

To: Files

From: Ronald E. Myers

Subject: Proposed revision of AP-42 section 11.1 for Hot mix Asphalt Plants dated December 2, 2003.

As indicated in the attached copy of the CHIEF web page, a revision of the AP-42 Section for Hot Mix Asphalt Plants was proposed on December 2, 2003 with a comment period that extended to January 16, 2004. At the end of January 2004, Una Connoly of the National Asphalt Pavement Association (NAPA) was informed by telephone that there were no comments received on the proposed revisions and that the section could be revised as indicated in the November 21, 2003 Memorandum from Brian Shrager and Rick Marinshaw of RTI International to Ron Myers of the U.S. Environmental Protection Agency.

On March 11, 2004, I received the attached e-mail from Una Connoly of NAPA transmitting the final revisions of the section and background report. On March 17, 2004, I received a package containing paper copies of the AP-42 section, the background report, the final source test report, the final test/QA plan and a CD-ROM containing the Adobe Acrobat files transmitted by e-mail. In addition, the CE-ROM contained the Word Perfect files that were used to create the Adobe Acrobat files. The revised files were reviewed to determine that the revisions that were proposed were incorporated into the final section, that the evaluations supporting the proposed revision were incorporated into the final background report and that the formatting was in accordance with the Procedures for Preparing Emission Factor Documents, EPA-454/R-95-015, November 1997.

After reviewing the revised section and background report, the AP-42 section was revised to change the date of revision from February 2004 to March 2004. In addition, text was added between the end of the text and the first table chronicling the revisions that have occurred since the initial publication of the Fifth edition of AP-42 in 1995.

Attachments:

Web page announcing proposed revisions

e-mail from Una Connoly to Ron Myers

Memorandum from Brian Shrager and Rick Marinshaw



## U.S. Environmental Protection Agency

# Technology Transfer Network Clearinghouse for Inventories & Emission Factors

[Contact Us](#) | [Print Version](#) Search:  [GO](#)

[EPA Home](#) > [Technology Transfer Network](#) > [Clearinghouse for Inventories & Emission Factors](#)  
> [Emission Factor Information](#) > [AP-42, Compilation of Air Pollutant Emission Factors](#) > [Chapter 11:  
Mineral Products Industry](#) > Proposed Revision to AP-42, 11.1 Hot Mix Asphalt Plants

Emission Factor &  
Inventory Information

Conferences

Publications

Emission Inventory  
Improvement  
Program

AirDATA

Related Sites

Site Index

## Proposed Revision to AP-42, 11.1 Hot Mix Asphalt Plants

**December 2, 2003**

The National Asphalt Pavement Association (NAPA) has proposed a revision of the emission factors for hot oil heaters at hot mix asphalt plants. A preliminary review of their proposal was performed by EPA to verify that the published procedures for developing emission factors ([Procedures for Preparing Emission Factor Documents](#), EPA-454/R-95-015, November 1997, PDF 477K) were followed. As a result, the proposed revisions are being posted on the CHIEF web site as draft for comment. EPA will accept comments on the draft revisions until **January 16, 2004**. Comments concerning the proposed revisions should be e-mailed to Ron Myers at [myers.ron@epa.gov](mailto:myers.ron@epa.gov) with copies to Una Connolly of NAPA at [uconnolly@hotmix.org](mailto:uconnolly@hotmix.org).

To assist reviewers in commenting on the revisions, the following documents are being made available on the CHIEF web site:

Memo from Bryan Shrager and Rick Marenschaw of RTI International to Ron Myers of EPA proposing Hot Mix Asphalt AP-42 Revision. ([PDF 57K](#))

Quality Assurance Project Plan & Site-specific Test Plan, Formaldehyde Emissions Testing from Asphalt Heaters - March 19, 2003. ([PDF 2.2M](#))

Test Report - Formaldehyde Emissions Testing from Asphalt Heaters - October 2003. ([PDF 1.8M](#))

Comprehensive Emission Inventory Report As Required Under The Air Toxics Hot Spots Information & Assessment Act Of 1987, September 1990, Reference 35 for Hot Mix Asphalt Plants ([PDF 2.75M](#))

At the conclusion of the comment period, EPA will provide the comments to NAPA for evaluation, preparation of responses and revision of the portions of the Section and Background report. EPA will evaluate the responses and revisions prepared by NAPA and determine whether they are scientifically and technically sound and consistent with established EPA procedures. While the information included in this draft concerns only formaldehyde, CO and CO<sub>2</sub> emissions from hot oil heaters, the final AP-42 Section and Background Report will be published as a single set of documents which incorporate these revisions.

### [AP-42 Emission Factors by Chapter](#)

| [Office of Air Quality Planning & Standards](#) | [Technology Transfer Network](#) |  
| [Clearinghouse for Inventories & Emission Factors](#) |

---

[EPA Home](#) | [Privacy and Security Notice](#) | [Contact Us](#)

Last updated on Tuesday, December 2nd, 2003  
URL: [http://www.epa.gov/ttn/chief/ap42/ch11/related/c11s01\\_revison.html](http://www.epa.gov/ttn/chief/ap42/ch11/related/c11s01_revison.html)



**Una Connolly**  
<una@hotmix.org>

03/11/2004 02:25 PM  
Please respond to  
"uconnolly@hotmix.org"

To: Ron Myers/RTP/USEPA/US@EPA  
cc: Mike Toney/RTP/USEPA/US@EPA  
Subject: FW: Final AP-42 Section 11.1, Hot Mix Asphalt Plants, and Background Report

Good Afternoon Ron and Mike -

Sorry for the long delay in getting back to in regards to the formaldehyde emissions testing. I have basically been out of the office since the middle of February. I have just opened the box from Rick Marinshaw that contains the completed documentation for the revised AP-42 section 11.1 and Background document. Attached to this email are these two documents in Adobe Acrobat. I will be mailing you a hard copy, a memo from RTI discussing the project and a CD-ROM containing all of the documentation.

Again, I apologize for the delay and if you have any questions or concerns please don't hesitate to contact me.

Sincerely,

Una

Una Connolly  
Director - Environment & Safety  
National Asphalt Pavement Association  
5100 Forbes Blvd.  
Lanham, MD 20706  
Phone: 888-468-6499  
Fax: 301-731-4621

-----Original Message-----

From: Marinshaw, Richard [SMTP:rjmarinshaw@rti.org]  
Sent: Wednesday, February 11, 2004 9:03 AM  
To: Una Connolly (E-mail)  
Subject: Final AP-42 Section 11.1, Hot Mix Asphalt Plants, and Background Report

Ms. Una Connelly  
Director, Environment and Safety  
National Asphalt Pavement Association  
NAPA Building  
5100 Forbes Boulevard  
Lanham, Maryland 20706-4407

Dear Una,

Attached are the PDF files for the final versions of AP-42 Section 11.1, Hot Mix Asphalt Plants, and the accompanying Background Report. We did have some trouble with the formatting of both documents, but I think we have fixed the problem.

As we discussed yesterday, we will be sending three hard copies of the final

AP-42 section and Background Report, along with a cover letter that documents the external review (public comment). We plan to include the hard copies of the AP-42 section in the bound Background Reports, attached at the back, if that is OK with you. In addition, we will send you the AP-42 section and Background Report on CD in both WordPerfect and PDF file formats. In the meantime, please let me know if you have any problems with the attached files, or if you have any questions about this project.

Rick Marinshaw

Richard J. Marinshaw, P.E.  
Research Environmental Engineer  
RTI International  
3040 Cornwallis Road  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194  
Phone: (919) 316-3735  
Fax: (919) 541-7155  
<<d11s01a-Feb-10-2004.pdf>> <<D11s01-Feb-10-2004.pdf>>



d11s01a-Feb-10-2004.p D11s01-Feb-10-2004.p

From: Brian Shrager  
Richard Marinshaw

To: Ron Myers, U.S. Environmental Protection Agency

Date: November 21, 2003

Project: Hot Mix Asphalt AP-42 Revision

Re: Emission factors for hot oil systems at hot mix asphalt plants

## I. INTRODUCTION

The National Asphalt Pavement Association (NAPA) recently conducted an emission testing program to measure formaldehyde and carbon monoxide (CO) emissions from hot oil systems (HOS), which are the systems that heat the hot asphalt oil that is used in the production of hot mix asphalt (HMA). The tests also included measurements of carbon dioxide (CO<sub>2</sub>) emissions. Following the recommendation of the United States Environmental Protection Agency (EPA), HOS at four facilities located in North Carolina were selected for testing. EPA approved the site specific test plans (SSTPs) and quality assurance project plan (QAPP) upon which the testing was based. The State of North Carolina was provided the SSTPs and QAPP and provided observers during the emission testing program. This memorandum presents a review and summary of the new HOS emission test report, a discussion of the previously available test data used to develop the current formaldehyde emission factor for hot oil heaters (in AP-42 Section 11.1), and the development of new emission factors that are recommended for inclusion in AP-42 Section 11.1, Hot Mix Asphalt Plants. The HOS test report is included as Appendix A to this memorandum.

## II. REVIEW AND SUMMARY OF THE NEW HOS EMISSION TEST REPORT

The following text is proposed for inclusion in the background report for AP-42 Section 11.1, Hot Mix Asphalt Plants:

4.2.1.357 Reference 395. This report includes four separate emission tests that were conducted for NAPA at four hot mix asphalt plants. Each test included three 72-minute test runs that measured formaldehyde and carbon monoxide emissions from hot oil systems (HOS), which are the systems that heat the hot asphalt oil that is used in the production of HMA. Formaldehyde emissions were measured using EPA Method 316, CO emissions were measured using EPA Method 10, and CO<sub>2</sub> emissions were measured using EPA Method 3 (Fyrite analyzer). The HOS burners were operated at high-fire, constant load conditions during testing, and heat sinks were used to prevent the burners from shutting down during testing. The facilities tested were: (1) S.T. Wooten, Franklinton, NC; (2) S.T. Wooten, Clayton, NC; (3) REA Construction, Mallard Creek, NC; and (4) REA Construction, North Mecklenburg, NC. The following paragraphs discuss unique aspects of each of the individual emission tests.

Testing at S.T. Wooten, Franklinton, NC, was conducted on March 25, 2003. The HOS was fired with No. 2 fuel oil at a rate of 3.0 gallons per hour (gph) during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 million British thermal units [MMBtu] per 1,000 gallons), this fuel usage rate is equivalent to 0.42 MMBtu/hr. One problem that was reported during the testing was that the Run 1 pre-test flow rate was 12.6 percent greater than the post-test flow rate. This may have introduced a positive bias of up to 12.6 percent on the formaldehyde and CO emissions reported for Run 1. No other problems were reported. The data from this test are assigned a B rating because of the problem documented during Run 1.

Testing at S.T. Wooten, Clayton, NC, was conducted on March 27, 2003. The HOS was fired with No. 2 fuel oil at a rate of 6.5 gph during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 MMBtu per 1,000 gallons), this fuel usage rate is equivalent to 0.91 MMBtu/hr. Formaldehyde was not detected during Runs 2 and 3, and the detection limits for the two runs were 1.55 parts per billion by volume, dry basis (ppbv), and 1.39 ppbv, respectively. No problems were reported. The formaldehyde data from this test are assigned a B rating because two of the three test runs did not detect formaldehyde, and for purposes of emission factor development, emissions from these two runs were estimated as one-half of the detection limit. The carbon monoxide data from this test are assigned an A rating. The CO<sub>2</sub> data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

Testing at REA Construction, Mallard Creek, NC, was conducted on April 1, 2003. The HOS was fired with natural gas at a rate of 1,700 cubic feet per hour (cfh) during all three test runs. Using the average natural gas heating value documented in AP-42 Section 1.4 (1,020 Btu per standard cubic foot [scf]), this fuel usage rate is equivalent to 1.73 MMBtu/hr. In the test report, the maximum natural gas heating value (from AP-42 Section 1.4) of 1,050 Btu/scf was used as a conversion factor, but for purposes of developing emission factors for AP-42, the average value of 1,020 Btu/scf was used. Carbon

monoxide was not detected during any test run at a detection limit of 0.2 parts per million by volume, dry basis (ppmv). No problems were reported. The formaldehyde data from this test are assigned an A rating. The CO data from this test are assigned a B rating because CO was not detected during any test run, and for purposes of emission factor development, a value equal to one-half of the detection limit was used to estimate CO emissions. The CO<sub>2</sub> data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

Testing at the REA Construction North Mecklenburg facility was conducted on April 2 and 3, 2003. The HOS was fired with No. 2 fuel oil at a rate of 7.0 gph during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 MMBtu per 1,000 gallons]), this fuel usage rate is equivalent to 0.98 MMBtu/hr. No problems were reported. The formaldehyde and CO data from this test are assigned an A rating. The CO<sub>2</sub> data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

### III. DISCUSSION OF PREVIOUSLY AVAILABLE FORMALDEHYDE TEST DATA

The following paragraph is an excerpt from the background report for AP-42 Section 11.1 that presents a brief review of the Reference 35 emission test, which is included as Appendix B to this memorandum, that currently serves as the basis for the hot oil heater formaldehyde emission factor:

“The plant tested was a drum-mix facility with the dryer fired by propane and emissions controlled by a fabric filter. The test included three runs measuring trace metals, total chromium and hexavalent chromium (Cr and Cr<sup>+6</sup>), PAHs, benzene, toluene, xylene, methyl chloroform, formaldehyde, and hydrogen sulfide emissions from the dryer at the fabric-filter outlet. Also included were three test runs measuring PAHs, polychlorinated dibenzofurans (TCDFs, PCDFs, HxCDFs, HpCDFs, and OCDFs), polychlorinated dibenzo(p)dioxins (TCDDs, PeCDDs, HxCDDs, HpCDDs, and OCDDs), benzene, and formaldehyde emissions from the hot oil heater stack. The hot oil heater was fired with No. 2 fuel oil. Trace metals were measured using draft EPA Method 200.7, and PAHs were tested using EPA MM5 (Semi-VOST). The other pollutants were measured using CARB test procedures, which are similar to EPA methods for the pollutants tested. For target pollutants that were not detected in one or two test runs, emissions from the “nondetect” runs were estimated using one-half of the pollutant detection limit. Several target pollutants were not detected in any run. Radionuclide emissions also were

sampled during this test, but the information provided is insufficient for emission factor development.

*A rating of B was assigned to most of the data from this test. A rating of C was assigned if a pollutant was detected in only one of three test runs. The report included some detail, but it provided only an average production rate and did not describe the control system. The test methodology appeared to be sound, and no problems were reported in the valid test runs.”*

During the NAPA-sponsored HOS emission tests, we identified additional shortcomings associated with the emission test documented in Reference 35. Most importantly, NAPA recognized prior to testing that HOS are operated with a thermostat that allows the burners to shut down when the oil reaches a specified temperature. The NAPA-sponsored tests included provisions (installation of heat sinks on each burner to prevent the burners from shutting down during testing) to ensure that each HOS system was operating continuously during testing. Without these provisions, the system operation would have been intermittent, resulting in extreme changes in flow and stack gas conditions. It is unclear how the Reference 35 emission test accounted for the intermittent operation of the system, and the results of the test, therefore, are questionable. In addition, Reference 35 does not include any field data sheets, calculations, quality assurance information, description of the test program, or discussion of problems with the testing. Therefore, we recommend that the data for hot oil heaters from Reference 35 be assigned a D rating. Specifically, we recommend that the last paragraph above (shown in *italics*) be replaced with the following paragraph:

For the drum mix dryer emission testing, a rating of B is assigned to most of the data. A rating of C is assigned if a pollutant was detected in only one of three test runs. The report included some detail, but it provided only an average production rate and did not describe the control system. The test methodology appeared to be sound, and no problems were reported in the valid test runs. The hot oil heater emission test data are assigned a D rating because of the lack of documentation and, more importantly, the large amount of uncertainty associated with the testing and how the testing accounted for the intermittent operation of the system and the resultant changes in exhaust flow and stack gas conditions.

#### IV. DEVELOPMENT OF NEW EMISSION FACTORS FOR HOS

The following paragraphs are proposed to replace the existing section 4.2.4.2 in the background report for AP-42 Section 11.1:

4.2.4.2 Hot Oil Systems. Emission factors for HOS, which are the systems that heat the hot asphalt oil that is used in the production of HMA, were developed using the data presented in Table 4-13. Table 4-13a shows the development of emission factors for formaldehyde, CO, and CO<sub>2</sub> (pollutants for which more than one test is available). The formaldehyde, CO, and CO<sub>2</sub> emission factors for each test were calculated with units of kilogram per liter (kg/l) (pounds per gallon [lb/gal]) for oil-fired HOS and kilogram per standard cubic meter (kg/m<sup>3</sup>) (pounds per standard cubic foot lb/ft<sup>3</sup>) for natural gas-fired HOS. These emission factors then were normalized to a common basis, pounds per MMBtu (lb/MMBtu), so that the data for fuel oil-fired and natural gas-fired HOS could be compared and combined (if appropriate). The normalized average emission factors were then converted back to a kg/l (lb/gal) basis for fuel oil fired HOS and a kg/m<sup>3</sup> (lb/ft<sup>3</sup>) basis for natural gas-fired HOS. The average emission factors for HOS are shown in Table 4-18. The following paragraphs describe the emission factor development.

Uncontrolled emission factors for PAHs and several polychlorinated dibenzofurans and dibenzo(p)dioxins, including 1,2,3,7,8,9-HxCDD, 1,2,3,4,7,8-HxCDD, total HxCDD, 1,2,3,4,6,7,8-HpCDD, total HpCDD, total OCDD, total TCDF, total PeCDF, total HxCDF, total HpCDF, 1,2,3,4,6,7,8-HpCDF, and total OCDF were developed from a single D-rated test. These emission factors are assigned E ratings.

Emission factors for uncontrolled formaldehyde emissions from HOS were developed from two A-rated and two B-rated tests conducted at four facilities. Data from one additional D-rated test, Reference 35, were not used for emission factor development because, as specified in the AP-42 procedures manual, C- or D-rated data should not be combined with A- or B-rated data. The formaldehyde data (from HOS fired by different fuels) were first normalized to a lb/MMBtu basis, and, because the emission factors were similar regardless of the HOS fuel type, the data from all four tests were combined to develop a single formaldehyde emission factor for HOS. This average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m<sup>3</sup> (lb/ft<sup>3</sup>) basis for natural gas-fired HOS. These formaldehyde emission factors are assigned a C rating.

An emission factor for uncontrolled CO emissions from HOS was developed from three A-rated tests and one B-rated test conducted at four facilities. The CO data were first normalized to a lb/MMBtu basis, and the data from all four tests were combined to develop a single CO emission factor for HOS. The

average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m<sup>3</sup> (lb/ft<sup>3</sup>) basis for natural gas-fired HOS. The CO emission factors are assigned a C rating.

An emission factor for uncontrolled CO<sub>2</sub> emissions from HOS was developed from four B-rated tests conducted at four facilities. The CO<sub>2</sub> data were first normalized to a lb/MMBtu basis, and, because the emission factors were similar regardless of the HOS fuel type, the data from all four tests were combined to develop a single CO<sub>2</sub> emission factor for HOS. The average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m<sup>3</sup> (lb/ft<sup>3</sup>) basis for natural gas-fired HOS. These CO<sub>2</sub> emission factors are assigned a C rating.

Table 4-13. SUMMARY OF TEST DATA FOR HOT MIX ASPHALT PRODUCTION  
HOT OIL SYSTEMS

Type of control	Fuel fired	Pollutant	No. of test runs	Data rating	Emission factor range, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Ref. No.
None	No. 2 fuel oil	Naphthalene	3	D	$1.2 \times 10^{-6}$ - $2.8 \times 10^{-6}$ ( $1.1 \times 10^{-5}$ - $2.3 \times 10^{-5}$ )	$2.0 \times 10^{-6}$ ( $1.7 \times 10^{-5}$ )	35
None	No. 2 fuel oil	Acenaphthylene	3	D	$1.7 \times 10^{-8}$ - $3.0 \times 10^{-8}$ ( $1.4 \times 10^{-7}$ - $2.5 \times 10^{-7}$ )	$2.4 \times 10^{-8}$ ( $2.0 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Acenaphthene	3	D	$6.2 \times 10^{-8}$ - $6.7 \times 10^{-8}$ ( $5.2 \times 10^{-7}$ - $5.6 \times 10^{-7}$ )	$6.4 \times 10^{-8}$ ( $5.3 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Fluorene	3	D	$1.6 \times 10^{-7}$ - $4.6 \times 10^{-7}$ ( $1.3 \times 10^{-6}$ - $3.8 \times 10^{-6}$ )	$2.8 \times 10^{-7}$ ( $2.3 \times 10^{-6}$ )	35
None	No. 2 fuel oil	Phenanthrene	3	D	$4.8 \times 10^{-7}$ - $8.2 \times 10^{-7}$ ( $4.0 \times 10^{-6}$ - $6.8 \times 10^{-6}$ )	$5.9 \times 10^{-7}$ ( $4.9 \times 10^{-6}$ )	35
None	No. 2 fuel oil	Anthracene	3	D	$1.7 \times 10^{-8}$ - $2.9 \times 10^{-8}$ ( $1.4 \times 10^{-7}$ - $2.4 \times 10^{-7}$ )	$2.2 \times 10^{-8}$ ( $1.8 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Fluoranthene	3	D	$3.4 \times 10^{-9}$ - $6.2 \times 10^{-9}$ ( $2.8 \times 10^{-8}$ - $5.2 \times 10^{-8}$ )	$5.3 \times 10^{-9}$ ( $4.4 \times 10^{-8}$ )	35
None	No. 2 fuel oil	Pyrene	3	D	$3.2 \times 10^{-9}$ - $4.7 \times 10^{-9}$ ( $2.7 \times 10^{-8}$ - $3.9 \times 10^{-8}$ )	$3.8 \times 10^{-9}$ ( $3.2 \times 10^{-8}$ )	35
None	No. 2 fuel oil	Benzo(b)fluoranthene	3	D	$7.2 \times 10^{-9}$ - $1.8 \times 10^{-8}$ ( $6.0 \times 10^{-8}$ - $1.5 \times 10^{-7}$ )	$1.2 \times 10^{-8}$ ( $1.0 \times 10^{-7}$ )	35
None	No. 2 fuel oil	TCDF (total)	3	D	$6.7 \times 10^{-14}$ - $8.2 \times 10^{-13}$ ( $5.6 \times 10^{-13}$ - $6.8 \times 10^{-12}$ )	$4.0 \times 10^{-13}$ ( $3.3 \times 10^{-12}$ )	35
None	No. 2 fuel oil	PCDF (total)	3	D	$2.4 \times 10^{-14}$ - $1.2 \times 10^{-13}$ ( $2.0 \times 10^{-13}$ - $1.0 \times 10^{-12}$ )	$5.8 \times 10^{-14}$ ( $4.8 \times 10^{-13}$ )	35
None	No. 2 fuel oil	HxCDF (total)	2	D	$1.6 \times 10^{-14}$ - $5.8 \times 10^{-13}$ ( $1.3 \times 10^{-13}$ - $4.8 \times 10^{-12}$ )	$2.4 \times 10^{-13}$ ( $2.0 \times 10^{-12}$ )	35
None	No. 2 fuel oil	HpCDF (total)	2	D	$3.8 \times 10^{-14}$ - $2.6 \times 10^{-12}$ ( $3.2 \times 10^{-13}$ - $2.2 \times 10^{-11}$ )	$1.2 \times 10^{-12}$ ( $9.7 \times 10^{-12}$ )	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDF	3	D	$9.4 \times 10^{-14}$ - $1.0 \times 10^{-12}$ ( $7.6 \times 10^{-13}$ - $8.4 \times 10^{-12}$ )	$4.2 \times 10^{-13}$ ( $3.5 \times 10^{-12}$ )	35
None	No. 2 fuel oil	OCDF	3	D	$1.2 \times 10^{-13}$ - $3.7 \times 10^{-12}$ ( $1.0 \times 10^{-12}$ - $3.1 \times 10^{-11}$ )	$1.4 \times 10^{-12}$ ( $1.2 \times 10^{-11}$ )	35
None	No. 2 fuel oil	HxCDD (total)	3	D	$2.3 \times 10^{-13}$ - $1.3 \times 10^{-12}$ ( $1.9 \times 10^{-12}$ - $1.1 \times 10^{-11}$ )	$7.4 \times 10^{-13}$ ( $6.2 \times 10^{-12}$ )	35
None	No. 2 fuel oil	1,2,3,7,8,9-HxCDD	3	D	$3.8 \times 10^{-14}$ - $1.2 \times 10^{-13}$ ( $3.2 \times 10^{-13}$ - $1.0 \times 10^{-12}$ )	$9.1 \times 10^{-14}$ ( $7.6 \times 10^{-13}$ )	35
None	No. 2 fuel oil	1,2,3,4,7,8-HxCDD	3	D	$3.8 \times 10^{-14}$ - $1.1 \times 10^{-13}$ ( $3.2 \times 10^{-13}$ - $9.2 \times 10^{-13}$ )	$8.3 \times 10^{-14}$ ( $6.9 \times 10^{-13}$ )	35
None	No. 2 fuel oil	HpCDD (total)	3	D	$1.7 \times 10^{-13}$ - $6.7 \times 10^{-12}$ ( $1.4 \times 10^{-12}$ - $5.6 \times 10^{-11}$ )	$2.4 \times 10^{-12}$ ( $2.0 \times 10^{-11}$ )	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDD	3	D	$1.7 \times 10^{-13}$ - $4.6 \times 10^{-12}$ ( $1.4 \times 10^{-12}$ - $3.8 \times 10^{-11}$ )	$1.8 \times 10^{-12}$ ( $1.5 \times 10^{-11}$ )	35
None	No. 2 fuel oil	OCDD	3	D	$1.2 \times 10^{-12}$ - $5.3 \times 10^{-11}$ ( $1.0 \times 10^{-11}$ - $4.4 \times 10^{-10}$ )	$1.9 \times 10^{-11}$ ( $1.6 \times 10^{-10}$ )	35
None	No. 2 fuel oil	Formaldehyde	3	D	0.0019-0.0053 (0.016-0.044)	0.0032 (0.027)	35

TABLE 4-13. (continued)

Type of control	Fuel fired	Pollutant	No. of test runs	Data rating	Emission factor range, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Ref. No.
None	No. 2 fuel oil	Formaldehyde	3	B	$7.1 \times 10^{-7}$ - $1.4 \times 10^{-6}$ ( $6.0 \times 10^{-6}$ - $1.2 \times 10^{-5}$ )	$9.4 \times 10^{-7}$ ( $7.9 \times 10^{-6}$ )	395 <sup>a</sup>
None	No. 2 fuel oil	Carbon monoxide	3	A	$8.3 \times 10^{-5}$ -0.00089 (0.00070-0.0075)	0.00043 (0.0036)	395 <sup>a</sup>
None	No. 2 fuel oil	Carbon dioxide	3	B	2.4-2.6 (20-22)	2.5 (21)	395 <sup>a</sup>
None	No. 2 fuel oil	Formaldehyde	3	B	$1.9 \times 10^{-8}$ - $8.6 \times 10^{-8}$ ( $1.6 \times 10^{-7}$ - $7.2 \times 10^{-7}$ )	$4.2 \times 10^{-8}$ ( $3.5 \times 10^{-7}$ )	395 <sup>b</sup>
None	No. 2 fuel oil	Carbon monoxide	3	A	$2.8 \times 10^{-5}$ - $7.0 \times 10^{-5}$ (0.00024-0.00059)	$4.6 \times 10^{-5}$ (0.00039)	395 <sup>b</sup>
None	No. 2 fuel oil	Carbon dioxide	3	B	4.3-4.5 (36-38)	4.4 (37)	395 <sup>b</sup>
None	Natural gas	Formaldehyde	3	A	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) $9.8 \times 10^{-8}$ - $3.5 \times 10^{-7}$ ( $6.1 \times 10^{-9}$ - $2.2 \times 10^{-8}$ )	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) $2.6 \times 10^{-7}$ ( $1.6 \times 10^{-8}$ )	395 <sup>c</sup>
None	Natural gas	Carbon monoxide	3	B	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) $1.9 \times 10^{-6}$ - $1.9 \times 10^{-6}$ ( $1.2 \times 10^{-7}$ - $1.2 \times 10^{-7}$ )	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) $1.9 \times 10^{-6}$ ( $1.2 \times 10^{-7}$ )	395 <sup>c</sup>
None	Natural gas	Carbon dioxide	3	B	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) 2.7-2.7 (0.17-0.17)	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) 2.7 (0.17)	395 <sup>c</sup>
None	No. 2 fuel oil	Formaldehyde	3	A	$1.7 \times 10^{-7}$ - $8.0 \times 10^{-7}$ ( $1.4 \times 10^{-6}$ - $6.7 \times 10^{-6}$ )	$4.0 \times 10^{-7}$ ( $3.4 \times 10^{-6}$ )	395 <sup>d</sup>
None	No. 2 fuel oil	Carbon monoxide	3	A	$6.2 \times 10^{-5}$ -0.00013 (0.00052-0.0011)	$9.9 \times 10^{-5}$ (0.00083)	395 <sup>d</sup>
None	No. 2 fuel oil	Carbon dioxide	3	B	3.2-3.6 (27-30)	3.3 (28)	395 <sup>d</sup>

<sup>a</sup> S.T. Wooten, Franklinton, NC, facility.

<sup>b</sup> S.T. Wooten, Clayton, NC, facility.

<sup>c</sup> REA Construction, Mallard Creek, NC, facility.

<sup>d</sup> REA Construction, North Mecklenburg, NC facility.

Table 4-13a. SUMMARY OF EMISSION FACTOR DEVELOPMENT FOR FORMALDEHYDE, CARBON MONOXIDE, AND CARBON DIOXIDE FROM HOT MIX ASPHALT PRODUCTION – HOT OIL SYSTEMS

Type of control	Fuel fired	Pollutant	No. of tests	Emission factor rating	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted)	Converted emission factor, lb/MMBtu	Average emission factor, lb/MMBtu	Candidate emission factors and units	Ref. No.
<del>None</del>	<del>No. 2 fuel oil</del>	<del>Formaldehyde</del>	4	C	<del>0.0032 (0.027)</del>	<del>NA</del>	2.5x10 <sup>-5</sup>	<u>Fuel oil-fired HOS</u> 4.2x10 <sup>-7</sup> kg/l (3.5x10 <sup>-6</sup> lb/gal)  <u>Natural gas-fired HOS</u> 4.1x10 <sup>-7</sup> kg/m <sup>3</sup> (2.6x10 <sup>-8</sup> lb/ft <sup>3</sup> )	<del>35</del>
None	No. 2 fuel oil	Formaldehyde			4.2x10 <sup>-8</sup> (3.5x10 <sup>-7</sup> )	2.5x10 <sup>-6</sup>			395 <sup>b</sup>
None	Natural gas	Formaldehyde			kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) 2.6x10 <sup>-7</sup> (1.6x10 <sup>-8</sup> )	1.6x10 <sup>-5</sup>			395 <sup>c</sup>
None	No. 2 fuel oil	Formaldehyde			4.0x10 <sup>-7</sup> (3.4x10 <sup>-6</sup> )	2.5x10 <sup>-5</sup>			395 <sup>d</sup>
None	No. 2 fuel oil	Formaldehyde			9.4x10 <sup>-7</sup> (7.9x10 <sup>-6</sup> )	5.7x10 <sup>-5</sup>			395 <sup>a</sup>
None	Natural gas	Carbon monoxide	4	C	kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) 1.9x10 <sup>-6</sup> (1.2x10 <sup>-7</sup> )	0.00012	0.0087	<u>Fuel oil-fired HOS</u> 0.00015 kg/l (0.0012 lb/gal)  <u>Natural gas-fired HOS</u> 0.00014 kg/m <sup>3</sup> (8.9x10 <sup>-6</sup> lb/ft <sup>3</sup> )	395 <sup>c</sup>
None	No. 2 fuel oil	Carbon monoxide			4.6x10 <sup>-5</sup> (0.00039)	0.0028			395 <sup>b</sup>
None	No. 2 fuel oil	Carbon monoxide			9.9x10 <sup>-5</sup> (0.00083)	0.0059			395 <sup>d</sup>
None	No. 2 fuel oil	Carbon monoxide			0.00043 (0.0036)	0.026			395 <sup>a</sup>
None	No. 2 fuel oil	Carbon dioxide	4	C	2.5 (21)	150	200	<u>Fuel oil-fired HOS</u> 3.4 kg/l (28 lb/gal)  <u>Natural gas-fired HOS</u> 3.3 kg/m <sup>3</sup> (0.20 lb/ft <sup>3</sup> )	395 <sup>a</sup>
None	Natural gas	Carbon dioxide			kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) 2.7 (0.17)	170			395 <sup>c</sup>
None	No. 2 fuel oil	Carbon dioxide			3.3 (28)	200			395 <sup>d</sup>
None	No. 2 fuel oil	Carbon dioxide			4.4 (37)	260			395 <sup>b</sup>

<sup>a</sup> S.T. Wooten, Franklinton, NC, facility.

<sup>b</sup> S.T. Wooten, Clayton, NC, facility.

<sup>c</sup> REA Construction, Mallard Creek, NC, facility.

<sup>d</sup> REA Construction, North Mecklenburg, NC facility.

Table 4-18. SUMMARY OF EMISSION FACTOR DEVELOPMENT FOR HOT MIX ASPHALT PRODUCTION DRUM MIX FACILITY – HOT OIL HEATERS

Type of control	Fuel fired	Pollutant	No. of tests	Emission factor rating	Average emission factor, kg/l (lb/gal) fuel consumed, unless noted otherwise	Ref. No.
None	No. 2 fuel oil	Naphthalene	1	E	$2.0 \times 10^{-6}$ ( $1.7 \times 10^{-5}$ )	35
None	No. 2 fuel oil	Acenaphthylene	1	E	$2.4 \times 10^{-8}$ ( $2.0 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Acenaphthene	1	E	$6.4 \times 10^{-8}$ ( $5.3 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Fluorene	1	E	$2.8 \times 10^{-7}$ ( $2.3 \times 10^{-6}$ )	35
None	No. 2 fuel oil	Phenanthrene	1	E	$5.9 \times 10^{-7}$ ( $4.9 \times 10^{-6}$ )	35
None	No. 2 fuel oil	Anthracene	1	E	$2.2 \times 10^{-8}$ ( $1.8 \times 10^{-7}$ )	35
None	No. 2 fuel oil	Fluoranthene	1	E	$5.3 \times 10^{-9}$ ( $4.4 \times 10^{-8}$ )	35
None	No. 2 fuel oil	Pyrene	1	E	$3.8 \times 10^{-9}$ ( $3.2 \times 10^{-8}$ )	35
None	No. 2 fuel oil	Benzo(b)fluoranthene	1	E	$1.2 \times 10^{-8}$ ( $1.0 \times 10^{-7}$ )	35
None	No. 2 fuel oil	TCDF (total)	1	E	$4.0 \times 10^{-13}$ ( $3.3 \times 10^{-12}$ )	35
None	No. 2 fuel oil	PCDF (total)	1	E	$5.8 \times 10^{-14}$ ( $4.8 \times 10^{-13}$ )	35
None	No. 2 fuel oil	HxCDF (total)	1	E	$2.4 \times 10^{-13}$ ( $2.0 \times 10^{-12}$ )	35
None	No. 2 fuel oil	HpCDF (total)	1	E	$1.2 \times 10^{-12}$ ( $9.7 \times 10^{-12}$ )	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDF	1	E	$4.2 \times 10^{-13}$ ( $3.5 \times 10^{-12}$ )	35
None	No. 2 fuel oil	OCDF	1	E	$1.4 \times 10^{-12}$ ( $1.2 \times 10^{-11}$ )	35
None	No. 2 fuel oil	HxCDD (total)	1	E	$7.4 \times 10^{-13}$ ( $6.2 \times 10^{-12}$ )	35
None	No. 2 fuel oil	1,2,3,7,8,9-HxCDD	1	E	$9.1 \times 10^{-14}$ ( $7.6 \times 10^{-13}$ )	35
None	No. 2 fuel oil	1,2,3,4,7,8-HxCDD	1	E	$8.3 \times 10^{-14}$ ( $6.9 \times 10^{-13}$ )	35
None	No. 2 fuel oil	HpCDD (total)	1	E	$2.4 \times 10^{-12}$ ( $2.0 \times 10^{-11}$ )	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDD	1	E	$1.8 \times 10^{-12}$ ( $1.5 \times 10^{-11}$ )	35
None	No. 2 fuel oil	OCDD	1	E	$1.9 \times 10^{-11}$ ( $1.6 \times 10^{-10}$ )	35
None	No. 2 fuel oil	Formaldehyde	4	C	$4.2 \times 10^{-7}$ ( $3.5 \times 10^{-6}$ )	395
None	No. 2 fuel oil	CO	4	C	0.00015 (0.0012)	395
None	No. 2 fuel oil	CO <sub>2</sub>	4	C	3.4 (28)	395
None	Natural gas	Formaldehyde	4	C	$4.1 \times 10^{-7}$ kg/m <sup>3</sup> ( $2.6 \times 10^{-8}$ lb/ft <sup>3</sup> )	395
None	Natural gas	CO	4	C	0.00014 kg/m <sup>3</sup> ( $8.9 \times 10^{-6}$ lb/ft <sup>3</sup> )	395
None	Natural gas	CO <sub>2</sub>	4	C	3.3 kg/m <sup>3</sup> (0.20 lb/ft <sup>3</sup> )	395

## V. PROPOSED CHANGES TO AP-42 SECTION 11.1

Based on the new information provided in this memorandum, RTI recommends revising Table 11.1.13 in AP-42 Section 11.1 as shown on the following page. RTI also recommends adding the following reference citation to the list of references in AP-42 Section 11.1:

395. Test Report. Formaldehyde Emissions Testing from Asphalt Heaters. Prepared for: National Asphalt Pavement Association, Lanham, MD. MACTEC Federal Programs, Inc., Research Triangle Park, NC. October 2003.

Proposed Table 11.1-13. EMISSION FACTORS FOR HOT MIX ASPHALT HOT OIL SYSTEMS<sup>a</sup>

Process	Pollutant		Emission factor	Emission factor units	EMISSION FACTOR RATING	Reference	
	CASRN	Name					
Hot oil system fired with natural gas (SCC 3-05-002-06)	630-08-0	Carbon monoxide	8.9x10 <sup>-6</sup>	lb/ft <sup>3</sup>	C	395	
	124-38-9	Carbon dioxide	0.20	lb/ft <sup>3</sup>	C	395	
	50-00-0	Formaldehyde	2.6x10 <sup>-8</sup>	lb/ft <sup>3</sup>	C	395	
Hot oil system fired with No. 2 fuel oil (SCC 3-05-002-08)	630-08-0	Carbon monoxide	0.0012	lb/gal	C	395	
	124-38-9	Carbon dioxide	28	lb/gal	C	395	
	50-00-0	Formaldehyde	3.5x10 <sup>-6</sup>	lb/gal	C	395	
	83-32-9	Acenaphthene <sup>b</sup>	5.3x10 <sup>-7</sup>	lb/gal	E	35	
	208-96-8	Acenaphthylene <sup>b</sup>	2.0x10 <sup>-7</sup>	lb/gal	E	35	
	120-12-7	Anthracene <sup>b</sup>	1.8x10 <sup>-7</sup>	lb/gal	E	35	
	205-99-2	Benzo(b)fluoranthene <sup>b</sup>	1.0x10 <sup>-7</sup>	lb/gal	E	35	
	206-44-0	Fluoranthene <sup>b</sup>	4.4x10 <sup>-8</sup>	lb/gal	E	35	
	86-73-7	Fluorene <sup>b</sup>	3.2x10 <sup>-8</sup>	lb/gal	E	35	
	91-20-3	Naphthalene <sup>b</sup>	1.7x10 <sup>-5</sup>	lb/gal	E	35	
	85-01-8	Phenanthrene <sup>b</sup>	4.9x10 <sup>-6</sup>	lb/gal	E	35	
	129-00-0	Pyrene <sup>b</sup>	3.2x10 <sup>-8</sup>	lb/gal	E	35	
	Dioxins						
	19408-74-3	1,2,3,7,8,9-HxCDD <sup>b</sup>	7.6x10 <sup>-13</sup>	lb/gal	E	35	
	39227-28-6	1,2,3,4,7,8-HxCDD <sup>b</sup>	6.9x10 <sup>-13</sup>	lb/gal	E	35	
		HxCDD <sup>b</sup>	6.2x10 <sup>-12</sup>	lb/gal	E	35	
	35822-46-9	1,2,3,4,6,7,8-HpCDD <sup>b</sup>	1.5x10 <sup>-11</sup>	lb/gal	E	35	
		HpCDD <sup>b</sup>	2.0x10 <sup>-11</sup>	lb/gal	E	35	
	3268-87-9	OCDD <sup>b</sup>	1.6x10 <sup>-10</sup>	lb/gal	E	35	
		Total PCDD	2.0x10 <sup>-10</sup>	lb/gal	E	35	
	Furans						
	67562-39-4	TCDF <sup>b</sup>	3.3x10 <sup>-12</sup>	lb/gal	E	35	
		PeCDF <sup>b</sup>	4.8x10 <sup>-13</sup>	lb/gal	E	35	
		HxCDF <sup>b</sup>	2.0x10 <sup>-12</sup>	lb/gal	E	35	
		HpCDF <sup>b</sup>	9.7x10 <sup>-12</sup>	lb/gal	E	35	
		1,2,3,4,6,7,8-HpCDF <sup>b</sup>	3.5x10 <sup>-12</sup>	lb/gal	E	35	
		39001-02-0	OCDF <sup>b</sup>	1.2x10 <sup>-11</sup>	lb/gal	E	35
Total PCDF			3.1x10 <sup>-11</sup>	lb/gal	E	35	
Total PCDD/PCDF			2.3x10 <sup>-10</sup>	lb/gal	E	35	

<sup>a</sup> Emission factor units are lb/gal of fuel consumed. To convert from pounds per standard cubic foot (lb/ft<sup>3</sup>) to kilograms per standard cubic meter (kg/m<sup>3</sup>), multiply by 16. To convert from lb/gal to kilograms per liter (kg/l), multiply by 0.12. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code.

<sup>b</sup> Compound is classified as polycyclic organic matter, as defined in the 1990 Clean Air Act Amendments (CAAA). Total PCDD is the sum of the total tetra through octa dioxins; total PCDF is sum of the total tetra through octa furans; and total PCDD/PCDF is the sum of total PCDD and total PCDF.

APPENDIX A.

AP-42 SECTION 11.1, PROPOSED REFERENCE 395

Test Report. Formaldehyde Emissions Testing from Asphalt Heaters. Prepared for: National Asphalt Pavement Association, Lanham, MD. MACTEC Federal Programs, Inc., Research Triangle Park, NC. October 2003.

APPENDIX B.

AP-42 SECTION 11.1, REFERENCE 35