and Variations—THC**

### **60. Variation in THC Emissions over Time at Plant C**

COMMENT: The commentors (Nadkarni and Eberhard) express concern about several variations over time observed in the Plant C THC data for Runs 1, 2, 3, and 4. One commentor believes that variations in capture efficiency over time, changes in test conditions, and random error may have caused these variations, and they should be explained. Correcting for capture efficiency over discrete time intervals is suggested. Another commentor suggests that if emissions cannot be correlated with production parameters, there must be a problem with either the measurement system or with the capture efficiency. One commentor suspects that the capture efficiency is more of a problem.

RESPONSE: Capture efficiency and THC concentrations vary simultaneously but in an inverse relationship to each other. Further data interpretation provides some understanding of these variations. For Run 1, average TED THC concentrations during the last half of the run are clearly lower than those measured in the first half. It is possible that lower capture efficiency contributed to this effect. However, lower capture efficiency was also observed during the last half of Runs 2, 3, and 4, and THC plots for those runs do not show the same trend. No plant operating conditions or test conditions were observed to change midway during Run 1.

The Run 2 TED THC time plot shows an episode of high emissions for about 40 min, centered at approximately 0900. Since there is a parallel increase in the SED emissions at the same time, one would think that the two events might be linked. As with Run 1 above, no plant or test conditions changed to explain this phenomenon.

Run 3 THC data from the TED appear to show no trends clearly related to plant or test conditions. Variations in the data appear to be random.

Run 4 background variations are discussed earlier in Response 41.

Further analysis of the variations cannot be explained without a significant amount of additional analyses and may never be significantly attributable to any specific action. While some conjecture about the causes of the variations may be reasonable, it is not appropriate to speculate on differentiating the groups of data in an attempt to explain the variations or correlate possible causes with effects. Some variations may be due to variations in the emissions from the individual loading events. Some may be due to variations in the ability of the tracer gas injection to simulate the release and capture of the asphalt fumes created by the drop operations.

As the commentor has stated previously, the final step at the petroleum refinery in the production of paving asphalt is vacuum distillation. This process uses very low pressure and high temperature to separate vapor compounds from liquid compounds. It is unlikely that at normal atmospheric pressure, any measurable volatile material could remain following this process. Knowledgeable experts hypothesize that the volatiles released may be due to the cracking of the high molecular weight hydrocarbons and the release of the resulting low molecular weight hydrocarbons. (Reference: Telecom with John DeAngelo, Federal Highway Administration, Washington, D.C.) The variations may be the result of temperature conditions experienced by the asphalt and the duration of these conditions. The loss-on-heating analyses at different temperatures show that a small change in temperature creates a significant change in emissions.

As noted by one commentor, the measurement of the capture efficiency is more difficult than quantifying the tracer gas or emissions captured. It is believed that much of the variabilities in capture efficiency may be due to the inability of the released tracer to closely simulate with the actual emissions from the loading operation. Although the design of the tracer gas injection system was as close to replicating this process as practicable, the collection of the tracer gas by the ventilation system presented a greater challenge to the ventilation system than the collection of the loadout emissions (See next paragraph also). As a result, the capture efficiency indicated

by the tracer gas would provide a conservative underestimate of the actual capture efficiency of the asphalt fumes.

The following situations illustrate some factors that could contribute to variations in the correlation between (a) what is measured from the release of process emissions and (b) the tracer gas emissions:

1. The tracer gas was released outside the edge of the tallest truck bed, whereas actual emissions occurred generally from the entire bed area but primarily from the center. Therefore, the tracer gas was not thoroughly mixed with the gas containing the emissions.
2. The hot asphalt generated a buoyant stream that quickly rose to the ventilation system. This buoyant stream contained a concentrated mass of the emissions, whereas the tracer gas was injected toward the edge of this buoyant stream. Therefore, the gas containing the emissions would be captured better than the air containing the tracer gas.
3. The asphalt was loaded intermittently with emissions (both visible and measured) that peaked during the loading, decreased rapidly while the truck waited to be released, and then tailed off slowly after the truck left. This is significantly different than the constant continuous release of the tracer gas. Most of the visible emissions were released during a very short period when the truck was stopped in the tunnel. The truck being loaded (and the next truck waiting to enter the tunnel) blocked the movement of air through the tunnel, allowing for more effective capture of emissions and tracer gas. If a truck were not in the tunnel, wind effects would lower capture efficiency below the capture efficiency during actual load out. The tracer gas was also being injected during the time that trucks were moving in the tunnel and when there was no buoyant effect to help transport the tracer gas to the hood. The piston effect of truck movement would create air movement across the whole cross-section of the tunnel to draw the tracer gas away from the capture hood, thereby lowering the measured capture efficiency. Higher loadout rates (trucks per period) would exacerbate this situation and increase the differences in the capture of the emissions and tracer gas.
4. Not only were the nozzles that injected the tracer gas at the edge of the gas stream of the emissions, but they were splayed to inject the tracer gas from 45° below horizontal to 45° above horizontal. For the majority of trucks, about 33% of the tracer gas was injected down from a point even with, and about two feet from, the upper edge of the truck bed. As a result, the capture of the tracer gas would be diminished.
5. Because only two trucks were used to simulate operations during background testing, the entry of air into the tunnel was not blocked about half the time. In addition, delays in starting the background test resulted in testing when the wind speed and direction were greater than when the other tests were conducted. The magnitude of this increase cannot be verified since there was a malfunction in the meteorological data collection for this day. The combined effect of this situation is that the average measured capture efficiency for this test is much lower than the other testing days, and this was the only day with periods of zero capture efficiency.

The effects of any of these situations are speculative, and any attempts to over analyze the data to explain the variations may not be appropriate. Although most of the variations are probably random, averaging of the emission data is the most appropriate and unbiased method to analyze the collected data. In addition, the 90 percentile lower confidence limit of the average capture efficiency will be used to determine the daily capture efficiency for the test.

## **Trends and Variations—THC/MCEM**

### **61. Inconsistent Trends in THC and MCEM Emissions**

COMMENT: The commentor (Nadkarni) makes the point for Plant D that from day 1 through day 3 there is an upward trend in THC emissions and volatile content and a downward trend in MCEM emissions.

RESPONSE: In cases like this where all the numbers are low and close to the detection limit of the method, it is difficult and speculative to draw conclusions from individual data points. In cases like this it is usually better to use averages instead of individual data points. For example, the commentor presents the MCEM results in lb/100,000 tons from Run 2 of 8.8 for comparison with the MCEM result from Run 1 of 22.9. The results from Run 7, by contrast, which was run simultaneously with Run 2, were 21.2 lb/100,000 tons, which compares more favorably with the 22.9 of Run 1. A better approach would be to compare the averages from simultaneous Runs 1 and 6, 2 and 7, and 3 and 8. When this is done, the MCEM downward trend is less dramatic, and instead of 22.9, 8.8, and 9.9 lb/100,000 tons, we get 24.6, 15.0, and 12.7 lb/100,000 tons.

### **62. PM, MCEM, VOCs**

COMMENT: The commentor Nadkarni presents THC and MCEM emissions from the tunnel and includes his own calculated THC emissions from the silo (addressed by MRI in Number 15, above). An examination of emission levels from Runs 1, 2, and 3 shows a trend which parallels the asphalt volatiles content for those three runs.

RESPONSE: No attempt was made to duplicate the commentor's calculations as they involve adjusting the data for short term capture efficiency and to maximum specifications for loss on heating values. However, as discussed in Response 24, emissions from Silo Run 2 were recalculated. Trends observed by the commentor may or may not still be present. In any case, the issue of asphalt volatility and the effect on emission factor calculations is discussed in Response 52.

### 63. Plant D THC Data Trends Need Clarity or Statistical Analysis

COMMENT: The commentor (Nadkarni) raises the question of statistical analysis for the Plant D data set and discusses confidence limits for the testing. Explanations were requested for apparent trends observed in Runs 1 and 3.

RESPONSE: A statistical analysis of the Plant D THC data is presented in Table 14. For a standard distribution, 95% confidence interval for individual data is obtained at the mean (average) value, plus or minus twice the standard deviation. A visual inspection of time plots from the Plant D test runs shows that some data points fall above and some below the calculated confidence limits. Variations observed in the data appear to be random.

Both of the specific time intervals examined by the commentor (Run 1, 1033-1227; Run 3, 0738-0854) contain several data points above the 95% confidence limits. There were no observed changes in plant operations or testing to clarify data observed during these time periods. Other points in the testing also showed data below the 95% confidence limit for which there were no observed explanations. These variations appear to be a normal distribution of data. It should be noted that the 95% confidence interval for the average concentration is determined by adding or subtracting from the mean twice the standard deviation divided by the square root of the number of data. These values are also included in Table 14.

**Table 14. Plant D Statistical Analysis**

Plant D Statistics	Run 1	Run 2	Run 3
Avg. THC Conc. (ppm)	3.1	3.5	3.6
Values measured.	240	240	240
Std Dev. (ppm)	1.11	1.28	1.44
Upper Conf. Limit of single value (95%)	5.32	6.06	6.48
Lower Conf. Limit of single value (95%)	0.88	0.94	0.72
Upper Conf. Limit of Average (95%)	3.2	3.7	3.8
Lower Conf. Limit of Average (95%)	3.0	3.3	3.4

## Dispersion Analysis

### 64. Dispersion of Fugitive Emissions

COMMENT: The commentor (Zeller) states that emissions from transport, while dispersed over distance, add to the total effect of the plant. The commentor further states that ambient temperature affects the buoyancy of the emissions. The commentor also mentions other meteorological parameters that affect the dispersion of emissions. The commentor indicates that the SCREEN3 dispersion model uses an annual average temperature of 68° F, while the ambient temperatures during plant operation may be higher or lower. The commentor indicated that this

matters when specifying daily or hourly limits that may not be exceeded. The commentor stated that the draft report failed to address this situation.

RESPONSE: Estimates of the emissions from the transport or asphalt are covered in another portion of this response. While the SCREEN3 dispersion model may use average annual temperatures, this model also is designed as a screening model that predicts ground-level concentrations that are significantly biased high. Other models (such as ISCST3, CTSCREEN, and CTDMPPLUS) that address the complexities of air dispersion more effectively are available and are indicated when the SCREEN3 model predicts concentrations that may be unacceptable. These models can also accept meteorological variables that are more reflective of the conditions at a modeled facility operation. In addition, these models are designed to address variations in terrain and exposure periods more effectively. Guidance on the applicability and use of these and other models to estimate ground level pollutant concentrations is available on the Support Center for Regulatory Air Models website (<http://www.epa.gov/ttn/scram/t23.htm#reg>). There was no intention for the reports to address the situations the commentor requests or to include dispersion modeling. The report does address the needs to estimate emissions from the fugitive emissions sources at hot mix asphalt plants. Specific local situations will need to be addressed locally.

## **65. Use of Fugitive Emissions Estimates in an Air Guide One Analysis**

COMMENT: The commentor (Yatzyshyn) asks whether the fugitive emission estimates can be used in an Air Guide One Analysis. The commentor also wants to know the impact if the emission can be used in the analysis.

RESPONSE: Air Guide One is a New York State computer program that estimates the ground-level concentration of a pollutant. This program is similar to a number of EPA dispersion models. However, more information is required to run the program than emission estimates derived from the EPA hot mix asphalt plants test program. In order to estimate the impacts using Air Guide One, additional information is required for each modeled facility, such as meteorological conditions at each facility, production level of each facility, the release conditions of the various emission points at the plant to be modeled (e.g., temp, velocity, height) and the type of terrain surrounding each modeled facility.

## **Risk Assessment**

### **66. Presentation of Short-Term Emissions Concentrations**

COMMENT: The commentor (Napadensky) states that the use of the average concentration obscures the true hazard to human health of some chemicals emitted at the plants. The commentor states that for some measured sources the concentrations were above a number of short-term exposure limits. The commentor indicates that in safety studies one needs to know the maximum values and not the average. The commentor cites the construction standards for resistance to wind speed and snow load as examples. The commentor cites specific measured

concentrations for toluene, hexane, THC from the silo, and CO from the dryer stack as values that exceed the short-term exposure limits. The commentor states that some atmospheric and terrain features may prevent the emissions from being diluted before they reach employees or people living nearby.

RESPONSE: The terms “toluene” and “hexane” in the draft report used to describe emissions from the silo exhaust were misleading. As explained in Response 30, these terms were chosen to describe a complex mixture of mostly aliphatic hydrocarbons. The manual methods (Method 0030, Method 18, and portable GC/MS) measured this same mixture and provided better information for certain specific compounds. These methods also used short sampling times and consistently measured concentrations well below the short-term OSHA, NIOSH and ACGIH exposure limits cited by the commentor. It should also be noted that under current assessment practices, risks and exposure for carcinogens and development of cancer are evaluated for lifetime scenarios, not for very short term "peak" concentrations.

With respect to CO from the dryer stack, the ambient air standard for CO is 35ppm, but the measurement period is 1 hr. As mentioned by the commentor, these emissions are diluted prior to reaching the ground. The emissions described by the commentor are released at elevated heights with differing levels of thermal buoyancy and downwash. As a result, the emission concentrations measured are not concentrations to which the general population may be exposed. Additionally, as stated in Response 29, the emissions factor for the highest 1-hr period was 0.03 lb/ton of asphalt produced, which is lower than the average AP-42 CO emission factor of 0.15 lb/ton of asphalt. Therefore, a presentation of these extreme values will not have a more severe impact than the use of the existing emission factor or the range of values that were used to develop the factor. Different atmospheric conditions and terrain cause differences in the concentrations at ground level. These situations necessitate the use of dispersion analyses to predict ground-level concentrations. Such dispersion analyses are not a part of this study and would likely show significant dilution of the stack gas before reaching ground level.

## **67. Present Emission Concentrations in Executive Summary**

COMMENT: The commentor (Napedensky) states that emissions concentrations, in addition to emission factors, should be presented in the Executive Summary. The commentor states that concentrations are needed to evaluate health effects.

RESPONSE: Health standards are generally based upon the ambient air exposure concentrations which only can be related to emissions concentrations with air dispersion modeling. These dispersion models require emissions on a mass-per-time basis. Additional information on the gas release parameters (height, velocity, diameter, and temperature) and atmospheric conditions that are specific to the facility and location are needed to arrive at an estimated ground-level concentration. The presentation of the release concentrations in the Assessment of Emissions at Hot Mix Asphalt Plants report do not directly relate to ground-level concentrations and could be misinterpreted as the concentration to which people might be exposed.

## Miscellaneous

### 68. Intermittent Loadout Tests Need Clarification

COMMENT: The commentor raises two issues, one concerning the clarity of Figure 3-4 of MRI's Plant C draft report and one requesting a detailed discussion of the intermittent loadout testing itself. The commentor states that the purpose of the intermittent loadout testing is not stated and implies that it was designed to simulate batch plant operations to evaluate whether emissions from drum mix plants are different from batch mix plants. The commentor states that a one minute period between drops was more typical of batch plant operation rather than the 30 periods used to simulate this operation. The commentor attempts to simulate the longer periods between drops by adjusting the intermittent loadout data using the results from the intermittent test with the longest sampling period. The commentor states that the revised information indicates a significant difference between the two drop methods.

RESPONSE: Figure 3-4 in the draft report shows horizontal lines to isolate the peaks included in the analysis. In order to more clearly show the integration areas, the commentor requested that vertical lines be used instead. Figure 7 contains the revisions. The "minor discrepancies" raised by the commentor were examined by MRI. The data presented in the Plant C draft report were correct, but Table 3-8 has been clarified by adding the "Drop Run Number" to the table. The maximum value for the THC concentration in Appendix E was corrected and is described in Response 70 (Miscellaneous Typos).

The intermittent loadout testing was included as an attempt to measure potential biases due to what was termed "incremental loading versus total loading" (MRI Plant C Site Specific Test Plan, page 3-8). The idea was to provide a rough indication of relative emissions from a batch mixing operation versus a continuous (silo) operation. A 30-sec time interval was selected based on discussions with control room operators, and was not intended to provide data directly comparable to the later Plant D tests. Furthermore, at the time of the Plant C testing, the batch mixing test site had not been selected, and it was not possible to know in advance that 1-min loadout drops would be more representative of the later Plant D testing. Additionally, while the specific test site had not been selected, it was known that one of several batch plants that had been observed by the commentor would be selected for subsequent testing. The intermittent loading tests were conducted to obtain additional information on the possible range of concentrations that should be planned for during the subsequent test.

Table 3-8 of MRI's Plant C draft report summarizes the raw data and statistical analysis for the intermittent loadout testing. Given the fact that the Plant D tests were subsequently added to the overall test program and provide data from an actual batch hot mix asphalt plant, Table 3-8 is supplemental information. Although, this supplemental information and statistical analysis will not be used to determine whether loadout emissions from batch and drum mix facilities are similar, we have evaluated the method used by the commentor to better approximate the longer periods between intermittent drops.



### THC Concentrations During Intermittant Loadout Testing

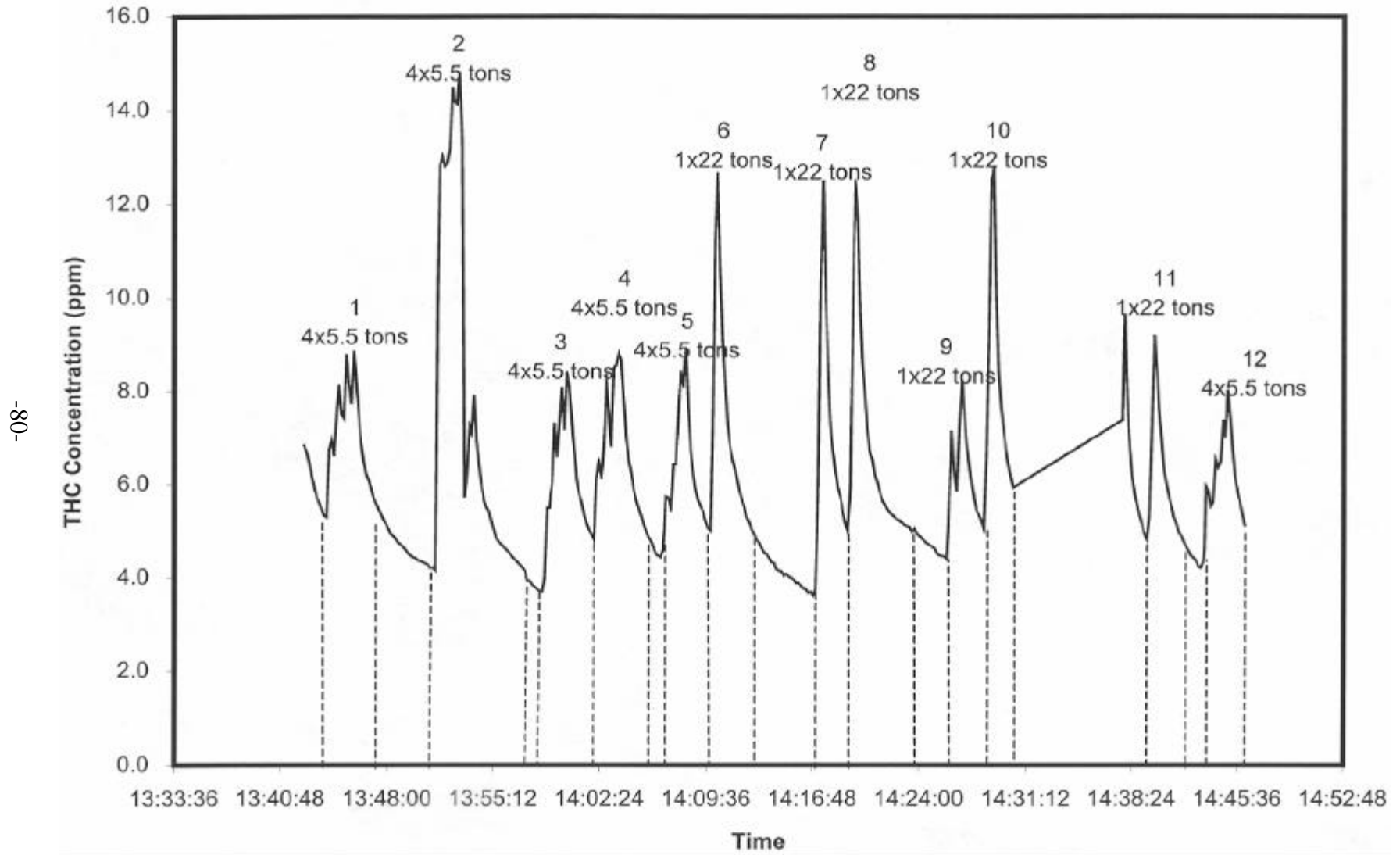


Figure 7. THC Concentration During Intermittant Loadout Testing

The commentator has selected the integration of the second intermittent load out run to replace the remaining five intermittent loadout results. Although the second run used the longest integration period, this run also demonstrated the highest initial rise in concentration of any of the twelve intermittent or single drop loadouts. The rise in concentration is 6.3 ppm higher than the next highest intermittent drop and is 1.1 ppm higher than the highest single drop loadout. This maximizes the adjustment to the data in two ways. First, the remaining five intermittent drop runs (1, 3, 4, 5 and 12) which have lower initial concentrations rises are replaced by the drop with the highest initial rise. This results in the greatest emissions of all the drops in Figure 8. Second, because of the shorter periods between intermittent drops, drops subsequent to the first drop would begin at a higher concentration than would occur with longer periods between drops. As a result, the peak and subsequent concentrations for the second through fourth intermittent drops would also be higher than would occur with longer periods between drops. These higher concentrations would result in greater emissions than would occur with longer periods between drops.

The commentator then performs a statistical analysis to compare the intermittent load out data with the single drop load out data. In comparing these two data sets, this statistical analysis uses the variance in each data set. By using the same value for all of the intermittent loadouts, the variance of the intermittent data is artificially set to zero thereby misstating the statistical significance. Several other methods can be applied to simulate longer periods between drops. However, each method incorporates assumptions that introduce uncertainties in the resulting analyses.

Four methods are presented for simulating longer periods between drops. Two methods do not alter the concentrations measured during the test while two methods attempt to estimate the effects on the measured concentrations due to the lower concentrations that would result from these longer periods between drops. The four methods are as follows:

- Option 1. This method results in the highest value and is obtained by extending the concentrations recorded prior to the second through fourth intermittent drops for an additional 30 seconds. This disregards the fact that the concentrations would decrease during this period and that the concentrations for the second through fourth intermittent drops would be lower due to these decreases.
- Option 2. This method is similar to option 1. However, estimates of the decreases in concentration are made for the additional 30 second periods. This also disregards the resulting lower concentrations for the second through fourth intermittent drops.
- Option 3. This option attempts to accommodate the decreases in the concentrations for the additional 30 second periods and the decreased concentrations for the second through fourth intermittent drops. This was accomplished by subtracting a constant value from the second through fourth intermittent drop concentrations presented in option 2. The value was selected to arrive at a concentration increase due to these drops that was the same as measured during the test.

Option 4. This option also attempts to accommodate the decreases in the concentrations for the additional 30 second periods and the decreased concentrations for the second through fourth intermittent drops. However, since the concentrations are lower, the concentration reductions following the second through fourth intermittent drops are less severe than option 3 and are more like the reductions measured following the fourth intermittent drop.

Rather than performing this adjustment to all six runs, only the first run was adjusted and the remainder of the intermittent data was increased in proportion to the changes in this one run.

Table 15 presents the original measured data for run number 1 and the four options described above to adjust this data from 30 second to 60 second periods between intermittent drops. Table 16 presents the integrated data for the six single drop and six intermittent drop loadouts and the four sets of adjusted intermittent drop data. As can be seen, all of the methods used to adjust the intermittent data produce lower integrated values than used by the commentor and all of the methods produce t-values that are significantly lower than the 8.3 arrived at by the commentor. The first two options indicate that a difference between loadouts using single and multiple drops does exist between the data at a confidence level greater than 99%. For the two more likely options, it is not clear whether the difference between the loadouts using single and multiple drops is statistically significant at the generally accepted confidence level of 95%. However, at a less restrictive confidence level of 90% both options would result in a statistically significant difference. As indicated previously, this analysis is highly uncertain because of the amount of manipulation of the Plant C intermittent load out data to simulate intermittent drops at one minute interval.

**Table 15. Adjusted Intermittent Loadout Data**

Time	Drop Amount (tons)	Measured Data (ppm)	Option 1 Maximum (ppm)	Option 2 Moderate (ppm)	Option 3 Likely (ppm)	Option 4 Likely (ppm)
01:43:54 PM		5.3	5.3	5.3	5.3	5.3
01:44:04 PM	5.5	6.7	6.7	6.7	6.7	6.7
01:44:14 PM		7.0	7.0	7.0	7.0	7.0
01:44:24 PM		6.6	6.6	6.6	6.6	6.6
			6.6	6.3	6.3	6.3
			6.6	6.2	6.2	6.2
			6.6	6.0	6.0	6.0
01:44:34 PM	5.5	7.5	7.5	7.5	6.9	6.9
01:44:44 PM		8.1	8.1	8.1	7.5	7.1
01:44:54 PM		7.5	7.5	7.5	6.9	6.8
01:45:04 PM		7.4	7.4	7.4	6.8	6.5
			7.4	6.8	6.2	6.3
			7.4	6.4	5.8	6.2
			7.4	6.1	5.5	6.1
01:45:14 PM	5.5	8.8	8.8	8.8	6.9	7.0
01:45:24 PM		8.1	8.1	8.1	6.3	6.7
01:45:34 PM		7.7	7.7	7.7	5.8	6.4
			7.7	7.1	5.2	6.2
			7.7	6.7	4.8	6.1
			7.7	6.4	4.5	6
01:45:44 PM	5.5	8.9	8.9	8.9	5.7	7.1
01:45:54 PM		8.2	8.2	8.2	5.0	6.8
01:46:04 PM		7.5	7.5	7.5	4.3	6.5
01:46:14 PM		6.9	6.9	6.9	3.7	6.3
01:46:24 PM		6.5	6.5	6.5	3.3	6.2
01:46:34 PM		6.2	6.2	6.2	3.0	6.1
01:46:44 PM		6.1	6.1	6.1	2.9	5.9
01:46:54 PM		5.9	5.9	5.9	2.7	5.7
01:47:04 PM		5.7	5.7	5.7	2.5	5.6
01:47:14 PM		5.6	5.6	5.6	2.4	5.5
01:47:24 PM		5.5	5.5	5.5	2.3	5.4
01:47:34 PM		5.4	5.4	5.4	2.1	5.3
Sum ppm-sec		1590.4	2296.4	2224.9	1651.9	2059.3

**Table 16. Statistical Analysis of Adjusted Intermittent Loadout Data**

Run Numbers (single/multiple)	Single Drop	Multiple Drops				
	Measured	Measured	Option 1	Option 2	Option 3	Option 4
6,1	1,243	1,564	2,243	2,172	1,631	2,007
7,2	917	2,304	3,306	3,201	2,403	2,958
8,3	1,729	1,243	1,783	1,726	1,296	1,595
9,4	935	1,524	2,187	2,117	1,590	1,957
10,5	936	1,189	1,706	1,652	1,241	1,527
11,12	934	1,040	1,492	1,445	1,085	1,335
Average	1,115	1,477	2,120	2,052	1,541	1,897
Standard Deviation	325	452	649	628	472	581
Variance	105,939	204,546	421,074	394,666	222,549	337,114
Difference		362	1004	937	426	781
t-value		1.59	3.39	3.24	1.82	2.88
Significance level of t- test		0.1426	0.0069	0.0088	0.0989	0.0165

#### **69. Annual Emissions in MRI Plant D Appendices Need Clarity**

COMMENT: The commentors (Nadkarni and Fillion) expressed concern over the annual emissions calculated by MRI in the Plant D draft report, Appendix B. These results were not repeated or explained in the main body of the draft report.

RESPONSE: Annual emissions were calculated in MRI's Plant D spreadsheets using the g/min of measured emissions and scaling them up on to operations of 24-hr/day, 365 days/yr. At the request of EPA/EMC, these emissions were not included in the main text since they were not an accurate characterization of either the facility tested or any other known facility. Since production utilization is highly dependent on local weather and paving needs, all reference to annual emissions will be removed from MRI's final report. Discussions related to calculating the annualized emissions should be directed to local regulatory authorities.

#### **70. Miscellaneous Typos**

COMMENT: Several of the commentors (Nadkarni, Fillion, Nowick and Acott) noticed typographical errors that should be corrected.

RESPONSE: The following corrections will be made to the final reports:

- a. MRI Plant C, page 1-1, second paragraph—the plant production capacity is 650 tons per hour, not tons per day.
- b. MRI Plant C, Appendix E—shows an incorrect maximum concentration for the intermittent loadout test. This error did not affect the data elsewhere in the appendix or main body of the report. The error will be corrected in the final report.
- c. MRI Plant D, page 1-1, second paragraph—the acronym “CAAP” will be changed to refer to “Coalition Against the Asphalt Plant.”
- d. New item not identified in comments: small changes in PES flowrate data versus draft report, small effect on capture calculations.
- e. New item not identified in comments: MRI error of *dscfm* vs. *wscfm*, effect on calculations.
- f. New item not identified in comments: MRI typo error on stack propane, Run 1 (spreadsheet problem, calculated using mol. wt. of methane in draft report), final result goes up by ratio of mol. wt. (44/16, or 2.75).

## 71. Clarification of Information Source for Executive Summary Data

COMMENT: The commentor (Fillion) notes that some unreferenced information is contained in the Background and Industry Profile sections of the Executive Summary Report. The commentor also states that the Executive Summary should include a reference to the failure of the temporary enclosure to completely capture the emissions. This should be added to the Method 204 discussion that describes why capture efficiency testing was not required at Plant D.

RESPONSE: References on the source of information contained in the Assessment of Emissions at Hot Mix Asphalt Plants report will be included in the final version of the report. A summary of the capture efficiency analysis of the Plant D total temporary enclosure will also be included. The results of the capture efficiency analysis is addressed in Response 11.

## 72. Water Vapor in RAP and Silo Exhaust

COMMENT: The commentor (Acott) identifies the high moisture conditions that were experienced during the testing of the silo exhaust. They stated that the test report attributes this high water content to the processing of RAP. It is stated that discussions regarding the 30% to 70% water content would be very valuable regarding the source of visible emissions. The commentor also surmises that the water contained in the RAP could easily be the primary source of vapor clouds that are visible during loadout at batch plants. The commentor states that this information would dispel the incorrect perception that the vapor clouds are mainly VOCs.

RESPONSE: Discussions on the potential amount of water contained in asphalt mixes and on possible visible occurrences is not suitable for emission test reports. Test reports are

intended only to document the testing activities, the relevant production information, and to present calculations to arrive at emissions measurements. However, some limited discussion can be included in the Industry Profile section of the Assessment of Emissions at Hot Mix Asphalt Plants report . The discussion will include a statement that emissions may be visible from a number of sources at hot mix asphalt plants. Visible emissions can be from dust, condensed particulate, and condensed water vapor. Visible dust emissions may vary due to the quantity and size of the dust emitted. Because of the small size of the condensed particulate and water, these emissions bend light more effectively and thus are easier to see. Differentiating the emissions of condensed particulate from the water may be difficult under some operating and meteorological conditions.

### **73. No Ambient Wind Inside Tunnel or TTE, Emissions Changed?**

COMMENT: The commentor is concerned that tests performed using an enclosure may not represent actual load-out conditions since most plants are not enclosed. The effects of ambient winds should be considered since they may increase emissions of a falling stream of asphalt.

RESPONSE: The test enclosures did block most of the effect of ambient winds since they were designed to control and/or capture the emissions. However, asphalt dropping from the silo to a truck takes a relatively small amount of time, and is then mostly blocked from ambient winds by the truck body itself. In addition, the thermal buoyancy created by the hot asphalt creates a modest air velocity over the surface of the hot asphalt. This thermal buoyancy is a major factor that allows for the improved capture of emissions by the hood system. If we assume that a truck occupies one-half the cross-sectional area of the tunnel, winds from the induced draft fan also create a 1- to 2-mph breeze across the truck bed. While this is clearly lower than most ambient winds, lack of wind inside the test enclosures is not expected to cause a significant bias in the test data.

## TECHNICAL REPORT DATA

*(Please read Instructions on reverse before completing)*

1. REPORT NO. <b>EPA-454/R-00-029</b>	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE <b>Hot Mix Asphalt Plants Response to Comments On Testing Program for Asphalt Plants C and D</b>	5. REPORT DATE <b>May 2000</b>	
	6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) <b>Ron Myers (EPA) Frank Phoenix (PES) Scott Klamm (MRI)</b>	8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS  <b>U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711</b>	10. PROGRAM ELEMENT NO.	
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	14. SPONSORING AGENCY CODE <b>EPA/200/04</b>	
15. SUPPLEMENTARY NOTES		
16. ABSTRACT  <p>The United States Environmental Protection Agency (EPA) Emission Factors and Inventory Group (EFIG) is investigating the Hot Mix Asphalt industry to identify and quantify criteria and hazardous air pollutants (HAP's) emitted from transport truck loading and silo filling. EFIG requested that EPA's Emission Measurement Center (EMC) conduct the required testing. Under separate EPA contracts, Midwest Research Institute (MRI) and Pacific Environmental Services (PES) performed two emissions tests. The primary objective of the testing program was to characterize uncontrolled emissions of the criteria pollutants particulate matter (PM) and total hydrocarbons (THC) and emissions of volatile and semi-volatile organic HAP's including polycyclic organic matter, phenol, benzene, toluene, xylene, ethylbenzene, 2-butanone, cumene, formaldehyde, hexane, isooctane and others. The two test reports were distributed for comments to environmental groups, state air pollution agencies, consultants and industry. This document summarizes the comments received, presents detailed responses to the comments and identifies how the comment will be accommodated in the reports.</p>		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
<b>Hot Mix Asphalt Silo Filling Truck Loading Particulate Matter Volatile Organic Compounds Total Hydrocarbons Hazardous Air Pollutants</b>	<b>Air Pollution control</b>	
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