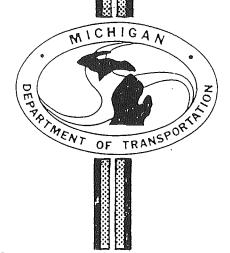


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MATERIALS and TECHNOLOGY DIVISION

Michigan Department of Transportation Construction and Technology Support Area Research Report No. R - 1477

EVALUATION OF EXHAUST GAS EMISSIONS AND WORKER EXPOSURE FROM ASPHALT-RUBBER BINDERS IN HOT MIX ASPHALT MIXTURES

Final Report

Prepared for
Michigan Department of Transportation
and
Federal Highway Administration

by Wildwood Environmental Engineering Consultants, Inc.

May 1994

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EXECUTIVE SUMMARY

The Michigan Department of Transportation developed this project to evaluate the Air Quality concerns of the Michigan Department of Natural Resources (MDNR). The worker exposure testing was added to the project because of contractor concerns.

The project was set up to evaluate stack emissions at the hot mix facility and to limit the number of variables that might affect those emissions. Because of this the mixtures used were not designed for best performance, but they were acceptable. The project measured seven mixtures; a control mixture, a RAP mixture, a wet rubber mixture, a dry rubber mixture, a rubber RAP mixture, a mixture with wet rubber and rubber RAP, and a control mixture with a hard Asphalt Cement. 3600 tons of each mixture was produced and tested both at the hot mix facility and at the paving site. The results of this testing are enclosed with this report.

This report will be presented to the Michigan Department of Natural Resources for review. After this review they will issue a statement of findings and decisions as to Air Quality permits for hot mix facilities using crumb rubber. Until this review is complete, no crumb rubber projects can be completed in Michigan.

The conclusions discussed in this report are those of the testing consultant. The Michigan Department of Transportation will prepare its conclusions and issue a final summary after MDNR has reviewed the testing data and issued its opinion as to Air Quality.

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1.0 INTRODUCTION.

The Michigan Department of Transportation (MiDOT) developed and sponsored a project designed to look at the possible environmental and worker exposure effects that might result from the addition of crumb rubber to asphalt paving materials as a modifier or additive. Crumb rubber can be added to asphalt paving materials using two methods. One method is to mix the crumb rubber into the asphalt cement binder prior to mixing with aggregate materials. The other method is to add the crumb rubber to the manufacturing process as a separate process material. The first method is generally referred to as a "WET" process, and the latter method is generally referred to as a "DRY" process. MiDOT chose to use the Rouse method for the WET process, and developed their own mix design for the DRY process.

1.1 The WET Asphalt-Rubber Binder Method.

The Rouse method uses a very fine crumb rubber material, 100% passing an 80 mesh screen. The crumb rubber is blended into a very high penetration (i.e. very soft) asphalt cement which has been heated to 375°F in a primary mixing tank and mixed for a specified period of time to initiate digestion of the rubber. It is then transferred to a secondary mixing tank for further mixing and digestion. When this second step is completed, the asphalt-rubber binder is transferred to either directly the manufacturing process or to intermediate storage. At this point it is at about a temperature of 375°F. The mix design for the MiDOT project specified an amount of crumb rubber to be added to the asphalt cement binder in sufficient quantities to provide a ratio of 20 pounds of crumb rubber per ton of Hot Mix Asphalt (HMA).

1.2 The DRY Asphalt-Rubber Binder Method.

The DRY process uses a larger size crumb rubber. MiDOT specified a size passing a 1/4 inch sieve. The MiDOT mix design for the DRY process specified an amount of crumb rubber to be added to the asphalt manufacturing process in sufficient quantities to provide a ratio of 40 pounds of crumb rubber per ton of HMA. The point of introduction of the crumb rubber into the manufacturing process was not specified, but would depend on the type of equipment the successful bidding contractor would use--a batch mix facility, a parallel-flow drum mix facility, or a counter-flow drum mix facility.

1.3 Mixes to be Tested.

The MiDOT determined that seven mixes would be tested. Three of those mixes are considered Control Mixes, the other four are considered Rubber Mixes. Six of the mixes were to be manufactured with the same asphalt cement as required for the asphalt-rubber binder -- an asphalt cement of 200-250 penetration (roughly equivalent to an AC-2.5 asphalt cement). The low viscosity asphalt cement is

required in an asphalt-rubber binder because it is believed that the digestion process causes the rubber to absorb substantial amounts of light ends from the asphalt cement. MiDOT chose to use the same asphalt cement throughout the stack testing program to eliminate one variable -- asphalt cement related emissions. The seventh mix, Control Mix 1, was added to the program at a later date as a comparison for a "typical" mix compared to the "rubber" mixes because of the low viscosity asphalt cement used in the rubber mixes. There was concern that there might be emissions reported, particularly with the volatile organic compounds, that might be high because of the asphalt cement. The mixes are as follows:

Control Mix 1: This mix was to be a typical HMA using an asphalt cement with a penetration of 85-100, which is roughly equivalent to an AC-10 asphalt cement. This mix was included at a later date and was added because of concerns that the asphalt cement specified in the Rubber Mixes was a very soft asphalt and might result in emissions not normally found while producing HMA paving materials with a more viscous asphalt cement. The "typical" mix being produced during the stack testing which could be manufactured with an 85-100 PEN asphalt cement also contained 30% reclaimed asphalt pavement (RAP). This mix was designated as BM13A, Bituminous Mixture 13A -- no Rubber, 30% RAP.

Control Mix 2: This mix was to contain 100% virgin aggregates and asphalt cement with a penetration of 200-250 (roughly equivalent to an AC-2.5 asphalt cement). This mix was designated as MBM01, Modified Bituminous Mixture 01 -- no rubber, no RAP.

Control Mix 3: This mix was to contain 20% "regular" RAP materials. "Regular" as opposed to RAP with an asphalt-rubber binder. There has long been concern on the part of the paving industry as to the recyclability of asphalt pavements produced with an asphalt-rubber binder. Michigan had a roadway paved in the late 1970s with a mix containing an asphalt-rubber binder. The roadway was milled up in order to be used in this testing program. This mix was designated as MBM02, Modified Bituminous Mixture 02 -- no Rubber, 20% RAP.

Rubber Mix 1: The mix was to contain 100% virgin aggregates and an asphalt-rubber binder, manufactured by the WET process. This mix was designated as MBM03, Modified Bituminous Mixture 03 -- **Rubber-WET**, **no RAP**.

Rubber Mix 2: The mix was to contain 20% "rubber-RAP." "Rubber-RAP" because the pavement was originally manufactured with an

asphalt-rubber binder. The asphalt cement binder would not be modified with rubber crumb. This mix was designated as MBM05, Modified Bituminous Mixture 05 -- no Rubber, 20% rubber-RAP.

Rubber Mix 3: This mix was to contain 20% "rubber-RAP" and an asphalt-rubber binder, manufactured by the WET process. This mix was designated as MBM06, Modified Bituminous Mixture 06 -- Rubber-WET, 20% rubber-RAP.

Rubber Mix 4: The mix was to contain rubber, manufactured by the DRY process, with 100% virgin aggregates. This mix was designated as MBM04 -- **Rubber-DRY**, no RAP.

1.4 Development of the Stack Testing and Worker Exposure Assessment Program.

MIDOT consulted with the National Asphalt Pavement Association (NAPA) as to what environmental and worker exposure measurement approaches should be taken. They then consulted with the Michigan Department of Natural Resources Air Quality Division (MiDNR) about NAPA's recommendations. NAPA provided MiDOT with a copy of their stack testing protocol they had developed for their own stack testing program and the worker exposure sampling protocol NAPA had also developed, in conjunction with the Asphalt Institute. MiDNR endorsed the protocol, but made some additions. Furthermore, the protocol was distributed around the country for review, primarily to USEPA branches and some state air quality agencies. The additions were based on their feed back, and on MiDNR's practices and requirements. The stack testing methods specified by MiDOT are provided in Table 1.

The NAPA Stack Testing Protocol was developed by NAPA for a Stack Testing Program they were organizing. The purpose of the Stack Testing Program was gather emissions data for various pollutants for which the HMA Industry anticipated future regulation. EPA had conducted stack testing for these pollutants on ONE HMA facility in the mid to late 1970's and reported the results for that ONE test in their "Compilation of Air Pollution Emission Factors (AP-42)." This HMA facility was a batch mix facility equipped with a wet washer for particulate control. The NAPA members organizing the Stack Testing Program were concerned that the emissions did not reflect what might actually be occurring in more "modern" HMA facilities.

1.5 Description of the Hot Mix Asphalt Facility at which the Stack Sampling was Conducted.

The HMA facility that was involved in the stack testing program was a parallel-flow drum mix HMA facility rated at a production capacity of 600 tons of HMA per hour. Parallel-flow meaning that the exhaust gases and process materials move in the

same direction in the drum as the process materials are dried and heated to the desired mixing temperature. It is equipped with a 100% air burner capable of burning fuel oil or natural gas. The fuel used during the stack testing was a reprocessed used oil. The fuel was heated generally to 125°F to meet the SSU viscosity requirements of the burner manufacturer.

The original flights in the mixing section of the drum were replaced in 1991 with flights that *DO NOT* veil the asphalt-coated aggregate through the cross-section of the drum, thereby substantially minimizing the asphalt surface area to exhaust gas contact ratio between the exhaust gas and the asphalt cement--the primary cause of visible emissions in a drum mix HMA facility. The RAP is introduced to the process through a center entry inlet. The 1/4 inch crumb rubber was introduced into the process through the RAP center entry inlet for the DRY process. The air pollution control equipment for this facility is a baghouse for particulate control with a 120,000 CFM exhaust fan. The baghouse fines are conveyed to a silo prior to introduction to the process.

The design of the HMA facility used in this project is the best choice because it is likely to have almost the worst case emissions where asphalt-related emissions are concerned. The only design that is likely to generate higher levels of asphalt-related pollutant emissions is the parallel-flow drum mixer where the mixing flights veil the asphalt-coated aggregate particles through the cross-section of the drum. This veiling provides the maximum asphalt surface area to exhaust gas contact. It is also the design most likely to have asphalt vapor visible emissions--i.e., a condensing hydrocarbon plume. Careful design considerations can minimize the hydrocarbon plume problem even with veiling asphalt-coated aggregate. Another significant factor is the quality of the asphalt cement and the viscosity.

2.0 STACK SAMPLING PROCEDURES AND COMPOUNDS TO BE ANALYZED AND QUANTITATED.

The following text provides explanations as to why these particular procedures were conducted for the MiDOT Stack Testing Program and, if necessary, a list of the compounds for which analysis was to be conducted and any other specifics not provided in Table 1. It will also provide how the feedback from reviewers was incorporated, where applicable. Descriptions of the methods are provided in the appropriate appendices. EPA Methods 1, 2, 3, and 4 are required with all sampling trains for the determination of stack gas volumetric flow rates and stack gas moisture content.

2.1 Continuous Measurement of Carbon Monoxide, Oxides of Nitrogen, Sulfur Dioxide, Total Hydrocarbons, Oxygen, and Carbon Dioxide Emissions.

The compounds listed under the Continuous Emissions Measurement section in Table 1 are Products of Combustion (CO $_2$ and O $_2$) and Products of Incomplete Combustion (CO, NO $_x$, SO $_2$, and THC). Measurement of the Products of Combustion is required for all stack sampling procedures in order to determine the physical characteristics of the exhaust gas. Measurement of the Products of Incomplete Combustion was included to monitor the combustion process of the HMA manufacturing system in order to demonstrate that normal operations were maintained throughout the stack testing program. It should be noted that the THC method, Method 25A, is efficient at collecting hydrocarbons containing up to 9 to 10 carbons. Therefore, it is theorized that asphalt fume is not reflected in this emission rate.

2.2 Particulate Emissions Measurement.

Particulate emissions measurements were conducted to determine if the asphalt-rubber binder mixes caused an increase in particulate emissions, and if so, did the particulate emission with asphalt-rubber binder mixes comply with the EPA New Source Performance Standard (NSPS) for Hot Mix Asphalt facilities -- a maximum allowable particulate emission concentration of 0.04 grains per standard cubic foot of dry exhaust gas (90 mg/DSCM), and less than 20% opacity for visible emission (excluding water vapor). The condensible particulate emissions measurement were conducted to determine if the asphalt-rubber binder mixes result in a higher level of asphalt vapor or fume. The condensible catch is believed to be condensed asphalt vapor. When heavy fuel oils are burned, the condensible catch could also include unburned fuel vapor.

2.3 Polynuclear Aromatic Hydrocarbon Emissions and Semi-Volatile Emissions Measurement.

2.3.1 Polynuclear Aromatic Hydrocarbon Emissions Collection and Analysis.

The polynuclear aromatic hydrocarbons (PAHs) for which sampling and analysis were to be conducted included the 17 PAHs listed in the National Institute for Occupational Safety and Health's Test Method 5506, plus 15 additional PAHs and semi-volatile compounds. The 17 NIOSH PAHs are:

Acenaphthene Acenaphthylene

Benzo(g,h,i)perylene Benzo(j)fluoranthene Fluorene

Anthracene

Benzo(k)fluoranthene

Indeno(1,2,3-cd)pyrene Naphthalene

Benz(a)anthracene

Chrysene

Phenanthrene

Benzo(a)pyrene

Dibenzo(a,h)anthracene

Pyrene

Benzo(e)pyrene

Fluoranthene

The NAPA Stack Testing Protocol also included 2-Methylnaphthalene, 2-Chloronaphthalene, o-Cresol (2-methylphenol), m-Cresol (3-methylphenol), p-Cresol (4-methylphenol), and Cumene. The latter four compounds are included because they appear in the list of Hazardous Air Pollutants in Title III of the Clean Air Act.

MiDNR added the following PAHs for which analysis and quantitation was to be conducted, in accordance with their definition of "asphalt PAH fume":

Anthanthrene

Benzo(c)fluorene

Picene

Benzo(a)fluorene Benzo(b)fluorene

Chrysene Coronene

Perylene Triphenylene

The laboratories that were contacted about performing the required analyses on the SW-846/0010 samples reported that analysis could not be conducted for all of the listed PAHs and that, in some cases, one compound co-eluted with another. Their discussion of these issues is summarized as follows:

PAH Compounds for which standards are available and can be done by Method SW-846/8270 using a single point calibration: Benzo(a)fluorene and Benzo(b)fluorene.

PAH Compounds which co-elute--a total concentration for co-eluting compounds will be reported: Triphenylene co-elutes with Chrysene; Benzo(j)fluoranthene co-elutes with Benzo(b)fluoranthene and Benzo(k)fluoranthene.

PAH Compounds which will not be attempted because the retention time under the GC/MS conditions of SW-846/8270: Coronene.

PAH Compounds for which standards cannot be found commercially: Anthanthrene, Benzo(a)fluorene, and Picene.

2.3.2 Analysis for Pre-cursers of Dioxin Formation.

The USEPA Combustion Research Branch, which had reviewed the draft protocol, had recommended stack testing for dioxin. After some discussion with their representative, it was decided that, instead of adding a whole stack sampling train to the project when very little evidence existed to suggest that dioxin emissions would occur in the exhaust gas of a HMA manufacturing facility, analysis of the SW-846/0010 sample would include analysis for the various chlorobenzenes and chlorophenols found in the SW-846/8270 semi-volatiles list. SW-846/8270 is the analytical part of determining PAHs and semi-volatiles emissions in exhaust gases of waste incinerators and other combustion processes. Hence, analysis of the SW-846/0010 sample also included the following compounds:

2-Chlorophenol	2,4-Dichlorophenol	1,3-Dichlorobenzene
4-Chloro-3-	2,4,5-Trichlorophenol	1,4-Dichlorobenzene
Methylphenol	2,4,6-Trichlorophenol	1,2,4-Trichlorobenzene
Pentachlorophenol	1,2-Dichlorobenzene	Hexachlorobenzene

2.3.3 Analysis for "Rubber" Semi-volatile Organic Compounds.

NAPA recommended analyzing the SW-846/0010 samples for Nitrosamines, compounds inherent in rubber. The Nitrosamines for which analysis was specified were: n-Nitrosodimethylamine, n-Nitrosodipropylamine, n-Nitrosodibutylamine, and n-Nitrosodiphenylamine. The laboratories reported that they would only be able to analyze for n-Nitrosodipropylamine and n-Nitrosodiphenylamine.

2.3.4 Scan and Quanitfication of all Other SW-846/8270 Semi-Volatile Compounds.

NAPA also suggested having a complete 8270 scan conducted on the SW-846/0010 samples to see if there were compounds in the exhaust gas of a HMA facility that had not been looked for in previous studies of semi-volatile organic emissions from HMA facilities stacks. Following is a list of the compounds on the 8270 list that have not already been listed. The compounds highlighted with bold indicate they were found in detected levels in at least one run. The compounds that are italicized were found in both the samples and the laboratory blank, which indicates possible contamination by the laboratory procedures.

Hexachlorobutadiene 2,4-Dinitrophenol Hexachlorocyclopentadiene 4-Nitrophenol 2-Nitroaniline Dibenzofuran Dimethylphthalate Diethylphthalate 2,6-Dinitrotoluene 4-Nitroaniline 3-Nitroaniline 4,6-Dinitro-2-methylphen	Di-n-octylphthalate
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2.4 Heavy Metals Emissions Measurement.

Heavy metals were included primarily because of the metals used in manufacturing the steel-belted tires from which the rubber crumb was to come. MiDNR added zinc to the eight heavy metals listed in the Toxicity Characteristic Leachate Procedure and lead. Zinc is a substantial metal constituent of rubber tires.

2.5 Formaldehyde Emissions Measurement.

Formaldehyde stack testing is part of the NAPA Stack Testing Protocol. It is a product of incomplete combustion. Acetone was included because two EPA stack test reports for HMA facilities reported very high quantities of acetone. Review of the timing of when the formaldehyde stack testing was conducted compared to when the particulate stack testing was conducted suggested that perhaps the acetone was a contaminant from the particulate stack testing procedure. Acetone is used to rinse all the equipment during recovery of the sample. Since there was no additional cost involved, acetone analysis was included to determine if in fact acetone did occur in such high quantities. The project specifications required that the formaldehyde sampling be conducted on the day that particulate sampling was not conducted.

2.6 Volatile Organic Emissions Measurement.

The NAPA Stack Testing Protocol required measurement of Benzene, Toluene, Ethylbenzene, and all isomers of Xylene (BTEX). Styrene was specified because it is part of the rubber polymer. Chlorobenzene was included as discussed in Section 2.3.2. MiDNR added methyl-isobutylKetone. In addition, NAPA suggested also conducting a scan for all the SW-846/8240 compounds.

2.7 Method 18 Emissions Measurement.

1,3-Butadiene is part of the rubber polymer. Methane was included because most states regulate volatile organic compound emissions as non-Methane Total Hydrocarbons (NMTHC). Since Method 25A cannot distinguish methane from all the other hydrocarbons during analysis, methane must be measured separately and subtracted from the Method 25A results to obtain a non-Methane Total Hydrocarbon quantity.

3.0 FIELD WORK.

The stack sampling was carried out during the latter half of September 1993 and the first few days of October 1993 (9/15 through 10/5). Entropy Environmentalists, Inc. performed the stack testing, under the direction of Herbert Dixon, Project Manager. The stack testing and worker exposure sampling were overseen by Kathryn O'C. Gunkel, P.E. of WILDWOOD Environmental Engineering Consultants, Inc. Ms. Gunkel also oversaw collection of process materials samples, recordation of operating data, and recordation of process materials moisture content. There were some delays-mostly weather related. One major delay was caused by delivery problems with the 1/4 inch rubber crumb and the project had to be carried over another weekend.

3.1 Stack Testing Problems.

There were virtually no stack testing problems. It was discovered after the first day of stack sampling was completed, Control Mix 1, that the SW-846/0030 sampling had not been conducted. NAPA had been definitive on the issue that the SW-846/0010 and SW-846/0030 be conducted simultaneously. Entropy agreed to collect three more SW-846/ sample at their cost while conducting method SW-846/0030. These three runs were collected during the testing program when making one of the other mixes was not possible.

On the first Saturday of the stack testing program the total hydrocarbon analyzer went out--it was not maintaining temperature. Another analyzer was obtained and ready for testing by the following Monday. Stack testing was not delayed because of the problem with the hydrocarbon analyzer. It was felt that there were sufficient runs collected that the project should not be held up for this problem. Several other THC runs were lost throughout the stack testing program due to problems with the analyzer, but no more than two runs (out of six) were lost for any one mix, except the mix stack tested on that first Saturday (Control Mix 3). On the last day of stack testing, the stack testing team was advised that the laboratory had lost two SW-846/0010 samples, one for Control Mix 1 and one for Control Mix 2.

3.2 Visible Emission Observations.

The MiDOT stack testing program specified that visible emissions observations would be made for at least 20 minutes during each stack test run. Unfortunately, such readings were not possible during this program. Typically, when emissions occur at a parallel-flow drum mix HMA facility, they are a white to gray color, sometimes blue if the asphalt cement is burned. However, given the length and diameter of the drum at the HMA facility where the stack testing was conducted,

burning of the asphalt cement was not at all likely. Bright blue, clear skies occurred on only two days during the entire stack testing program, and one of those days was a Sunday, when no stack testing was conducted. Otherwise, the weather consisted mostly of overcast skies. Unfortunately, the skies were the same color as the visible emission that might be expected from this drum mix HMA facility. The terrain around the HMA facility did not provide elevated locations sufficiently high enough above the stack and "read" the visible emission against a more suitable background. Consequently, sufficient visible emission observations were not conducted to make any conclusions about the impact of rubber on visible emissions.

3.3 Odors from the Stack.

Odors were very noticeable during the manufacture of the mixes with the asphalt-rubber WET binders. It was described by observers as having "an old radiator hose smell." The odor was worse when RBR 3 was being manufactured.

4.0 DISCUSSION OF RESULTS.

The results of the various stack testing procedures are grouped together, where applicable. In some cases, there are separate tables for each unit of measurement provided. In all cases, all the operating data and stack conditions data are provided at the top of each table for quick reference. The data table are grouped together at the end of the report beginning at page 19.

4.1 Continuous Emissions Measurement (CEM) Results.

The results of the CEMs are presented in Tables 2, 3, and 4. The emissions are provided in units of lbs/hour, mg/m³, and PPM. Since these emissions are strictly due to fuel combustion, emission factors, if desired, should be calculated on the basis of fuel use as opposed to production. Fuel use will change according to the moisture content in the aggregate and the amount of HMA being produced. The same amount of fuel is required for casing heat losses regardless of the amount of HMA being produced for a given mix temperature. The changes in fuel consumption per ton of HMA were reflected in the operations recordings according to weather conditions. For example, Monday, September 27, 1993, was lost completely due to a drenching rain. The next several days, the per ton fuel consumption was markedly higher than it had been the previous week.

The results are very consistent for the three Control Mixes and the first three Rubber Mixes. They are markedly higher for Rubber Mix 4, the DRY process. The CEM readings were checked regularly during the stack testing and the change in the readings was noted during the stack testing.

In checking the operations, it was found that the fuel temperature was lower than normal. It had been at around 125°F during all of the previous stack testing, however, it was down around 110°F. The heater was adjusted to increase the fuel oil temperature and it was brought up to temperature by the second run. The exhaust fan damper is automatically controlled via the pressure in the bulkhead of the drum and it was operating at what appeared to be normal. It was noted that the mix design for this mix was considerably different than the other six mixes in that it did not include as much fine aggregates as did the others. However, a clear, definitive cause for the markedly higher readings could not be determined. Clearly, however, the high CEM values are related to the mix because all the concentrations dropped to what was common during manufacture of the other six mixes when the SW-846/0010 run was conducted to replace the sample broken by the lab.

The stack conditions provided in the tables for the CEM and Method 18 results reflect averages of the stack conditions for sampling trains operated simultaneously. For example, the first three CEM runs and the Method 18 runs were conducted while the Particulate/Condensible and Metals sampling conducted with two different trains. The stack conditions reported for each run for each train were averaged and then the average for the Particulate/Condensible train was averaged with the average for the Metals train. Likewise for the second three CEM runs which were conducted while the PAHs and VOST sampling was conducted. The operating data provided is an average of the operating for the two days (or three days) over which all the stack sampling was conducted for a given mix. It is for this reason that these values will not match exactly with those provided in other tables.

4.1.1 Carbon Dioxide (CO₂) and Oxygen (O₂) Results.

The CEM results for these two compounds are fairly consistent for all the mixes except RBR 3. They correlate well with the Orsat measurements, which are essentially grab samples collected during the runs, for three of the seven mixes. The CEM results are likely more reliable than the Orsat results because of the continuous measurement nature of the sampling. The CO_2 and O_2 concentration are an indication of the excess air levels in the system. A certain amount of excess air is required for combustion, but there is the potential in HMA facilities for more excess air than is necessary. This affects fuel combustion efficiency and production efficiency. More excess air than is necessary generally occurs as a result of inadequate fan damper adjustments or leakage of ambient air into the system.

EPA and many states require many combustion sources to report their CEM results adjusted to a specified concentration of CO_2 , O_2 , or excess air. Typically these specified concentrations are 3% CO_2 , 7% O_2 , or 50% or 100% excess air, by volume. This prevents purposeful dilution of the stack gases which would result in low emission concentration results. HMA facilities, for one reason or another, are not generally required to make this adjustment. When reviewing CEM pollutant data, particularly from different facilities, it is best to compare emission rates based on a weight per time unit of measurement. It eliminates all issues surrounding the emission concentration results and excess air impacts. Hence, the reason for the results being provided in several sets of units.

The higher CO_2 concentration for RBR 3 reflects the higher fuel consumption rate that occurred. In fact, a comparison of the CO_2 to fuel consumption rate finds a range of $0.0093~\%CO_2$ per gal/hr to $0.0108~\%CO_2$ per gal/hr with an average ratio of $0.0099~\%CO_2$ per gal/hr. The closeness of the results is not surprising since the O_2 concentrations were so consistent—there is a difference of 1.54% between the highest and lowest values.

4.1.2 Carbon Monoxide and non-Methane Total Hydrocarbon Carbon Results.

These two pollutants are primarily a reflection of incomplete combustion. Incomplete combustion occurs if material contacts the flame. The combustion reaction is short-circuited. Instead of going all the way to CO₂, the carbon-oxygen reaction stops at CO. The THC reflects the amount of fuel vapor that never gets involved in the combustion process. This is mostly due to inefficient atomization of the fuel, however, it could be caused by high exhaust gas velocities, too much excess air in the combustion zone (cools the flame), or not enough excess air (starves the flame of oxygen).

These pollutants are generally regulated on a parts per million basis where concentrations of CO under 500 PPM for a HMA facility is generally considered to represent good combustion conditions. Concentrations of THC up to 250 PPM are considered to represent good combustion conditions (good atomization efficiency)--for natural gas and distillate fuel combustion. It is not surprising to see higher THC concentrations and rates for heavier fuels--particularly those that require heating. This is where atomization efficiency of heavy fuels can differ radically from combustion of natural gas and distillate fuels.

4.1.3 Oxides of Nitrogen (NO_x) Results.

The NO_X emissions are a result of combustion of the N_2 in the fuel and also in the combustion air. As a rule, burner adjustments made to decrease CO emissions will result in higher NO_X emissions and vice versa. This is demonstrated in the CEM results for RBR 4. It should be noted that the burner opening (an operating parameter recorded during stack testing) during stack testing of RBR 4 was significantly smaller than for the other mixes--about 60% to 75% of the burner openings recorded for the other six mixes.

4.1.4 Sulfur Dioxide (SO₂) Results.

Sulfur dioxide is a result of oxidation of the sulfur found in the fuel being burned. Its concentration (by weight) increases with heavier fuel oils. The fuel oil/reprocessor reported that the sulfur content was fairly consistent at about 0.5 %. Using this sulfur number, rough estimates show that the SO_2 emissions actually measured were substantially lower than the calculated SO_2 emissions calculated from the amount of fuel consumed and the sulfur content. Furthermore, the data showed that the SO_2 emissions were much lower for mixes which had no RAP and a high percentage of fines.

4.2 Particulate and Condensible Matter Results.

The results of the Particulate and Condensible Matter stack sampling are presented in Table 5. Emission rates, concentrations, and factors are provided as follows: grains/SCFD, mg/m³, lbs/hour, and lb/ton HMA.

4.2.1 Filterable Particulate Matter Results.

The NSPS for HMA facilities uses only the results of the filterable particulate (Method 5) for compliance demonstrations. The results of the Method 5 sampling demonstrated compliance with the NSPS for all seven mixes, by a wide margin.

4.2.2 Condensible Particulate Results.

As for the condensible emissions, no clear pattern emerges. The condensible particulate is most likely a vapor emission--asphalt vapor. Setting aside the RBR 4 results, it is clear that RAP plays a role in the quantity of condensible emissions reported. RBR 1 had 2/3 of the condensible emission rate that CTRL 2 had. This could be indicative of the rubber sucking up the light ends. However, the combined emission rate of both particulate do not reflect the same ratio. It should be noted that while the condensible emission most likely reflects a vapor emission (in the case of a HMA facility), the filterable particulate could reflect a combination of solid particulate emissions and vapor emissions. The vapor emissions on the filter would be asphalt vapor that condenses at the filter temperature (usually 250°F) or is prone to adsorb onto solid particulate when in contact with it. If the filters had been treated in the same manner as the worker exposure filter--where they are extracted with benzene to remove the hydrocarbons--could it be estimated as to how much of the filter catch was solid particulate and how much was condensed vapor. This procedure is not routinely performed on stack sample filters.

4.3 Results of Metals Stack Sampling and Metals Analysis of the Process Materials, Fuel Oil, and Baghouse Fines.

The results of the metals stack testing are provided in Table 6. The results of the materials analyses are provided in Tables 7, 8, and 9. The metals emission rates were extremely low--less than 4/1000 of a pound per hour (1.8 grams/hour) for any one metal. The used fuel oil contained detected quantities of Barium and Zinc only and their contribution to the total Barium and Zinc into the process was minor compared to the quantity of each introduced with the aggregate and RAP--1.38% of the total Barium and 5% of the total Zinc into the process. The rest of the Barium and Zinc and all the other metals (except for two) were introduced into the process with the aggregate and RAP materials. The rubber-RAP had higher concentrations of Zinc than the regular RAP--most likely due to the asphalt-rubber binder in the rubber-RAP.

4.4 Formaldehyde and Methyl-Isobutyl-Ketone Emissions Sampling Results.

The results of the formaldehyde and MIBK stack sampling are provided in Table 10. Formaldehyde is also a product of incomplete combustion for much the same reasons as the CO and THC. The formaldehyde results track almost exactly with the THC and CO results--where RBR 4 had the highest emission concentrations and rates of THC and CO, it also had the highest emission concentrations and rates of formaldehyde, and where RBR 3 had the lowest THC and CO results, it also had the lowest Formaldehyde results.

4.5 Volatile Organic Sampling Results.

The volatile organic samples are usually collected for 20 minute periods of time, according to the method specifications. However, at the suggestion of USEPA-RTP, three VOST samples were collected during each PAH run--one for 10 minutes, one for 20 minutes, and one for 40 minutes. The purpose for this was primarily because there was not time (nor funding) to send out a "scouting" team to collect some VOST stack samples for analysis to see what would be an optimum sampling time. If the 20 minute sample contains excessive amounts of more volatile volatiles, then they will mask the results of other volatiles that may also be present, and there is no way to dilute the sample which would not affect analysis of the other volatiles. If there are not sufficient amounts in the sample for detection, there is no way to concentrate the sample to improve the detection of the compounds. As it turns out, it was good advice on the part of USEPA-RTP. The 20 minute samples could not be used. The 10 minute samples were used in all cases. Even so, many of the samples for the rubber mixes reported saturated peaks for several of the compounds, which means that the amount of the compound reported is underestimated.

The results of the VOST sampling and analysis are provided in Tables 11, 12, and 13. The stack conditions provided in these three tables are the averages of the stack conditions reported for the formaldehyde and the PAHs sampling trains.

4.5.1 Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Emissions Results.

The BTEX emission rates were all significantly higher for all the mixes using the 200-250 PEN asphalt cement, with or without rubber than were the BTEX emission for the mix with 85-100 PEN asphalt cement--CTRL 1. Comparing these BTEX results to those reported for an identical HMA facility located in Grand Rapids, Michigan, shows that the VOST method and analysis is much more sensitive than an onsite gas chromatograph which was used at the Grand Rapids facility. The BTEX results for the Grand Rapids facility were "not detected" with a detection limit of 1 PPM for each compound.

4.5.2 Styrene Emissions Results.

Styrene was detected in all mixes, but at considerably higher levels for the rubber mixes. There was one exception--RBR 1 had only slightly more styrene than CTRL 1. That CTRL 1 had some styrene detected is not surprising because of the RAP which had years of contact with vehicle tires.

4.5.3 Methyl-Isobutyl-Ketone (MIBK) Emissions Results.

Methyl-isobutyl-Ketone was reported for the two mixes containing the asphalt-rubber binders--RBR 1, RBR 3, and RBR 4. A small amount was reported for CTRL 1, at 24% of the RBR 1 MIBK result, at 6.46% of the RBR 3 result, and at 8.02% of the RBR 4 result.

4.5.4 Chlorobenzene Emissions Results.

Chlorobenzene was detected in one run each of CTRL 1, RBR 2, and RBR 3. It was reported detected in all three runs of RBR 4. The quantity of chlorobenzene reported for the asphalt-rubber binder mixes was 1,300% to a little over 8,000% higher than the quantity reported for CTRL 1.

4.6 Results of PAHs and Semi-Volatiles Sampling and Analysis.

In 1992, MiDNR established an emission concentration for "Total PAHs" in a permit to install condition for a HMA facility seeking such a permit for installation of a HMA facility in Grand Rapids, Michigan (the same one discussed in Section 4.5.1). They defined "Total PAHs" as the summation of the reported quantities of 25 PAHs, listed in Section 2.3.1, excluding the Naphthalene compounds. Stack testing was required to demonstrate compliance with the specified emission concentration. In 1993, MiDNR proposed to list asphalt fume PAHs on their List of Screening Levels with a maximum allowable annual ground level concentration of 0.0016 ug/m³. MiDNR specified that for any compound reported as "Not Detected," the detection limit had to be used, i.e., zero could not be used for any compound not detected. EPA has not established a policy on handling "Not Detected," however, there is a work group reviewing the issue. In the case of waste incinerators, they require that detection limits be used for compounds reported as not detected if sampling time was not sufficient or analysis was not sufficiently sophisticated. Otherwise, they generally allow the use of zero for compounds reported as not detected. The state of California does not allow the use of zero for not detected compounds, however, 50% of the detection limit is used for not detected compounds.

There are two analytical procedures available for the analysis of the SW-846/0010 samples, commonly called "Low-resolution GC/MS analysis" and "High-

resolution GC/MS analysis." The latter procedure is more sensitive and can detect lower quantities of compounds than can the "low-res" procedure, on the order of three magnitudes lower. The "high-res" procedure was used by the Grand Rapids facility, and was specified in the Asphalt-Rubber project. However, it could not be used for analysis of the Asphalt-Rubber project samples because of extremely high concentrations of the more volatile semi-volatile compounds--naphthalene, 2-methyl-naphthalene, cumene, and phenanthrene. Consequently, the low-res analytical procedure was used for the Asphalt-Rubber project. The detection limits reported for not detected compounds were reported in units of micrograms (10-6 grams). The high-res analytical procedure was used successfully on the Grand Rapids facility samples and there was a reported quantity for virtually every PAH compound for which analysis could be performed. However, the reported results were in units of nanograms (10-9 grams).

Since this report is expected to be circulated out of Michigan, since NAPA's stack test program results have been reported, and since NAPA used zero for not detected compounds, the PAH data has been provided in two sets. One set is identified as "MiDNR PAHs" and reflects MiDNR's requirement to use the detection limit as a result for a not-detected compound. The other set is identified as "NAPA PAHs" and reflects the was NAPA reported the PAH results of its stack testing program--with zero for not-detected compounds. Also, the NAPA PAH results included Naphthalene and 2-methylNaphthalene, whereas, MiDNR's did not.

The results of the PAH, Cumene, and Cresol emissions measurements using the MiDNR criteria that not-detected compounds be set equal to their reported detection limit are provided in Tables 14, 15, 16, 20, 21, 22, 23, and 24. The results of the PAH, Cumene, and Cresol emissions measurements following the NAPA (and EPA) method of setting not-detected compounds equal to zero are provided in Tables 17, 18, 19, 20, 21, 22, 23, and 24.

The results of the Chlorobenzene, Chlorophenol, Nitrosamines, and 8270 Scan using the MiDNR criteria for not-detected compounds are provided in Tables 25, 26, and 27. The results for these compounds following the NAPA (and EPA) method of setting not-detected compounds equal to zero are provided in Tables 28, 19, and 30.

4.6.1 Target Polynuclear Aromatic Hydrocarbon (PAH) Emissions Results.

Reclaimed asphalt pavement clearly contributes to the PAH emission rate. Asphalt type (penetration) and rubber (wet) do not appear to make much difference. However, since a virgin mix with 85-100 PEN was not stack tested for PAH emissions at the same time, it is difficult to know if a difference exists with asphalt type. The PAH stack testing performed in Grand Rapids was on a 100% virgin aggregate mix with 85-100 PEN asphalt cement and natural gas. The MiDNR average PAH

concentration for three runs for the Grand Rapids facility was 0.0649 mg/m³ and the NAPA concentration was 0.535 mg/m³. The MiDNR average PAH concentration for CTRL 2 and RBR 1 was 0.1835 mg/m³ and the NAPA average PAH concentration was 0.8815 mg/m³. For the mixes containing RAP, the average MiDNR PAH concentration was 1.4351 mg/m³ and the average NAPA PAH concentration was 3.099 mg/m³. For the Grand Rapids facility, the production rate was similar to the one used in the Asphalt-Rubber project (avg. 368 TPH), the volumetric exhaust gas flow rate was slightly lower (avg. 40,188 DSCFM), and the CO₂ and O₂ concentrations were slightly higher (avgs. 4.5% and 13.6%, respectively). These results could be interpreted to indicate that asphalt cement type also plays a role in the PAH emissions results. There is also the possibility for PAHs to be in the fuel oil since the fuel used in the Asphalt-Rubber project was a reprocessed oil.

The higher PAH results for could be caused by the detection limit issue for not-detected compounds. The Asphalt-Rubber average PAH result for virgin mixes (excluding RBR 4) is 2.83 times higher than the Grand Rapids MiDNR average PAH result, while in the case of the NAPA PAHs, the Asphalt-Rubber average PAH result is 1.65 times higher. In comparing the RAP PAH results to the Grand Rapids results the MiDNR Asphalt-Rubber average PAH result is 22 times higher than the Grand Rapids MiDNR PAH result, and the NAPA result is only 5.8 times higher than the Grand Rapids NAPA result.

The quantities of 2-methylNaphthalene were considerably higher for the rubber mixes, especially for the ones with rubber-RAP. To a lesser degree, this was also true for phenanthrene. These compounds make up a substantial percentage of the total PAHs. In terms of percent of Total PAHs, the naphthalene compounds occurred at considerably higher percentages in the virgin mixes, as compared to the RAP mixes, while just the opposite is true for phenanthrene.

The laboratory had difficulty analyzing for Benzo(a)fluorene, and reported results for several hydrocarbons that elute at about the same point as Benzo(a)fluorene should. With no direction as to how to use these results--which hydrocarbon is the most likely to represent benzo(a)fluorene, all the reported results for the various hydrocarbons were averaged and the average used to calculate emission concentrations and rates. In some cases, nothing was reported for the "target" hydrocarbons, not even detection limits.

4.6.2 Cumene Emissions Results.

Cumene quantities were reported for all samples for all mixes. The concentrations did not range much, ranging from $0.0272~\text{mg/m}^3$ to $0.0573~\text{mg/m}^3$ (0.0046 to 0.0095 lb/hr) for the seven mixes. The Grand Rapids facility reported 0.0956 mg/m 3 (0.0115 lb/hr) for cumene.

4.6.3 Cresol Emissions Results.

Cresols were reported for all the mixes, although some individual samples had not-detected levels for o-Cresol. The combined concentrations for all three Cresols ranged from 0.0493 to 0.1489 mg/m³ (0.0069 to 0.0168 lb/hr) for the three control mixes and RBR 1, 2, and 3 (where not-detected samples used zero). RBR 4 reported a combined concentration of 0.3198 mg/m³ (0.0343 lb/hr). Cresols were reported as not detected for the Grand Rapids facility.

4.6.4 Dioxin Precursor Emissions Measurements Results.

Of the chlorophenols and chlorobenzenes, dioxin precursors, 2-chlorophenol was detected for all but CTRL 3 RBR 2 (two RAP mixes), at less than 0.0123 mg/m³ (0.0016 lb/hr), while RBR 4 reported 0.0244 mg/m³ (0.0041 lb/hr). The only other "precursor" detected was 1,2,4-Trichlorobenzene for three mixes, CTRL 1 (0.0052 mg/m³, 0.0008 lb/hr), CTRL 2 (0.0119 mg/m³, 0.0020 lb/hr), and RBR 4 (0.0354 mg/m³, 0.0058 lb/hr).

4.6.5 Nitrosamines Emissions Measurements Results.

N-Nitrosodiphenylamine was found in detected quantities for at least one run of RBR 1 (0.0043 mg/m³, 0.0007 lb/hr).

4.6.6 Results of Scan for other SW-846/8270 Semi-Volatile Compounds.

Six of the remaining compounds on the 8270 semi-volatile list had reported quantities for at least a couple of the mixes. Three of them were also found in the laboratory blank. Of particular interest is that Dibenzofuran and Phenol were reported at detected levels for all seven mixes. Again the emission concentrations and rates for both of these compounds were higher for mixes containing RAP, except for RBR 3, which was just between the results for the virgin mixes and the other RAP mixes for dibenzofuran and less than the virgin mixes for phenol. However, the phenol results were not as varied as were the dibenzofuran results. The phenol results ranged from 0.1891 to 0.4049 mg/m³ (0.0321 to 0.0646 lb/hr) for the RAP mixes and 0.2030 to 0.2155 mg/m³ (0.0347 to 0.0398 lb/hr) for the virgin mixes, not including RBR 4 which reported 1.0290 mg/m³ (0.1706 lb/hr). The dibenzofuran results ranged from 0.0498 to 0.1713 mg/m³ (0.0085 to 0.0277 lb/hr) for the RAP mixes and from 0.0229to 0.0236 mg/m3 (0.0039 to 0.0044 lb/hr) for the virgin mixes, with RBR 4 reporting 0.0671 mg/m³ (0.0111 lb/hr). These compounds are products of incomplete combustion, and referring back to the CO/THC and formaldehyde results, the results for these two compounds appear to track with those results, particularly the phenol results. Whether they are a function of using reprocessed used oil or not cannot be addressed since they have not been looked for in other sampling with other types of fuels. These two chemicals are of particular interest in that they are both listed in the Clean Air Act Title III list of Hazardous Air Pollutants.

5.0 CONCLUSIONS.

Overall, in this limited stack testing, it cannot be said that adding rubber to HMA paving materials, either by the WET or DRY process, increases significantly the emissions of any undesirable compounds. However, it appears that the RAP used in this study, regardless of whether or not the original binder had rubber in it, increased the emissions of PAHs and SO₂. The amount of SO₂ emitted was around 25% to 30% of the theoretical emissions, calculated from the fuel consumption and fuel sulfur content, when the feed materials were all virgin aggregates. It was as high as 48% of the theoretical emissions when the feed materials included RAP. The soft asphalt cement appears to result in increased emissions of BTEX.

Odors from the stack caused by the use of rubber in HMA the manufacturing process could, however, present a problem for Hot Mix Asphalt facilities, especially those in heavily populated areas. Any future testing programs conducted for crumb rubber asphalt pavements should include an odor testing procedure (with odor panel) similar to the Wayne County, Michigan, procedure.

Do any of these emissions pose a health risk to communities near HMA facilities? It is difficult to say from just at the emission rates and emission concentrations. An analysis in conformance with Michigan's Toxic Air Contaminant rule would be in order for Michigan facilities. For facilities in other states, a similar analysis should be performed in conformance with that state's toxic air pollutant regulations. However, given the limited number of hours a HMA facility is generally operated annually, it is highly *unlikely* that an allowable fenceline concentration limit based on an annual averaging period would be exceeded.

TABLE 1. STACK SAMPLING AND ANALYTICAL PROCEDURES FOR MICHIGAN DEPARTMENT OF TRANSPORTATION'S ASPHALT-RUBBER BINDER STACK TESTING PROJECT

Compound	Method/Procedure Name	Designation
CONTINUOUS EMISSIC	ONS MEASUREMENT	
Carbon Dioxide (CO_2) and Oxygen (O_2)	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)	EPA RM 3A
Sulfur Dioxide (SO ₂)	Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)	EPA RM 6C
Oxides of Nitrogen (NO _x)	Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)	EPA RM 7E
Carbon Monoxide (CO)	Determination of Carbon Monoxide Emissions from Stationary Sources	EPA RM 10
Total Hydrocarbons (THC)	Determination of Total Gaseous Organic Concentrations using a Flame Ionization Analyzer	EPA RM 25A
PARTICULATE EMISSIO	NS MEASUREMENT	
Particulate Matter (PM)	Determination of Particulate Emissions from Stationary Sources	EPA RM 5
Condensible Particulate Matter	Determination of Condensible Particulate Emissions from Stationary Sources	EPA RM 202
POLYNUCLEAR AROMA MEASUREMENT	ATIC HYDROCARBON EMISSIONS & SEMI-VOLATILE	EMISSIONS
PAHs (Semi-volatiles), Chlorobenzenes, and Chlorophenols	Collection of Semivolatile Principal Organic Hazardous Compounds (POHCs) from Incineration Systems	EPA Method SW- 846/0010, SW- 846/8270, CARB 429
HEAVY METAL EMISSIO	ONS MEASUREMENT	
Heavy Metals	Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes	Draft EPA RM 29

Table 1. (continued)

Compound	Method/Procedure Name	Designation		
FORMALDEHYDE AND	ACETONE EMISSIONS MEASUREMENT			
Formaldehyde (CHCO), Acetone	Determination of Aldehyde and Ketone Emissions from Stationary Sources	EPA Draft Method 0011		
VOLATILE ORGANIC EMISSIONS MEASUREMENT				
Benzene, Toluene, Ethyl-benzene, Xylene, Styrene, Chlorobenzene	Collection of Volatile Principal Organic Hazardous Constituents (POHCs)	EPA Method SW- 846/0030, SW- 846/8240		
METHANE AND 1,3-BUTADIENE EMISSIONS MEASUREMENT				
Methane and 1,3-Butadiene	Measurement of Gaseous Organic Compound Emissions by Gas Chromatography	EPA RM 18		

CONTINUOUS EMISSIONS MEASUREMENTS RESULTS and METHOD TABLE 2. 18 RESULTS (Units: PPM)

Mix Type >	> CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all r	uns for each	mix)					
HMA Production Rate (TPH)	349	351	352	357	3 5 0	361	345
Dry Aggregate Rate (TPH)	234	330	245	333	267	277	320
Asphalt Cement Added (%)	4.26%	5.75%	4,78%	6.84%	4.67%	5.12%	7.50%
RAP Content (%)	28.50%	7333333373	25.67%		19.00%	18.17%	7.3078
Mat'ls Moisture Content (%, dry)	5,35%	4.17%	5.25%	5.21%	4.79%	5.61%	3.94%
Fuel Consumption (gal/hr)	677	655	657	690	666	757	619
Exhaust Gas Temperature (F)	311	311	312	324	314	333	331
Mix Temperature (F)	284	296	289	316	296	308	310
STACK CONDITIONS (average of a	l runs for ea	ch mix)				1	
Sample Volume (SCF)	45,289	46,501	42.799	42.823	41,668	43.937	39.912
Sample Volume (cu. m)	1.282	1.317	1.212	1.213	1.180		
Exhaust Gas Moisture (%)	30.40%	27.0%	30.8%	29.3%	29.5%	1.244	1:130
Stack Temperature (F)	262	260	256	271	29.5%	31.8%	24.2%
Actual Exhaust Gas Flow (ACFM)	88,946	89,540	85,706	95,450		276	203
Dry Exhaust Gas Flow (DSCFM)	44.447	47.076	42.874	1.30	88,001	95,427	82,772
Dry Exhaust Gas Flow (DSCMM)	1,259	1.333	1,214	47,836	45,267	45,638	44,385
CO2, %, Orsat Result	6.45%	5.79%	6.07%	1,355 6.02%	1,282	1,292	1,257
O2, %, Orsat Result	11.97%	12.75%		100000000000000000000000000000000000000	6.05%	6.62%	6.27%
N2, %, Orsat Result	81.58%	81.46%	12.42% 81.52%	12.10%	12.40%	11.97%	12.27%
THE TOTAL MODELL	1 01.50%	01.4076	01.32%	81.88%	81.55%	81.42%	81.47%
CARRON PLOYING AND CONCENT					- William - Will		
CARBON DIOXIDE AND OXYGEN I		describeration from 1991		W. 110 1 1 1 1 1 1 1 1 1		·	,
Carbon Dioxide (CO2)	6.84%	6.00%	6.77%	6.48%	6.65%	7.17%	6.23%
Oxygen (O2)	11.68%	12.87%	11.84%	12.18%	11.96%	11.34%	12.66%
CO, NOx, SO2, and NMTHC RESU	TS, correcte	d PPM (avera	ige of all ru	ins for each r	nix).		
Carbon Monoxide (CO)	339.1	369.7	434.7	222.8	291.5	140.0	529.6
Nitrogen Oxides (NOx)	81.4	72.8	81.8	65.0	69.2	74.7	58.5
Sulfur Dioxide (SO2)	58.5	27.9	63.5	28.8	45.9	65.9	71.2
NMTHC as Carbon	324.0	338.0	535.3	274.4	309.2	106.4	666.9
METHANE RESULTS Method 18 (a	verage of al	l runs for eac	h mix).				
Methane (CH4) as measured	24.0	41.5	50.0	15.9	34.7	14.7	41.5
Methane as Carbon	17.9	31.0	37.4	11.9	26.0	11.0	31.1
				4		L	
NON-METHANE HYDROCARBON (CALCULATIO	NS (average	of all runs	for each mix)	•		
Total Hydrocarbons (THC) as Carbon	338.5	367.5	562.3	286.8	335.1	111.7	704.9
Methane as % of THC	4.30%	8.01%	4.79%	4.53%	7.71%	5.12%	5:29%
					Marine Committee of the	I	
1,3-BUTADIENE RESULTS Method	18 (average	of all runs fo	r each mix	().		*************************************	
1,3-Butadiene	T	5.0	0.9	T.			
	1	PROGRESSION CO.		100000000000 Ag 2		I	12.0

^{1 &}gt;> NMTHC = Non-methane Total Hydrocarbons.
2 >> The Sample Volume, Exhaust Gas Moisture, Stack Temperature, and Actual Exhaust Gas Flow have. been averaged between the two sample trains that were operated during the CEM operations. Except for Condition A–Mix Runs 1, 2, and 3 are from the Particulate/Condensible train, and Mix Runs 4, 5, and 6 are from the PAHs train. Based on how the sample trains were operated, the Metals and Particulate/-Condesibles trains are averaged together and the PAHs and Formaldehyde trains are averaged together.

 ^{3 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.
 4 >> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

TABLE 3. CONTINUOUS EMISSIONS MEASUREMENTS RESULTS and METHOD 18 RESULTS (Units: lbs per hour)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rur	s for each						
HMA Production Rate (TPH)	349	351	352	357	350	361	345
Dry Aggregate Rate (TPH)	234	330	245	333	267	277	320
Asphalt Cement Added (%)	4.26%	5:75%	4.78%	6.84%	4.67%	5.12%	7:50%
RAP Content (%)	28.50%	"""	25.67%		19.00%	18.17%	7.0078
Mat'ls Moisture Content (%, dry)	5.35%	4.17%	5.25%	5.21%	4.79%	5.61%	3.94%
Fuel Consumption (gal/hr)	677	655	657	690	666	757	619
Exhaust Gas Temperature (F)	311	311	312	324	314	333	331
Mix Temperature (F)	284	296	289	316	296	308	310
STACK CONDITIONS (average of all				1		1 000	
Sample Volume (SCF)	45.289	46.501	42.799	42.823	41,668	43,937	39.912
Sample Volume (cu. m)	1.282	1.317	1.212	1213	1.180	1.244	1.130
Exhaust Gas Moisture (%)	30.40%	27.0%	30.8%	29.3%	29.5%	31.8%	24.2%
Stack Temperature (F)	262	260	256	271	247	276	265
Actual Exhaust Gas Flow (ACFM)	88.946	89,540	85,706	95,450	88,001	95,427	82.772
Dry Exhaust Gas Flow (DSCFM)	44,447	47,076	42,874	47,836	45,267	45,638	44,385
Dry Exhaust Gas Flow (DSCMM)	1,259	1.333	1,214	1,355	1,282	1,292	1.257
CO2, %, Orsat Result	6.45%	5.79%	6.07%	6.02%	6.05%	6.62%	6.27%
O2, %, Orsat Result	11.97%	12.75%	12.42%	12.10%	12.40%	11.97%	12.27%
N2, %, Orsat Result	81.58%	81.46%	81.52%	81.88%	81.55%	81.42%	81.47%
		10.00 (a.00) (a.00) (a.00) (a.00) (a.00)		same mercenson			
CARBON DIOXIDE AND OXYGEN RE	SULTS (ave	rage of all ru	ns for each	mix).			
Carbon Dioxide (CO2)	6.84%	6.00%	6.77%	6.48%	6.65%	7.17%	6.23%
Oxygen (O2)	11.68%	12.87%	11.84%	12.18%	11.96%	11.34%	12.66%
			Vac-101-1-101				1 25, 11 24 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
CO, NOx, SO2, and NMTHC RESULT	S, correcte	d PPM (avera	ge of all ru	ns for each r	nix).		
Carbon Monoxide (CO)	66.1	75.9	81.5	46.1	57.5	27.9	102.5
Nitrogen Oxides (NOx)	25.9	24.6	25.1	22.3	22.4	24.4	18.6
Sulfur Dioxide (SO2)	25.9	13.1	27.2	13.8	20.7	30.1	31.5
NMTHC as Carbon	36.3	41.7	57.4	33.3	35.2	12.1	74.0
						<u> </u>	Last Age - 100 pt a gray
METHANE RESULTS Method 18 (av	erage of all	runs for eac	h mix).				
Methane (CH4) as measured	2.7	4.9	5.4	1.9	3.8	1.7	4.6
Methane as Carbon	2.0	3.7	4.0	1.4	2.9	1.2	3.4
		1 W. 855 5 5005 1	<u> </u>	1		<u></u>	promo e I.Dakishi
NON-METHANE HYDROCARBON CA	LCULATIO	NS (average	of all runs	for each mix)	•		
Total Hydrocarbons (THC) as CH4	37.9	43.4	60.3	34.8	38.1	25.4	78.2
NMTHC as Carbon	36.3	39.9	57.4	33.3	35.2	24.2	74.0
		I proceedings of the processing			The state of the s	<u> </u>	Takasa - makasa
1,3-BUTADIENE RESULTS Method 1	8 (average	of all runs fo	r each mix).			
1,3-Butadiene	- 	1.980	0.324				
	_	g 440° 4		Fre 30 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1	 1. 5 (0.00) (0.00) (0.00) (0.00)

NOTES:

1 >> NMTHC = Non-methane Total Hydrocarbons.

^{2 &}gt;> The Sample Volume, Exhaust Gas Moisture, Stack Temperature, and Actual Exhaust Gas Flow have been averaged between the two sample trains that were operated during the CEM operations. Except for Condition A-Mix Runs 1, 2, and 3 are from the Particulate/Condensible train, and Mix Runs 4, 5, and 6 are from the PAHs train. Based on how the sample trains were operated, the Metals and Particulate/Condesibles trains are averaged together and the PAHs and Formaldehyde trains are averaged together.

^{3 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{4 &}gt;> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

CONTINUOUS EMISSIONS MEASUREMENTS and METHOD 18 TABLE 4. RESULTS (Units: mg/m³)

Mix Type >	> CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	DDD 6	T
OPERATING DATA (average of all re	ins for each			SKOR. I See	KBK Z	RBR 3	RBR 4
HMA Production Rate (TPH)	349	351	352			T	
Dry Aggregate Rate (TPH)	234	330	245	357	350	361	345
Asphalt Cement Added (%)	4.26%	5.75%	4.78%	333	267	277	320
RAP Content (%)	28.50%	1 3.73.76		6.84%	4.67%	5.12%	7,50%
Mat'ls Moisture Content (%, dry)	5.35%	4.17%	25.67% 5.25%		19.00%	18.17%	
Fuel Consumption (gal/hr)	677	655	657	521%	4.79%	5.61%	3.94%
Exhaust Gas Temperature (F)	311	311	312	690	666	757	619
Mix Temperature (F)	284	296	289	324	314	333	331
STACK CONDITIONS (average of all				316	296	308	310
Sample Volume (SCF)	45	. 14	10.700	F. serger, Magazines of			
Sample Volume (cu. m)	1	46.501	42.799	42.823	41.668	43.937	39.912
Exhaust Gas Moisture (%)	30.40%	1.317	1.212	1.213	1.180	1.244	1.130
Stack Temperature (F)	262	27.0%	30.8%	29.3%	29.5%	31.8%	24.2%
Actual Exhaust Gas Flow (ACFM)	88,946	260	256	271	247	276	265
Dry Exhaust Gas Flow (DSCFM)	44,447	89,540	85,706	95,450	88,001	95,427	82,772
Dry Exhaust Gas Flow (DSCMM)	1,259	47,076	42,874	47,836	45,267	45,638	44,385
CO2, %, Orsat Result	6.45%	1,333	1,214	1,355	1,282	1,292	1,257
O2, %, Orsat Result	11.97%	5.79%	6.07%	6.02%	6.05%	6.62%	6.27%
N2, %, Orsat Result	81.58%	12.75%	12.42%	12,10%	12.40%	11.97%	12.27%
	01.50%	81/46%	81.52%	81.88%	81.55%	81.42%	81.47%
CARRON DIOVIDE AND OWICEN D							
CARBON DIOXIDE AND OXYGEN RI Carbon Dioxide (CO2)	SULIS (ave		ns for each	mix).			
Oxygen (O2)	6.84%	6.00%	6.77%	6.48%	6.65%	7.17%	6.23%
Oxygen (O2)	11.68%	12.87%	11.84%	12.18%	11.96%	11.34%	12.66%
							na a angajanja s
CO, NOx, SO2, and NMTHC RESULT	S, corrected	PPM (avera	ge of all ru	ns for each m	ix).		
Calbott Mottoxide (CO)	394.8	430.5	506.1	259.5	339.4	163.0	616.7
Nitrogen Oxides (NOx)	155.7	139.3	156.4	124.4	132.3	142.8	111.8
Sulfur Dioxide (SO2)	155.7	74.4	169.1	76.7	122.3	175,6	
NMTHC as Carbon	216.1	225.5	357.0	183.0	206.2	71.0	189.6 444.8
		**************************************	<u> </u>			71,0	
METHANE RESULTS Method 18 (av	erage of all	runs for each	n mix).				
Methane (CH4) as measured	16.0	27.7	33.3	10.6	22.2	0.0	Lat
Methane as Carbon	12.0	20.7	24.9	7.9	23.2 17.3	9.8	27.7
		manta ta Tabba			11.3	7.4	20.7
NON-METHANE HYDROCARBON CA	LCULATION	NS (average o	fall suns 4:				D. C
otal Hydrocarbons (THC) as Carbon	225.7	OAF 4					
IMTHC as Carbon	216.1	245.1		191.3	223.5	149.0	470.1
	210.1	225.5	357.0	183.0	206.2	141.9	444.8
,3-BUTADIENE RESULTS Method 1	9 /220	-	· ·				
.3-Butadiene	o (average d	11.24					
			2.03				

1 >> NMTHC = Non-methane Total Hydrocarbons.

^{2 &}gt;> The Sample Volume, Exhaust Gas Moisture, Stack Temperature, and Actual Exhaust Gas Flow have been averaged between the two sample trains that were operated during the CEM operations. Except for Condition A-Mix Runs 1, 2, and 3 are from the Particulate/Condensible train, and Mix Runs 4, 5, and 6 are from the PAHs train. Based on how the sample trains were operated, the Metals and Particulate/ Condesibles trains are averaged together and the PAHs and Formaldehyde trains are averaged together.

^{3 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{4 &}gt;> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

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TABLE 5. PARTICULATE and CONDENSIBLES MEASUREMENTS RESULTS (Units: all units)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rul	ns for each	mix).	in the second			The state of the s	
HMA Production Rate (TPH)	339	345	349	358	348	361	343
Dry Aggregate Rate (TPH)	225	324	221	333	266	275	317
Asphalt Cement Added (%)	4.54%	5.97%	4.62%	7.00%	4.41%	5.47%	7.51%
RAP Content (%)	29.00%		32.00%		19.00%	18.33%	1.0.7
Mat'ls Moisture Content (%, dry)	4.86%	4.39%	4.72%	5.30%	4.77%	5.71%	3.81%
Fuel Consumption (gal/hr)	644	634	629	685	658	768	641
Exhaust Gas Temperature (F)	311	310	312	329	311	332	332
Mix Temperature (F)	285	294	287	321	293	307	308
STACK CONDITIONS (average of all	runs for eac	ch mix).		·		<u> </u>	
Sample Volume (SCF)	49.497	48.562	46.717	44.817	44.176	45.851	42.307
Sample Volume (cu. m)	1.402	1.375	1.323	1.269	1.251	1.298	1.198
Exhaust Gas Moisture (%)	28.1%	25.3%	29.3%	27.7%	28.7%	31.7%	23.8%
Stack Temperature (F)	258	259	248	274	257	269	262
Actual Exhaust Gas Flow (ACFM)	87,151	90,233	84,176	95,799	87,444	95,570	82,678
Dry Exhaust Gas Flow (DSCFM)	45,335	48.731	43,569	49.051	44,892	45,913	44.747
Dry Exhaust Gas Flow (DSCMM)	1,284	1,380	1,234	1,389	1,271	1,300	1,267
CO2, %	6.20%	5.90%	5.89%	6.00%	5.96%	6.60%	6.03%
02, %	11.97%	12.63%	12.84%	12.07%	12.34%	12.03%	12.17%
N2, %	81.83%	81.47%	81.27%	81.93%	81.70%	81.37%	81.80%
							(Sept. 10.170.10)
Average PARTICULATE/CONDENSIBL	ES RESULTS	•	<<< g	rains/SCFD	>>>		
Particulate (front-half catch)	0.0029	0.0029	0.0018	0.0058	0.0030	0.00832	0.0055
Condensibles (back-half catch)	0.0412	0.0297	0.0480	0.0199	0.0422	0.04779	0.0634
						<u> </u>	People 100 1000
Average PARTICULATE/CONDENSIBL	ES RESULTS		<<<	mg/m3 >>>			
Particulate (front-half catch)	2.00	6.69	3.77	13.28	6.76	19.03	12.65
Condensibles (back-half catch)	94.2	68.0	104.1	45.6	96.7	109.4	145.0
Average PARTICULATE/CONDENSIBL	ES RESULTS		<<<	lbs/hour >>	>		
Particulate (front-half catch)	1.11	1.22	0.66	2.44	1.14	3.27	2.12
	16.0	12.4	17.9	8.4	16.3	18.8	24.3
Condensibles (back-half catch)						+	<u> </u>
			<u> </u>	· · · · · · · · · · · · · · · · · · ·			
Condensibles (back-half catch) Average PARTICULATE/CONDENSIBL	ES RESULTS		<<< lb	/ton HMA >	·>>		
	ES RESULTS 0.0033	0.0035	<< lb	/ton HMA >	0.0033	0.00907	0.0062

NOTE:

>> Shaded columns identify those mixes that DO NOT contain RAP.

TABLE 6. HEAVY METALS MEASUREMENTS RESULTS (Units: lb/hr & mg/m³)

Mix Type >>	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR:4				
OPERATING DATA (average of all ru	ns for each i	mix).								
HMA Production Rate (TPH)	345	349	358	348	361	343				
Dry Aggregate Rate (TPH)	324	221 -	333	266	275	317				
Asphalt Cement Added (%)	5.97%	4.62%	7.00%	4.41%	5.47%	7.51%				
RAP Content (%)	0.00%	32.00%	0.00%	19.00%	18.33%	0.00%				
Mat'ls Moisture Content (%, dry)	4.39%	4.72%	5.30%	4.7 7%	5.71%	3.81%				
Fuel Consumption (gal/hr)	634	629	685	658	768	641				
Exhaust Gas Temperature (F)	310	312	329	311	332	332				
Mix Temperature (F)	294	287	321	293	307	308				
STACK CONDITIONS (average of all runs for each mix).										
Sample Volume (SCF)	46.207	44.589	41.452	41.601	43.442	39.509				
Sample Volume (cu. m)	1.308	1.263	1.174	1.178	1.230	1.119				
Exhaust Gas Moisture (%)	26.6%	30.4%	29.5%	30.3%	33.4%	25.7%				
Stack Temperature (F)	260	251	275	246	271	264				
Actual Exhaust Gas Flow (ACFM)	87,103	82,910	93,276	84,435	94,550	83,004				
Dry Exhaust Gas Flow (DSCFM)	46,082	42,089	46,402	43,057	44,200	43,702				
Dry Exhaust Gas Flow (DSCMM)	1,305	1,192	1,314	1,219	1,252	1,238				
CO2, %	5.90%	5.90%	6.00%	5. 9 7%	6.60%	6.03%				
O2, %	12,64%	12.83%	12.07%	12. 3 3%	12.03%	12.17%				
N2, %	81.46%	81.27%	81.93%	81.70%	81.37%	81.80%				
METALS RESULTS (average of all runs	V		lbs/hr		1					
Arsenic	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000				
Barium	0.00481	0.00336	0.00105	0.00202	0.00154	0.00147				
Cadmium	0.00017	0.00009	0.00009	0.00014	0.00016	0.00014				
Chromium	0.00080	0.00029	0.00042	0.00052	0.00037	0.00035				
Lead	0.00026	0.00014	0.00020	0.00014	0.00018	0.00020				
Mercury	0.00119	0.00045	0.00053	0.00040	0.00051	0:00043				
Nickel	0.00056	0.00033	0.00041	0.00033	0.00030	0.00033				
Selenium	0.00013	0.00012	0.00015	0.00014	0.00014	0.00015				
Silver	0.00008	0.00005	0.00006	0.00010	0.00014	0.00006				
Zinc	0.00308	0.00201	0.00208	0.00337	0.00246	0.00288				

METALS RESULTS (average of all runs f	or each mix).		mg/cu. meter	•		
Arsenic	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Barium	0.00481	0.00336	0.00105	0.00202	0.00154	0.00147
Cadmium	⊕0.00017	0.00009	0.00009	0.00014	0.00016	0.00014
Chromium	0.00080	0.00029	0.00042	0.00052	0.00037	.0.00035
Lead	0.00026	0.00014	0.00020	0.00014	0.00018	0.00020
Mercury	0.00119	0.00045	0.00053	0.00040	0.00051	0.00043
Nickel	0.00056	0.00033	0.00041	0.00033	0.00030	0.00033
Selenium	0.00013	0.00012	0.00015	0.00014	0.00014	0.00015
Silver	0.00008	0.00005	0.00006	0.00010	0.00014	0.00006
Zinc	0.00308	0.00201	0.00208	0.00337	0.00246	0.00288

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

TABLE 7. RESULTS OF METALS ANALYSIS OF FUEL OIL AND PROCESS MATERIALS (Units: lb/hr)

METALS INTO THE PROCESS

FUEL METALS INT	O THE PROCESS		lbs/hr				
	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4	
Arsenic							
Barium	0.060	0.023	0.105	0.068	0.214	0.160	
Cadmium			*****	0.000	0.214	0.100	
Chromium							
Lead					l		
Mercury							
Nickel							
Selenium							
Silver							
Zinc	1,25	0.60	1.10	1.21	1.58	0.99	

AGGREGATE MET	ALS INTO THE PROC	ESS	lbs/hr			
	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
Arsenic	2.53	1.86	2.26	1.97	1.93	1.59
Barium	7.13	4.43	6.86	4.79	5.51	5.34
Cadmium				1	0.01	3.04
Chromium	5.19	3.10	4.66	3.72	3.85	3.81
Lead				0.72	0.00	5.01
Mercury						
Nickel	5.19	3.54	4.66	3.19	3.30	3.81
Selenium				5.10	3.30	7.01
Silver						
Zinc	18.85	9.29	12.65	13.83	25.88	10.15

RAP METALS INTO	THE PROCESS	_	lbs/hr				
there were the same of the sam	CTRL2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4	
Arsenic		1.24		0.98	0.43		
Barium		5.07		2.51	2.47		
Cadmium				2.01	2.77		
Chromium		2.09		1.24	1.14		
Lead		4.55		1.37	2.46		
Mercury				1.01	2.40		
Nickel		2.61		1.50	1.63		
Selenium				1.50	1.00		
Silver					ł		
Zinc		9.17		12.70	13.17		

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

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TABLE 8. ALL METALS INTO PROCESS and METALS OUT OF PROCESS (Units: lb/hr)

TOTAL META	L METALS INTO THE PROCESS				lbs/hr		
	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4	
Arsenic	2.53	3.10	2.26	2.95	2.36	1.59	
Barium	7.19	9.52	6.76	7.37	8.19	6.50	
Cadmium			***		0.15	0.50	
Chromium	5.19	5.18	4.66	4.96	5.00	3.81	
Lead		4.55		1.37	2.46	0.01	
Mercury				1.01	2.40		
Nickel	5.19	6.15	4.66	4.69	4.93	0.04	
Selenium		0.10	7.00	4.03	4.93	3.81	
Silver							
Zinc	18.11	19.06	13.76	27.74	40.62	11.14	

METALS OUT	WITH BAGHO	USE HOP	•	lbs/hr		
	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
Arsenic	0.0574	0.0056	0.0149	0.0237	0.0192	0.0032
Barium	0.0721	0.0389	0.1428	0.0783	0.1946	0.1101
Cadmium				0.07.00	0.1340	0.1101
Chromium	0.0220	0.0130	0.0458	0.0226	0.0609	0.0360
Lead	0.0440	0.0303	0.0901	0.0487	0.1340	0.0445
Mercury	0.0001	0.0001		0.0001	1 0	0.0440
Nickel	0,0391	0.0192	0.0726	0.0356	0.0866	0.0402
Selenium				0.0006	0.000	2.002
Silver	0.0024	0.0013	0.0049	0.0023	0.0065	0.0042
Zinc	0.2078	0.1411	0.3602	0.2066	0.6111	0.2965

METALS OUT	lbs/hr					
	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
Arsenic						
Barium	0.0048	0.0034	0.0011	0.0020	0.0015	0.0015
Cadmium	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001
Chromium	0.0008	0.0003	0.0004	0.0005	0.0004	0.0003
Lead	0.0003	0.0001	0.0002	0.0001	0.0002	0.0002
Mercury	0.0012	0.0004	0.0005	0.0004	0.0005	0.0004
Nickel	0.0006	0.0003	0.0004	0.0003	0.0003	0.0003
Selenium	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Silver	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
Zinc	0,0031	0.0020	0.0021	0.0034	0.0025	0.0029

MOTES:

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

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TABLE 9. PERCENTAGES OF METALS LEAVING PROCESS, IN THE MIX and IN THE EXHAUST GAS (Units: lb/hr)

	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
Arsenic	97.8%	99.8%	99.3%	99.2%	99.2%	99.8%
Banum	98.9%	99.6%	97.9%	98.9%	97.7%	98.3%
Cadmium				33.070	37.770	00.070
Chromium	99.6%	99.7%	99.0%	99.5%	98.8%	99.1%
_ead		99.3%		96.6%	94.8%	00.170
Mercury				00.070	34.070	
Vickel	99.2%	99.7%	98,5%	99.2%	98.3%	98.9%
Selenium				55.270	33.376	30.3%
Silver					·	
Zinc	98.8%	99.3%	97.4%	99.2%	98.5%	97.4%

	CTRL2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
Arsenic						
Banum	0.066%	0.035%	0.015%	0.027%	0.018%	0.022%
Cadmium				0.02,70	0.01070	O.ULL N
Chromium	0.015%	0.006%	0.009%	0.010%	0.007%	0.009%
Lead		0.003%		0.010%	0.007%	V.000.
Mercury					0.007,0	
Nickel	0.011%	0.005%	0.009%	0.007%	0.006%	0.008%
Selenium					3.55570	U.000A
Silver					ļ l	
Zinc	0.017%	0.010%	0.015%	0.012%	0.006%	0.025%

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

TABLE 10. FORMALDEHYDE AND ACETONE MEASUREMENTS RESULTS (Units: all units)

Mix Type >>	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all ru	ns for each	mix).				
HMA Production Rate (TPH)	357	355	357	353	361	348
Dry Aggregate Rate (TPH)	337	269	333	269	278	322
Asphalt Cement Added (%)	5.58%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	4 (44) (48)	19.33%	13.03.96	19.00%	18.00%	1 (S) (S) (S) (S)
Mat'ls Moisture Content (%, dry)	4.80%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	674	685	696	674	745	597
Exhaust Gas Temperature (F)	311	311	319	317	334	329
Mix Temperature (F)	296	292	311	299	308	311
STACK CONDITIONS (average of all	runs for ea	ich mix).	1-			
Sample Volume (SCF)	46.396	37.064	38.017	39.219	42.595	36.588
Sample Volume (cu. m)	1,314	1.050	1.077	1.111	1.206	1.036
Exhaust Gas Moisture (%)	27.4%	31.1%	29.8%	28.8%	30.5%	24.0%
Stack Temperature (F)	261	263	267	257	281	266
Actual Exhaust Gas Flow (ACFM)	91,280	88,311	93,214	94,109	96,795	83,387
Dry Exhaust Gas Flow (DSCFM)	47,684	43,490	46,515	48,121	47,062	44,784
Dry Exhaust Gas Flow (DSCMM)	1,350	1,231	1,317	1,363	1,333	1,268
CO2, %	5.67%	6.23%	6.03%	6.14%	6.63%	6.50%
O2, %	12.97%	12.00%	12.13%	12.48%	11.90%	12.37%
N2, %	81.36%	81.77%	81.83%	81.38%	81.47%	81.13%

Average FORMALDEHYDE RESULTS (for each mix)		lbs/hr			
Formaldehyde	2.5	2.3	1.2	2.0	0.79	4.1
Acetone	ND	ND	ND	ND	ND	ND

Average FORMALDEHYDE RESULTS (fo	or each mix)		PPM			
Formaldehyde	11.4	11.3	5.5	8.9	3.6	19.4
Acetone	ND	ND	ND	ND	ND	ND

Average FORMALDEHYDE RESULTS (fo	or each mix)		mg/m3			
1	14.2	14.1	6.9	11.1	4.5	24.3
	ND	ND	ND	ND	ND	ND

Formaldehyde Emission Factor – HOT	MIX ASPHALT	-	lbs/ton HM	A		
Formaldehyde	0.0071	0.0065	0.0034	0.0057	0.0022	0.0117
Acetone	ND	ND	ND	ND	ND	ND

Formaldehyde Emission Factor – FUEL	ehyde Emission Factor – FUEL OIL Ib/gal Fuel Oil									
Formaldehyde	0.0038	0.0034	0.0017	0.0030	0.0011	0.0068				
Acetone	ND ND	ND	ND	ND	ND	ND"				

^{1&}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

TABLE 11. VOLATILE ORGANIC MEASUREMENTS RESULTS FOR BTEX, STYRENE, MIBK, AND CHLOROBENZENE (Units: lb/hr)

Mix Type>>>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all run	is for each	mix)			- (10 Å) (10 M) (10 M)	. Lienianus - 2002	
HMA Production Rate (TPH)	348	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	236	337	269	333	269	278	322
Asphalt Cement Added (%)	3.97%	5.49%	4.93%	6.67%	4.92%	4.77%	7.48%
RAP Content (%)	28.33%		19.33%		19.00%	18.00%	1.70/0
Mat'is Moisture Content (%, dry)	5.42%	3.09%	5.78%	5.11%	4.81%	5.51%	4.08%
Fuel Consumption (gal/hr)	672	680	685	696	674	745	597
Exhaust Gas Temperature (F)	312	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for eac	ch mix)			-		
Sample Volume (SL)	4.726	5.119	5.820	4.643	4.286	5,144	4.487
Sample Volume (cu. m)	0.005	0.005	0,006	0.005	0.004	0.005	0.004
Exhaust Gas Moisture (%)	32.73%	28.13%	30.65%	30.03%	29,43%	31.05%	23.70%
Stack Temperature (F)	266	260	262	267	243	282	267
Actual Exhaust Gas Flow (ACFM)	90,740	90,412	87.870	96,362	90.063	95.794	82,70 3
Dry Exhaust Gas Flow (DSCFM)	43,559	46,745	42,920	47.946	46,560	46,221	44,545
Dry Exhaust Gas Flow (DSCMM)	1,233	1,324	1,215	1.358	1,318	1,309	1,261
CO2, %	6.70%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.97%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.33%	81.53%	81.77%	81.83%	81.40%	81.47%	81.13%

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to their reported Detection Limit.)								
Benzene	0.182	0.316	0.253	0.222	0.384	0.299	3 0.499		
Toluene	0.119	0.286	0.203	0.142	0.270	0.153	0.310		
Ethylbenzene	0.012	0.034	0.026	0.023	0.038	0.050	0.062		
m-/p-Xylene	0.047	0.122	0.091	0.155	0.143	0.264	0.168		
o-Xylene	0.038	0.044	0.089	0.025	0.062	0.046	0.079		
Styrene	0.030	0.067	0.056	0.033	0.199	0.151	0.207		
4-Methyl-2-pentanone (MIBK)	0.044	0.001	0.001	0.173	0.002	0.664	0.534		
Chlorobenzene	0.001	0.0005	0.0004	0:001	0.014	0.003	0.018		

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to Zero.)									
Benzene	0.181	0.316	0.254	0.223	0.383	0.298	0.499			
Toluene	0.118	0.286	0.204	0.142	0.270	0.153	0.310			
Ethylbenzene	0.012	0.034	0.026	0.023	0.038	0.050	0.062			
m-/p-Xylene	0.046	0.123	0.091	0.155	0.143	0.264	0.168			
o-Xylene	0.038	0.044	0.090	0.025	0.062	0.046	0:079			
Styrene	0.030	0.067	0.056	0.032	0.199	0.151	0.207			
4-Methyl-2-pentanone (MIBK)	0.043			0.179	000	0.664	0.534			
Chlorobenzene	0.0002	1 1 1 1 1 1 1 1 1 1 1 1 1		Æt. Bos.	0.015	0.003	0.018			

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

TABLE 12. VOLATILE ORGANIC MEASUREMENTS RESULTS FOR BTEX, STYRENE, MIBK, AND CHLOROBENZENE (Units: mg/m³)

Mix Type>>>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rur	s for each	mix)			Company of the Compan		
HMA Production Rate (TPH)	348	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	236	337	269	333	269	278	322
Asphalt Cement Added (%)	3.97%	5.49%	4.93%	6.67%	4.92%	4.77%	7.48%
RAP Content (%)	28.33%		19.33%	100	19.00%	18.00%	1.40%
Mat'ls Moisture Content (%, dry)	5,42%	3.09%	5.78%	5.11%	4.81%	5.51%	4.000/
Fuel Consumption (gal/hr)	6 72	680	685	696	674	745	4.08% 597
Exhaust Gas Temperature (F)	312	312	311	319	317	334	1 : 00000000000000000000000000000000000
Mix Temperature (F)	284	298	292	311	299	308	329 311
STACK CONDITIONS (average of all	runs for ea	ch mix)					1
Sample Volume (SL)	4,726	5.119	5.820	4.643	4.286	5.144	4,487
Sample Volume (cu. m)	0.005	0.005	0.006	0.005	0.004	0.005	
Exhaust Gas Moisture (%)	32.73%	28.13%	30.65%	30.03%	29.43%	31.05%	0.004
Stack Temperature (F)	266	260	262	267	243	282	23.70%
Actual Exhaust Gas Flow (ACFM)	90,740	90,412	87,870	96,362	90,063	95,794	267
Dry Exhaust Gas Flow (DSCFM)	43,559	46,745	42,920	47.946	46,560	į .	82,703
Dry Exhaust Gas Flow (DSCMM)	1,233	1.324	1.215	1.358	1,318	46,221	44,545
CO2, %	6.70%	5.70%	6.23%	6.03%	6.13%	1,309 6.63%	1,261
02, %	11.97%	12.77%	12.00%	12.13%	12.47%		6.50%
N2, %	81.33%	81.53%	81.77%	81.83%	81.40%	11. 9 0% 81.47%	12.37% 81.13%

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to their reported Detection Limit.)								
Benzene	1.116	1.803	1.575	1.237	0.384	1.726	2.992		
Toluene	0.727	1.635	1,266	0.789	0.270	0.884	1.857		
Ethylbenzene	0.073	0.192	0.159	0.130	0.038	0.291	0.369		
m-/p-Xylene	0.286	0.699	0.568	0.862	0.143	1.527	1.006		
o-Xylene	0.234	0.249	0.556	0.141	0.062	0.265	0.471		
Styrene	0.183	0.384	0.350	0.181	0.199	0.874	1.243		
4-Methyl-2-pentanone (MIBK)	0.269	0.006	0.006	0.963	0.002	3.837	3.201		
Chlorobenzene	0.003	0.0027	0.0025	0.003	0.014	0.019	0.109		

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to Zero.)									
Benzene Toluene Ethylbenzene m-/p-Xylene o-Xylene	1.116 0.727 0.073 0.286 0.234	1:803 1:635 0:192 0:699	1.575 1.266 0.159 0.568 0.556	1,237 0,789 0,130 0,862 0,141	2.202 1.549 0.218 0.818 0.353	1. 7 26 0.884 0.291 1.527	2.992 1:857 0:369 1.006			
Styrene 4-Methyl-2-pentanone (MIBK) Chlorobenzene	0.183 0.264 0.0014	0.384	0.350	0.181 0.963	0.078	0.265 0.874 3.837	0:471 1:243 3:201			

1 >> Shaded columns identify those mixes that DO NOT contain RAP.

TABLE 13. VOLATILE ORGANIC MEASUREMENTS RESULTS FOR BTEX, STYRENE, MIBK, AND CHLOROBENZENE (Units: PPM)

Mix Type>>>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rur	is for each	mix)		ulochen neuenstelle eine eine des		0.4.000.000.000.000.000.000.000.000.000	
HMA Production Rate (TPH)	348	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	236	337	269	333	269	278	322
Asphalt Cement Added (%)	3.97%	5.49%	4.93%	6.67%	4.92%	4.77%	7.48%
RAP Content (%)	28.33%		19.33%		19.00%	18.00%	1.40%
Mat'ls Moisture Content (%, dry)	5.42%	3.09%	5.78%	5.11%	4.81%	5.51%	4.08%
Fuel Consumption (gal/hr)	672	680	685	696	674	745	597
Exhaust Gas Temperature (F)	312	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for eac	h mix)					1
Sample Volume (SL)	4.726	5.119	5.820	4.643	4.286	5,144	4.487
Sample Volume (cu. m)	0.005	0.005	0.006	0.005	0.004	0.005	0.004
Exhaust Gas Moisture (%)	32.73%	28.13%	30.65%	30.03%	29.43%	31.05%	23.70%
Stack Temperature (F)	266	260	262	267	243	282	267
Actual Exhaust Gas Flow (ACFM)	90,740	90,412	87,870	96.362	90,063	95,794	82,703
Dry Exhaust Gas Flow (DSCFM)	43,559	46,745	42,920	47.946	46,560	46,221	44,545
Dry Exhaust Gas Flow (DSCMM)	1,233	1.324	1,215	1.358	1,318	1,309	1,261
CO2, %	6.70%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
02, %	11.97%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.33%	81.53%	81.77%	81.83%	81.40%	81.47%	81.13%

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to their reported Detection Limit.)									
Benzene	0.344	0.555	0.485	0.381	0.678	0.531	0.921			
Toluene	0.190	0.427	0.330	0.206	0.404	0.231	0.485			
Ethylbenzene	0.016	0.043	0.036	0.029	0.049	0.066	0.084			
m-/p-Xylene	0.065	0.159	0.129	0.195	0.185	0.346	0.228			
o-Xylene	0.053	0.056	0.126	0.032	0.080	0.060	0.107			
Styrene	0.042	0.089	0.081	0.042	0.263	0.202	0.287			
4-Methyl-2-pentanone (MIBK)	0.065	0.001	0.002	0.231	0.002	0.922	0.769			
Chlorobenzene	0.001	0.0006	0.0005	0.001	0.017	0.004	0.023			

VOC RESULTS (for each mix)	("Not-Detected" Compounds have been set equal to Zero.)									
Benzene	0.344	0.555	0.485	0.381	0.678	0.531	0.921			
Toluene	0.190	0.427	0.330	0.206	0.404	0.231	0.485			
Ethylbenzene	0.016	0.043	0.036	0.029	0.049	0.066	0.084			
m-/p-Xylene	0.065	0.159	0.129	0.195	0.185	0.346	0.228			
o-Xylene	0.053	0.056	0.126	0.032	0.080	0.060	0.107			
Styrene	0.042	0.089	0.081	0.042	0.263	0.202	0.287			
4-Methyl-2-pentanone (MIBK)	0.063			0.231	0.200	0.922	0.769			
Chlorobenzene	0.0003	24.8			0.017	0.004	0.023			

1 >> Shaded columns identify those mixes that DO NOT contain RAP.

PAH EMISSIONS MEASUREMENTS RESULTS, MDNR PAH TABLE 14. COMPOUNDS (Units: mg/m³)

Not-Detected Compounds have been set equal to their reported Detection Limit

Not-Detected Co	ompound:		i sei equa	i to their r	eportea L	Jetection	Limit.
Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all ru	ns for each	mix)					
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	7.4078
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for ea	ch mix)					
Sample Volumė (SCF)	42.862	44.841	42.827	47,004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89.544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43.396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)		("Not-Detected"	Compounds I	nave been set ec	ual to their red		10. 6 - 5 1 385 x000
Acenaphthene .	0.150	0.011	0.138	0.012	0.180	0.190	0.034
Acenaphthylene	0.036	0.013	0.043	0.014	0.060	0.150	0.112
Anthanthrene				""	0.000	0.030	0.112
Anthracene	0.077	0.003	0.083	0.002	0.049	0.071	0.014
Benzo(a)anthracene	0.004	0.002	0.004	0.002	0.009	0.007	0.006
Benzo(a)fluorene	0.005	0.001	0.010	0.001	0.005	0.012	
Benzo(a)pyrene	0.003	0.001	0.003	0.002	0.003	0.012	0.012 0.005
Benzo(b)fluoranthene	0.003	0.001	0.003	0.002	0.010	0.008	0.004
Benzo(b)fluorene			0.000	3.002	0.009	0.007	0.004
Benzo(c)fluorene							
Benzo(e)pyrene	0.004	0,001	0.004	0.003	0.013	0.010	0.006
Benzo(g,h,i)perylene	0.003	0.001	0.003	0.003	0.011	0.008	0.004
Benzo(j)fluoranthene					0.011	0.000	*******
Benzo(k)fluoranthene	0.003	0.001	0.003	0.002	0.010	0.007	0.004
Chrysene	0.004	0.003	0.004	0.002	0.010	0.007	0.006
Coronene							
Dibenzo(a,h)anthracene	0.004	0.001	0.004	0.003	0.012	0.009	0.005
Fluoranthene	0.161	0.018	0.177	0.015	0.044	0.053	0.037
Fluorene	0.230	0.030	0.243	0.030	0.120	0.131	0.085
Indeno(1,2,3-cd)pyrene	0.003	0.001	0.003	0.003	0.010	0.007	0.004
Phenanthrene	0.603	0.070	0.655	0.079	0.669	0.808	0.236
Picene					3.000	0.000	0.2.0
Pyrene	0.138	0.018	0.153	0.013	0.053	0.088	0:112
Perylene	0.003	0.001	0.003	0.002	0.010	0.008	0.005
Triphenylene					,0	0.000	- Per 1
		35.55 J. 8888.35 35 35	ويخيب بنورد المساحد والمسادد	22.00			Pays and services

1 >> Shaded columns identify those mixes that DO NOT contain RAP.

2 >> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.
 3 >> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

TABLE 15. PAH EMISSIONS MEASUREMENTS RESULTS, MDNR PAH COMPOUNDS (Units: lb/hr)

Not-Detected Compounds have been set equal to their reported Detection Limit.

1401-Defected Ci		The second second	-			1	
Mix Type >>	(1990) 3- N. S.	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rui				T			1.
HMA Production Plate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content %	28.40%		19.33%		19.00%	18.00%	
Mattls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption gat/hr)	675	669	685	696	674	745	597
Exhaust Gar. Temperature (F)	311	31 2	311	319	317	334	329
Mix Temperature (F)	284	29 8	292	311	2 9 9	308	311
STACK CONDITIONS (average of all	runs for ea	ch mix)					
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43,859	41.244
Sample Volume (Cu. m)	1.214	1.270	1.213	1.331	1,180	1.242	1.168
Exhaust Gall Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23,4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99.509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44.305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1.398	1,274	1,285	1.255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
02, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2. %	81.50%	81,53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)		("Not-Detected	" Compounds I	nave been set ed	rual to their re	ported Detection	35 7700,0000,000
Acenaphthene	0,0242	0,0018	0.0219	0.0021	0.0303	0.0324	0.0057
Acenaphthylene	0.0058	0:0022	0.0068	0.0026	0.0101	0.0095	0.0185
Anthanthrene		2.0	0.000		0.0101	0.0055	
Anthracene	0.0125	0.0005	0.0132	0.0003	0.0082	0.0121	0.0023
Benzo(a)anthracene	0.0006	0.0003	0.0007	0.0004	0.0015	0.0013	0.0011
Benzo(a)fluorene	0.0008	0.0002	0.0016	0.0001	0.0009	0.0013	0.0020
Benzo(a)pyrene	0.0005	0.0002	0.0016	0.0005	0.0009	0.0021	F 200000 (100 1 N T T T T T T T T T T T T T T T T T T
Benzo(b)fluoranthene	0.0003	0.0002	0.0005	0.0004	0.0018	0.0013	8000.0
Benzo(b)fluorene	0.0004	0.0002	0.0003	0.0004	0.0016	0.0012	0.0007
Benzo(c)fluorene						}	
Benzo(e)pyrene	0.0006	0.0002	0.0007	0.0006	0.0021	0.0016	0.0009
Benzo(g,h,i)perylene	0.0005	0.0002	0.0005	0.0006	0.0021	0.0014	0.0007
Benzo(j)fluoranthene	0.000		0.0000	0.000	0.0010	0.0014	0.0007
Велzo(k)fluoranthene	0.0004	0.0002	0.0005	0.0004	0.0016	0.0013	0.0007
Chrysene	0.0006	0,0005	0.0007	0.0004	0.0017	0.0013	0.0011
Coronene	0.000	202	0.0007	10 0 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.0017	0.0014	0000110
Dibenzo(a,h)anthracene	0.0006	0.0002	0.0006	0,000	0.0004	0.0045	00000
Fluoranthene*	0.0006	0.0002	0.0006	0.0006 0.0025	0.0021	0.0015	0.0008
Fluorene	0.0239	0.0051	0.0281	0.0025	0.0075 0.0203	0.0090	0.0061
Indeno(1,2,3-cd)pyrene	0.0372	0.0002	0.0386	0.0005	0.0203 0.0016	0.0223 0.0012	0.0140 0.0006
Phenanthrene	0.0975	0.0120	0.1039	0.0141			
Picene	0.0313	0.0120	0.1039	0.0141	0.1127	0.1373	0.0390
Pyrene	0.0222	0.0030	0.0244	0.0022	0.0089	0.0149	O O O O E
Perylene	0.0005	0.0000	0.0244	0.0022	0.0089	0.0149	0.0185
Triphenylene	0.0000	AK 1976 Sec. 1984	0.0003	0.0003	0.0017	0.0013	0,0008
				27.9 (2.42)/2/2	Constitution of the Consti	İ	

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{3 &}gt;> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

TABLE 16. PAH EMISSIONS MEASUREMENTS RESULTS, MDNR PAH COMPOUNDS (Units: PPM)

Not-Detected Compounds have been set equal to their reported Detection Limit.

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all run	All the state of t	Charles Company of the Company of th				, KDK o	NOR 7
HMA Production Rate (TPH)	349	356	355	357	353	361	2 348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%	0.7070	19.33%	0.07.70	19.00%	18.00%	7.40%
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	ľ	597
Exhaust Gas Temperature (F)	311	312	311	319	317	745 334	1.000 000 · 1.00000
Mix Temperature (F)	284	298	292	311	299	308	329
STACK CONDITIONS (average of all			232	percental of	233	300	311
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	42.950	30.24 04400
Sample Volume (cu. m)	1.214	1.270	1.213	120000000000000000000000000000000000000	41.676	43.859	41.244
Exhaust Gas Moisture (%)				1,331	1.180	1.242	1.168
Stack Temperature (F)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
, , ,	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)		("Not-Detected	* Compounds I	have been set e	qual to their rep	oorted Detection	n Limit.)
Acenaphthene	0.0234	0.0016	0.0215	0.0018	0.0280	0.0297	0.0053
Acenaphthylene	0.0057	0:0020	0.0067	0.0023	0.0095	0.0089	0.0176
Anthanthrene							
Anthracene	0.0104	0.0004	0.0112	0.0002	0.0066	0.0096	0.0019
Benzo(a)anthracene	0.0004	0.0002	0.0004	0.0002	0.0010	0.0008	0.0007
Benzo(a)fluorene	0.0006	0.0001	0.0011	0.0001	0.0006	0.0014	0.0007
Benzo(a)pyrene	0.0003	0.0001	0.0001	0.0002			1000 - 1 - 1 - 1000
Benzo(b)fluoranthene	0.0003	1.87 (1.57.00)		 Control of the State of the Control of	0.0010	0.0007	0.0004
Benzo(b)fluorene	0.0003	0:0001	0.0003	0.0002	0.0009	0.0007	0.0004
Benzo(c)fluorene						ļ	
Benzo(e)pyrene	0.0003	0.0001	0.0004	0.0000	0.0040	0.0000	
	0.0003	i		0.0003	0.0012	0.0009	0.0005
Benzo(g,h,i)perylene Benzo(j)fluoranthene	0.0003	0.0001	0.0003	0.0003	0.0009	0.0007	0.0004
Benzo(k)fluoranthene	0.0003	00004	0.0000				
` '	0.0003	0.0001	0.0003	0.0002	0.0009	0.0007	0.0004
Chrysene	0.0004	0.0003	0.0005	0.0002	0.0011	0.0009	0.0007
Coronene							
Dibenzo(a,h)anthracene	0.0003	0.0001	0.0003	0.0003	0.0011	8000.0	0,0004
Fluoranthene	0.0191	0.0021	0.0210	0.0018	0.0053	0.0063	0.0044
Fluorene	0.0333	0.0043	0.0352	0.0043	0.0174	0.0189	0.0122
Indeno(1,2,3-cd)pyrene	0.0002	0.0001	0.0003	0.0002	0.0008	0.0006	0.0003
Phenanthrene	0.0813	0.0095	0.0883	0.0107	0.0902	0.1090	0.0318
Picene				[*** ***			
Pyrene	0.0164	0.0021	0.0182	0.0015	0.0062	0.0105	0.0133
Perylene	0.0003	0.0001	0.0003	0.0002	0.0010	0.0007	0.0004
Triphenylene					2.2010	0.000	3.8
		No. 1000 to 150	-	1.00 M (1.00 M)			marking a marking a

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

3 >> No results for a compound, indicated by a blank space, are because analytical procedures were not available for the compound.

TABLE 17. PAH EMISSIONS MEASUREMENTS RESULTS, INCLUDING CUMENE AND CRESOLS (Units: mg/m³)

AAir Toman b	<u> </u>		-				
Mix Type >>	One of the second secon	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of a		- 00000000000 - 000000 to		long Transa		T	Tallian Comment
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F) Mix Temperature (F)	311	312	311	319	317	334	329
	284	298	292	317	299	308	311
STACK CONDITIONS (average of		The second contract of the Contract of the		100000000000000000000000000000000000000			
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each	mix)		("Not-Detecte	ed™ Comp <mark>oun</mark> ds h	ave been set	equal to Zero.)	
Acenaphthene	0.150	0.011	0.088	0.012	0.180	0.190	0.034
Acenaphthylene	0.036	0.013	0.032	0.014	0.060	0.056	0.112
Anthracene	0.077	0.002	0.051		0.049	0.071	0.014
Benzo(a)anthracene	0.001	0.001	0.003				0.002
Benzo(a)pyrene							
Benzo(b)fluoranthene							\$ 10 A.
Benzo(e)pyrene					•		
Benzo(g,h,i)perylene							
Benzo(k)fluoranthene						}	
Chrysene	0.001	0.002	0.002				∞ 0.002
Dibenzo(a,h)anthracene							Singlification
Fluoranthene	0.161	0.018	0.118	0.015	0.044	0.053	0.037
Fluorene	0.230	0.030	0.160	0.030	0.120	0.131	0.085
Indeno(1,2,3-cd)pyrene							\$ 100 pt 100
Naphthalene	0.620	0:294	0.519	0.337	0.497	0.419	0.842
Naphthalene, 2-Chloro-		1000000		#3000000			-860/MEERSER 1786
Naphthalene, 2-Methyl-	0.506	0.339	0.501	0.425	1.769	1,621	0.805
Phenanthrene	0.603	0.070	0.428	0.079	0.669	0.808	0.236
Pyrene	0.138	0.018	0.104	0.013	0.053	0.088	0.112
Average OTHER PAH RESULTS (or each mi	x)	("Not-Detecte	d" Compounds h	ave heen set	equal to Zero 1	-Leanning in
Cumene	0.028	0.032	0.039	0.037	0.027	0.041	0.057
o-Cresol (2-Methylphenol)	0.026	0.017	0.039	0.007	0.021	0.041	0.057
m-/p-Cresol (3-/4-Methylphenol)	0.066	0.031	0.100	0.031	0.050	0.049	0.113
		W. 2. 2. 2.	0.100		0.000	0.049	3 U/ZU/

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

TABLE 18. PAH EMISSIONS MEASUREMENTS RESULTS, INCLUDING CUMENE AND CRESOLS (Units: lb/hr)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of a	ll runs for	each mix)					300
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5,11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of	f all runs f	or each mix)					
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1:331	1.180	1,242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each	mix)		("Not-Detecte	d™ Compounds I	ave been set	equal to Zero.)	
Acenaphthene	0.0242	0.0018	0.0140	0.0021	0.0303	0.0324	0.0057
Acenaphthylene	0.0058	0.0022	0.0051	0.0026	0.0101	0.0095	0.0185
Anthracene	0.0125	0.0003	0.0082	0.0020	0.0082.	0.0033	0.0023
Benzo(a)anthracene	0.0002	0.0002	0.0005		0.0002.	0.0121	0.0004
Benzo(a)pyrene			0.0000				0.5004
Benzo(b)fluoranthene						 	
Benzo(e)pyrene							
Benzo(g,h,i)perylene							
Benzo(k)fluoranthene							
Chrysene	0.0002	0.0003	0.0004			1	0.0003
Dibenzo(a,h)anthracene			0.0001	\$188.000.000.00			0.0000
Fluoranthene	0.0259	0.0030	0.0189	0.0024	0.0075	0.0090	0.0061
Fluorene	0.0372	0.0051	0.0256	0.0055	0.0073	0.0030	0.0140
Indeno(1,2,3-cd)pyrene	5.5512	0.000	0.0250	0.0055	0.0203	0.0223	0.0140
Naphthalene	0.1005	0.0502	0.0839	0.0622	0.0837	0.0712	0.1396
Naphthalene, 2-Chloro-			0.0000	0.0022	0.0001	0.0712	0,1330
Naphthalene, 2-Methyl-	0.0822	0.0578	0.0813	0.0788	0.0000	0.0755	04005
Phenanthrene	0.0822	0.0378	0.0613	**************************************	0.2982	0.2755	0.1335
Pyrene	0.0975	0.0120	0.0684	0.0141	0.1127 0.0089	0.1373 0.0149	0.0390 0.0185
		200 / 10000		1988 5,300			0.0.103
Average OTHER PAH RESULTS (d™ Compounds I			T 3/5/1/201999
Cumene	0.0045	0.0056	0.0062	0.0069	0.0046	0.0069	0.0095
o-Cresol (2-Methylphenol)	0.0059	0.0029	0.0078	0.0011			0.0187
m-/p-Cresol (3-/4-Methylphenol)	0.0109	0.0052	0.0159	0.0058	0.0084	0.0084	0.0343

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

TABLE 19. PAH EMISSIONS MEASUREMENTS RESULTS, INCLUDING CUMENE AND CRESOLS (Units: PPM)

Not-Detected Compounds have been set equal to zero.											
Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR:1	RBR 2	RBR 3	RBR 4				
OPERATING DATA (average of a	ll runs for	each mix)									
HMA Production Rate (TPH)	349	356	355	357	353	361	348				
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322				
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%				
RAP Content (%)	28.40%		19.33%		19.00%	18.00%					
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%				
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597				
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329				
Mix Temperature (F)	284	298	292	311	299	308	311				
STACK CONDITIONS (average of	of all runs fo	or each mix)	1								
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41,676	43.859	41.244				
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168				
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%				
Stack Temperature (F)	26 5	260	261	267	228	282	267				
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020				
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305				
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255				
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%				
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%				
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%				
Average PAH RESULTS (for each	mix)		("Not-Detecte	d" Compounds I	ave been set	egual to Zero.)					
Acenaphthene	0.0234	0.0016	0.0137	0.0018	0.0280	0.0297	0.0053				
Acenaphthylene	0.0057	0.0020	0.0050	0.0023	0.0200	0.0089	0.0036				
Anthracene	0.0104	0.0003	0.0069		0.0066	0.0096	0.0019				
Benzo(a)anthracene	0.0002	0.0001	0.0003		0.0000	0.0000	0.0002				
Benzo(a)pyrene							0.000				
Benzo(b)fluoranthene											
Benzo(e)pyrene											
Benzo(g,h,i)perylene											
Benzo(k)fluoranthene						1					
Chrysene	0.0002	0.0002	0.0003	0.0000000000			0.0002				
Dibenzo(a,h)anthracene				2224			- 1011/200				
Fluoranthene	0.0191	0.0021	0.0140	0.0017	0.0053	0.0063	0,0044				
Fluorene	0.0333	0.0043	0.0232	0.0043	0.0174	0.0189	0.0122				
Indeno(1,2,3-cd)pyrene											
Naphthalene	0.1163	0.0551	0.0974	0:0632	0.0932	0.0786	0:1580				
Naphthalene, 2-Chloro-							2,000,000				
Naphthalene, 2-Methyl-	0.0857	0.0573	0.0847	0.0718	0.2992	0.2741	0.1362				
Phenanthrene	0.0813	0.0095	0.0578	0.0107	0.0902	0.1090	0.0318				
Pyrene	0.0164	0.0021	0.0124	0:0015	0.0062	0.0105	0.0133				
Average OTHER PAH RESULTS (for each mi	x)	("Not-Detected	d" Compounds I	ave been set	equal to 7em)	<u> </u>				
Cumene	0.0056	0.0065	0.0078	0.0075	0.0055	0.0081	0.0115				
o-Cresol (2-Methylphenol)	0.0030	0.0037	0.0078	0.0075	0.0055	0.0001	0.0115 0.0251				
m-/p-Cresol (3-/4-Methylphenol)	0.0148	0.0068	0.0110	0.0069	0.0111	0.0110	0.0460				
The state (a) intothylphonoly	5,5,70		0,0222	0.000	0.0111	0.0110	V:0400				

 ^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.
 2 >> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

TABLE 20. TOTAL PAH EMISSIONS DETERMINATION (Units: mg/m³)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all runs f	or each mix	()					***************************************
HMA Production frate (TPH)	349	356	35 5	357	353	361	348
Dry Aggregate Rate (TPH)	2 3 5	336	269	333	269	278	322
Aspha# Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%	Y 16 (1984)	19.33%	N. S.	19.00%	18.00%	1000000
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	31 1	319	317	334	329
Mix Temperature Fi	284	298	292	311	299	308	311
STACK CONDITIONS (average of all run	is for each	mix)					<u> </u>
Sample Volume (SCF)	42 862	44.841	42.827	47.004	41.676	43,859	41.244
Sample Volume (culim)	1 214	1,270	1.213	1.331	1,180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88 513	89,544	87,429	99,509	86.017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1.297	1.199	1.398	1,274	1,285	1.255
CO2 %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2 %	11 96%	12.77%	12.00%	12.13%	12,47%	11,90%	12.37%
N2, %	81 50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%

With "Not Detected" compounds set equal to their reported Detection Limit.	1 43	0.18	1.54	0.49	1.28	1.49	0.69
With "Not Detected" compounds set equal to Zero (0)	1 40	0.16	1.51	0.16	1,18	1,41	0.64
% Pnenanthrene of Total MDNR with "ND" = DL quantity	42 1%	39.7%	42.6%	41.5%	52.1%	54.3%	34,2%
% Higher with "ND" = DL vs. "ND" = 0.	2.11%	7.01%	2.06%	16.76%	8.80%	5.63%	7.05%

With "Not Detected" compounds set equal to Zero (0).	2 56	0.81	2.75	0,95	3,56	3.53	2.33
% Naphthalene Compounds of Total NAPA PAH quantity.	45.2%	79.6%	45.3%	82.9%	66.9%	60.0%	72.4%
% Phenanthrene of Total NAPA PAH quantity.	23.6%	8.7%	23.8%	8.3%	18.8%	22.9%	10.1%

Remember, NAPA PAHs include the Naphthalene compounds, which generally make up a high percentage of the Total PAH quantity.

TABLE 21. TOTAL PAH EMISSIONS DETERMINATION (Units: lb/hr)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all runs i	or each mi	x)				**************************************	
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	-311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all run	ns for each	mix)		,			
Sample Volume (SCF)	42.862	44.841	42.827	47,004	41.676	43,859	41:244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94.793	82.020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49.377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1.297	1,199	1.398	1,274	1,285	1.255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
02, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81,13%

With "Not Detected" compounds set equal to their reported Detection Limit.	0.231	0.030	0.244	0.034	0.216	0.253	0.114
With "Not Detected" compounds set equal to Zero (0).	0.227	0,028	0.239	0.029	0.199	0.240	0.107
% Phenanthrene of Total MDNR with "ND" = DL quantity.	42.1%	39.8%	42.6%	41.1%	52.1%	54.2%	34.2%
% Higher, with "ND" = DL vs. "ND" = 0.	2.12%	7.03%	2.05%	18.21%	8.81%	5.63%	7.07%

With "Not Detected" compounds set equal to Zero (0).	0.414	0.138	0.437	0.176	0,600	0.600	0.387
% Naphthalene Compounds of Total NAPA PAH quantity.	45.3%	79.6%	45.3%	83.5%	66,8%	60.0%	72.4%
% Phenanthrene of Total NAPA PAH quantity.	23.5%	8.7%	23.8%	8.0%	18.8%	22.9%	10.1%

Remember, NAPA PAHs include the Naphthalene compounds, which generally make up a high percentage of the Total PAH quantity

TABLE 22. TOTAL PAH EMISSIONS DETERMINATION (Units: PPM)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all runs f	or each mi	x)			***************************************		
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4,93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%	2000	19.00%	18.00%	1000000
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	6 75 -	669	685	696	674	745 .	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all run	s for each	mix)	····				
Sample Volume (SCF)	42,862	44.841	42.827	47.004	41,676	43,859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99.509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45.805	42,350	49,377	44,998	45,380	44.305
Dry Exhaust Gas Flow (DSCMM)	1,229	1.297	1,199	1.398	1,274	1,285	1.255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
02, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2. %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%

With "Not Detected" compounds set							
equal to their reported Detection Limit.	0.193	0.023	0.207	0.025	0.174	0.202	0.093
With "Not Detected" compounds set equal to Zero (0).	0.190	0.022	0.204	0.022	0.164	0.194	0.088
% Phenanthrene of Tolal MDNR with "ND" = DL quantity.	42.1%	40.3%	42.7%	42.5%	52.0%	54.0%	34.4%
% Higher, with "ND" = DL vs. "ND" = 0.	1.46%	4.97%	1.42%	11.78%	5.97%	3.86%	4.86%

NAPA PAHs PPM.				The Art Total State Conference on the State of S		Aug-thinis	
With "Not Detected" compounds set equal to Zero (0).	0.395	0.136	0.425	0.160	0.568	0.555	0.387
% Naphthalene Compounds of Total NAPA PAH quantity.	51.8%	83.5%	52.0%	86.0%	71.1%	65.0%	77.2%
% Phenanthrene of Total NAPA PAH quantity.	20.6%	7.0%	20.8%	6.6%	15.9%	19.7%	8.2%

Remember, NAPA PAHs include the Naphthalene compounds, which generally make up a high percentage of the Total PAH quantity.

TABLE 23. TOTAL PAH EMISSION FACTORS (Units: lb/ton HMA and lb/ton AC)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all runs	for each n	nix)					- One of the second second
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5,49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%	1	19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4:07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all ru	ns for eacl	h mix)					
Sample Volume (SCF)	42.862	44.841	42,827	47.004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86.017	94.793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1.398	1,274	1,285	1,255
CO2, %	6.54%	5:70%	6.23%	6.03%	6.13%	6.63%	6.50%
02, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81,50%	81.53%	81,77%	81.84%	81.40%	81.47%	81.13%

MICHIGAN DNR PAHs lbs per ton of HMA.											
With "Not Detected" compounds set equal to their reported Detection Limit.	0.00066	0.00009	0.00069	0:00010	0.00061	0.00070	0.00033				
With "Not Detected" compounds set equal to Zero (0).	0.00 06 5	80000.0	0.00067	0.00008	0.00056	0.00066	0.00031				

NAPA PAHs lbs per ton of HM.	Α.						
With "Not Detected" compounds set		asarotiya, se s		San Francisco			
equal to Zero (0).	0.00117	0.00039	0.00122	0.00048	0.00164	0.00162	0:00111

MICHIGAN DNR PAHs lbs per ton of asphalt binder.									
With "Not Detected" compounds set equal to their reported Detection Limit.	0.0162	0.0016	0.0140	0:0014	0.0124	0.0147	0:0044		
With "Not Detected" compounds set equal to Zero (0).	0.0159	0.0015	0.0137	0.0012	0.0114	0.0139	0.0041		

NAPA PAHs lbs per ton of asp	halt binder	•				,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
With "Not Detected" compounds set		andro Pilitara andro de Anno de la grada de Angres					.202 F 12.32
equal to Zero (0).	0.0288	0.0071	0.0247	0.0071	0.0335	0.0339	0.0145

Remember, NAPA PAHs include the Naphthalene compounds, which generally make up a high percentage of the Total PAH quantity

TABLE 24. TOTAL PAH EMISSION FACTORS
(Units: mg/ton HMA and mg/ton AC)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all runs	for each m	ix)					
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5,51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	. 334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all ru	ins for eacl	n mix)					
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
O2, 10	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%

MICHIGAN DNR PAHs mg per ton of HMA.										
With "Not Detected" compounds set equal to their reported Detection Limit.	3 01	38	312	44	278	318	149			
With "Not Detected" compounds set equal to Zero (0).	294	36	305	37	256	301	139			

NAPA PAHs mg per ton of HM.	Α.						
With "Not Detected" compounds set equal to Zero (0).	5 32	175	552	216	745	734	493

MICHIGAN DNR PAHs mg per ton of asphalt binder.								
With "Not Detected" compounds set equal to their reported Detection Limit.	7,3 58	712	6,328	654	5,646	6,670	1,996	
With "Not Detected" compounds set equal to Zero (0).	7,197	666	6,201	552	5,189	6,314	1,865	

NAPA PAHs mg per ton of aspl	halt binde	Γ.				- Marija	
With "Not Detected" compounds set equal to Zero (0).	13,073	3,202	11,194	3,239	15,188	15,396	6,595

Remember, NAPA PAHs include the Naphthalene compounds which generally make up a high percentage of the Total PAH quantity.

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TABLE 25. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: mg/m³)

Not-Detected Compounds have been set equal to their reported Detection Limit.

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4		
OPERATING DATA (average of all runs for each mix)									
HMA Production Rate (TPH)	349	356	355	357	353	361	348		
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322		
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%		
RAP Content (%)	28.40%		19.33%		19.00%	18.00%			
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%		
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597		
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329		
Mix Temperature (F)	284	298	292	311	299	308	311		
STACK CONDITIONS (average of all	runs for eac	ch mix)							
Sample Volume (SCF)	42.862	44.841	42.827	47,004	41.676	43.859	41.244		
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168		
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%		
Stack Temperature (F)	265	260	261	267	228	282	267		
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020		
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45.380	44.305		
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1.255		
CO2, %	6.54% 5.	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%		
O2, %		12.77%	12.00%	12.13%	12.47% 11.90%	12.37%			
N2, %	81.50%	81.53%	81.77%	81,84%	81.40%	81.47%	81.13%		
Average PAH RESULTS (for each mix)	"Not Dete	cted" Comp	ounds have	been set eg	ual to Dete	ction Limit.			
2,4-Dichlorophenol	0.011	0.005	0.012	0.007	0.035	0.026	0.019		
2,4,5-Trichlorophenoi	0.013	0.006	0.015	0.008	0.043	0.032	0.024		
2,4,6-Trichlorophenol	0.014	0.007	0.016	0.008	0.044	0.037	0.026		
Pentachlorophenol	0.020	0.009	0.024	0.012	0.054	0.048	0.034		
1,2-Dichlorobenzene	0.009	0:004	0.010	0.005	0.028	0.021	0.015		
1,3-Dichlorobenzene	0.008	0.004	0.010	0.005	0.027	0.020	0.015		
1,4-Dichlorobenzene	0.008	0.004	0.009	0.005	0.026	0.019	0.014		
1,2,4-Trichlorobenzene	0.014	0.015	0.011	0.006	0.032	0.024	0.049		
Hexachlorobenzene	0.013	0.006	0.015	0.007	0.035	0.029	0.023		
N-Nitrosodiphenylamine	0.006	0.003	0.007	0.007	0.019	0.015	0.011		
N-Nitroso-di-n-propylamine	0.019	0.008	0.021	0.012	0.063	0.046	0.032		
Benzoic Acid [4]	0.644	0.383	0.718	0.318	0.199	0.242	0.357		
Benzyl Alcohol	0.053	0.023	0.063	0.017	0.125	0.072	0.048		
bis(2-Ethythexyl)phthalate [4]	0.003	9.001	0.003	0.003	0.008	0:007	0.005		
Di-n-Butylphthalate [4]	0.158	0.014	0.011	0.006	0.132	0.008	0.022		
Dibenzofuran	0.171	0.023	0.170	0.024	0.084	0.053	0.067		
Phenol	0.321	0.203	0.405	0.215	0,323	0.189	1:029		

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{4 &}gt;> These compounds were also found in the laboratory blanks.

March 1994

TABLE 26. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: lb/hr)

Not-Detected Compounds have been set equal to their reported Detection Limit.

HMA Production Rate (TPH) Dry Aggregate Rate (TPH) Asphalt Cement Added (%)	235 4.20%	356	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4						
HMA Production Rate (TPH) Dry Aggregate Rate (TPH) Asphalt Cement Added (%)	349 235	356											
Dry Aggregate Rate (TPH) Asphalt Cement Added (%)	235	TOTAL PART AND A SECOND		OPERATING DATA (average of all runs for each mix)									
Asphalt Cement Added (%)			355	357	353	361	348						
	4.200/	336	269	333	269	278	322						
	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%						
RAP Content (%)	28.40%		19.33%		19.00%	18.00%							
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%						
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597						
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329						
Mix Temperature (F)	284	298	292	311	. 299	308	311						
STACK CONDITIONS (average of all	runs for eac	h mix)					- Annual						
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43,859	41.244						
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168						
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%						
Stack Temperature (F)	265	260	261	267	228	282	267						
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020						
Dry Exhaust Gas Flow (DSCFM)	43,396	45.805	42,350	49.377	44,998	45,380	44,305						
Dry Exhaust Gas Flow (DSCMM)	/ Exhaust Gas Flow (DSCMM) 1,229	1,297	1,199	1,398	1,274	1,285	1,255						
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%						
02, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%						
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%						
Average PAH RESULTS (for each mix)-	"Not Dete	cted* Comp	ounds have	been set ea	ual to Deter	ction Limit							
2,4-Dichlorophenol	0.0018	0,0009	0.0020	0.0013	0.0059	0.0044	0.0032						
2,4,5-Trichlorophenol	0.0022	0.0010	0.0024	0.0015	0.0033	0.0055	0.0032						
2,4,6-Trichlorophenol	0.0023	0.0011	0.0024	0.0015	0.0072	0.0055	0.0042						
Pentachlorophenol	0.0032	0.0015	0.0038	0.0023	0.0091	0.0081	0.0056						
1,2-Dichlorobenzene	0.0014	0.0007	0.0016	0.0011	0.0048	0.0035	0.0025						
1,3-Dichlorobenzene	0.0013	0.0006	0.0015	0.0010	0.0046	0.0034	0.0024						
1,4-Dichlorobenzene	0.0013	0.0006	0.0014	0.0010	0.0043	0.0033	0.0023						
1,2,4-Trichlorobenzene	0.0023	0.0025	0.0018	0.0012	0.0055	0.0041	0.0081						
Hexachlorobenzene	0.0021	0.0010	0.0024	0.0014	0.0059	0.0049	0.0038						
N-Nitrosodiphenylamine	0.0010	0.0005	0.0011	0.0012	0.0032	0.0025	0.0017						
N-Nitroso-di-n-propylamine	0.0030	0.0014	0.0033	0.0024	0.0106	0.0078	0,0053						
Benzoic Acid [4]	0.1049	0.0654	0.1138	0.0571	0.0335	0.0411	0.0595						
Benzyl Alcohol	0.0086	0.0039	0.0100	0:0033	0.0211	0.0123	0.0080						
bis(2-Ethythexyl)phthatate [4]	0.0005	0.0002	0:0004	0.0006	0.0014	0.0012	0.0008						
Di-n-Butyiphthalate [4]	0.0247	0.0023	0.0017	0.0010	0.0222	0.0013	0.0037						
Dibenzofuran	0.0277	0.0039	0.0270	0:0044	0.0141	0.0090	0.0111						
Phenol	0.0524	0.0347	0.0646	0:0398	0.0543	0.0321	0.1706						

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{4 &}gt;> These compounds were also found in the laboratory blanks.

TABLE 27. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: PPM)

Not-Detected Compounds have been set equal to their reported Detection Limit.

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rur	Company of the Control of the Contro	mix)	The second secon				1
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%	28.40%		19.33%		19.00%	18.00%	1
Mattls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for ea	ch mix)				<u> </u>	<u> </u>
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43.859	41.244
Sample Voiume (cu, m)	1,214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82.020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1.255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)	"Not Dete	cted" Comp	ounds have	been set ea	ual to Dete	ction Limit	
2,4-Dichlorophenol	0.0016	0.0007	0.0018	0.0010	0.0052	0.0038	0.0028
2,4,5-Tnchiorophenol	0.0016	0.0007	0.0019	0.0009	0.0052	0.0040	0.0029
2,4,6-Tnchiorophenol	0.0017	8000.0	0.0020	0.0010	0.0053	0.0046	0.0031
Pentachlorophenol	0.0018	8000,0	0.0022	0.0011	0.0048	0.0043	0.0031
1,2-Dichlorobenzene	0.0014	0.0006	0.0016	0.0009	0.0046	0.0034	0.0025
1,3-Dichlorobenzene	0.0014	-0.0006	0.0016	0.0009	0,0044	0.0033	0.0024
1,4-Dichlorobenzene	0.0013	0.0006	0.0015	0.0008	0.0042	0.0031	0.0023
1,2,4-Tnchlorobenzene	0.0019	0.0019	0.0015	0.0008	0.0043	0.0032	0.0065
Hexachlorobenzene	0.0011	0.0005	0.0013	0.0006	0.0030	0.0024	0.0019
N-Nitrosodiphenylamine	0.0007	0.0003	0.0008	0.0009	0.0023	0.0018	0.0013
N-Nitroso-d-n-propylamine	0.0034	0.0015	0.0039	0.0023	0.0116	0.0085	0.0060
Benzoic Acid [4]	0.1270	0.0754	0.1414	0.0626	0.0391	0.0476	0.0704
Benzyl Alcohol	0.0117	0.0050	0.0140	0.0038	0.0279	0.0161	0.0107
bis(2-Ethylhexyl)phthalate [4]	0.0002	0.0001	0.0002	0.0002	0.0005	0.0004	0.0003
Di-n-Butylphthalate [4]	0.0136	0.0012	0.0009	0.0005	0.0114	0.0007	0.0019
Dibenzofuran	0.0245	0.0033	0.0243	0.0034	0.0120	0.0075	0.0096
Phenol	0.0821	0.0519	0.1035	0.0551	0.0825	0.0483	0.2630

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2&}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

TABLE 28. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: mg/m³)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all run	s for each			the state of the s	<u> </u>		
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28,40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for eac	ch mix)					
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43,859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89.544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45.805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1.297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12:37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)	-"Not Dete	cted" Comp	nunds have	been set ea	ual Zero (0)	<u> </u>	
2,4-Dichlorophenol					441 ZC10 (0)	i I	
2,4,5-Trichlorophenol						-	
2,4,6-Trichlorophenol							
Pentachlorophenol						-	
1,2-Dichlorobenzene						1	
1,3-Dichlorobenzene							
1,4-Dichlorobenzene							
1,2,4-Trichlorobenzene	0.005	0.012					0.035
Hexachlorobenzene	0.000	0.0.2					0.055
N-Nitrosodiphenylamine				0.004			
N-Nitroso-di-n-propylamine				0.00			
Benzoic Acid [4]	0.644	0.383	0.718	0.318	0.199	0.242	0.357
Benzyl Alcohol	0.043	0.018	0.063	02.0	0.133	0242	U.J.J.
bis(2-Ethythexyl)phthalate [4]	0.013	0.010	0.003	0:003			
Di-n-Butylphthalate [4]	0.158	0.014	0.011	0.006	0.131	0.005	0.022
Dibenzofuran	0.171	0.023	0.170	0.024	0.084	0.050	0.067
Phenol	0.321	0.203	0.405	0.215	0.323	0.030	1.029
	J.J.	, , , , , , , , , , , , , , , , , , ,	V.,, U.	1	0.020	0.103	1:023

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{4 &}gt;> These compounds were also found in the laboratory blanks.

TABLE 29. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: lb/hr)

Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all run			CINES	KOK	KDK Z	KDK 3	KBK4
HMA Production Rate (TPH)	349	356	355	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	269	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	5.57%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	1.40%
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5.78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for eac	ch mix)					-
Sample Volume (SCF)	42.862	44.841	42.827	47,004	41,676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44 305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1,255
CO2, %	6.54%	5.70%	6.23%	6.03%	6.13%	6.63%	6.50%
O2, %	11.96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)	"Not Dete	cted" Comp	ounds have	been set ear	sal Zero (0)		
2,4-Dichlorophenol		i i			,,,,		
2,4,5-Trichlorophenol							
2,4,6-Trichlorophenol							
Pentachlorophenol							
1,2-Dichlorobenzene							
1,3-Dichlorobenzene							
1,4-Dichlorobenzene							
1,2,4-Trichlorobenzene	8000.0	0.0020					0.0058
Hexachlorobenzene							0.000
N-Nitrosodiphenylamine				0.0007			
N-Nitroso-di-n-propylamine							
Benzoic Acid [4]	0.1049	0.0654	0.1138	0.0571	0.0335	0.0411	0.0595
Benzyl Alcohol	0:0070	0.0030	0.0100	1 l		4.4T.1	0.000
bis(2-Ethythexyl)phthatate [4]			0.0004	0.0006			
Di-n-Butylphthelate [4]	0.0247	0.0023	0.0017	0.0010	0.0220	0.0009	0.0037
Dibenzofuran	0.0277	0.0039	0.0270	0.0044	0.0141	0.0085	0.0111
Phenol	0.0524	0.0347	0.0646	0.0398	0.0543	0.0321	0.1706

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{4 &}gt;> These compounds were also found in the laboratory blanks.

TABLE 30. 8270 SCAN INCLUDING CHLOROPHENOLS, CHLOROBENZENES, AND NITROSAMINES (Units: PPM)

	-	Trave beer				T	
Mix Type >>	CTRL 1	CTRL 2	CTRL 3	RBR 1	RBR 2	RBR 3	RBR 4
OPERATING DATA (average of all rur	s for each	mix)					
HMA Production Rate (TPH)	349	356	35 5	357	353	361	348
Dry Aggregate Rate (TPH)	235	336	269	333	26 9	278	322
Asphalt Cement Added (%)	4.20%	5.49%	4.93%	6.67%	4.93%	4.77%	7.48%
RAP Content (%)	28.40%		19.33%		19.00%	18.00%	
Mat'ls Moisture Content (%, dry)	5.47%	4.64%	5. 78%	5.11%	4.80%	5.51%	4.07%
Fuel Consumption (gal/hr)	675	669	685	696	674	745	597
Exhaust Gas Temperature (F)	311	312	311	319	317	334	329
Mix Temperature (F)	284	298	292	311	299	308	311
STACK CONDITIONS (average of all	runs for eac	h mix)		- Marcon			-
Sample Volume (SCF)	42.862	44.841	42.827	47.004	41.676	43.859	41.244
Sample Volume (cu. m)	1.214	1.270	1.213	1.331	1.180	1.242	1.168
Exhaust Gas Moisture (%)	31.5%	28.9%	32.4%	30.3%	30.1%	31.6%	23.4%
Stack Temperature (F)	265	260	261	267	228	282	267
Actual Exhaust Gas Flow (ACFM)	88,513	89,544	87,429	99,509	86,017	94,793	82,020
Dry Exhaust Gas Flow (DSCFM)	43,396	45,805	42,350	49,377	44,998	45,380	44,305
Dry Exhaust Gas Flow (DSCMM)	1,229	1,297	1,199	1,398	1,274	1,285	1.255
CO2, %	6.54%	5.70%	6.23%	6:03%	6.13%	6.63%	6.50%
O2, %	11,96%	12.77%	12.00%	12.13%	12.47%	11.90%	12.37%
N2, %	81.50%	81.53%	81.77%	81.84%	81.40%	81.47%	81.13%
Average PAH RESULTS (for each mix)	"Not Data	etad" Comp	ounds base	A0000000000000000000000000000000000000			
2,4-Dichlorophenol	- NOT DETE	cea Comp	ounus nave	been set eq	uai Zero (U)	'i	
2,4,5-Trichlorophenol							
2,4,6-Trichlorophenol							
Pentachlorophenol							
1,2-Dichlorobenzene							
1,3-Dichlorobenzene 1,4-Dichlorobenzene							
1,4-Dichlorobenzene 1,2,4-Trichlorobenzene							
Hexachlorobenzene	0.0007	0.0016					0.0047
N-Nitrosodiphenylamine				0.0005			
N-Nitroso-di-n-propylamine	88801 1201 1211 1211 1211 1211		A** \		******************		
Benzoic Acid [4]	0.1270						
Benzyl Alcohol	0.0095	0.0039	0.0140				
bis(2-Ethylhexyl)phthalate [4]			0.0002	0.0002			
Di-n-Butylphthalate [4]	0:0136	0.0012	0.0009	0.0005	0.0113	0.0005	0.0019
Dibenzofuran	0,0245	0.0033	0.0243	0:0034	0.0120	0.0071	0.0096
Phenol	0.0821	0.0519	0.1035	0.0551	0.0825	0.0483	0.2630

^{1 &}gt;> Shaded columns identify those mixes that DO NOT contain RAP.

^{2 &}gt;> Shaded rows identify those compounds that had detected/estimated quantities, but were not listed in the MDOT Special Conditions Document.

^{3 &}gt;> The horizontal lines in the list of compounds have no other significance than to help read numbers across the page.

^{4 &}gt;> These compounds were also found in the laboratory blanks.

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1.0 INTRODUCTION.

The Michigan Department of Transportation (MiDOT) developed and sponsored a project designed to look at the possible environmental and worker exposure effects that might result from the addition of crumb rubber to asphalt paving materials as a modifier or additive. Crumb rubber can be added to asphalt paving materials using two methods. One method is to mix the crumb rubber into the asphalt cement binder prior to mixing with aggregate materials. The other method is to add the crumb rubber to the manufacturing process as a separate process material. The first method is generally referred to as a "WET" process, and the latter method is generally referred to as a "DRY" process. MiDOT chose to use the Rouse method for the WET process, and developed their own mix design for the DRY process.

1.1 The WET Asphalt-Rubber Binder Method.

The Rouse method uses a very fine crumb rubber material, 100% passing an 80 mesh screen. The crumb rubber is blended into a very high penetration (i.e. very soft) asphalt cement which has been heated to 450°F in a primary mixing tank and mixed for a specified period of time to initiate digestion of the rubber. It is then transferred to a secondary mixing tank for further mixing and digestion. When this second step is completed, the asphalt-rubber binder is transferred to either directly to the manufacturing process or to intermediate storage. At this point it is at about a temperature of 375°F. The mix design for the MiDOT project specified an amount of crumb rubber to be added to the asphalt cement binder in sufficient quantities to provide a ratio of 20 pounds of crumb rubber per ton of Hot Mix Asphalt (HMA).

1.2 The DRY Asphalt-Rubber Binder Method.

The DRY process uses a larger size crumb rubber. MiDOT specified a size passing a 1/4 inch sieve. The MiDOT mix design for the DRY process specified an amount of crumb rubber to be added to the asphalt manufacturing process in sufficient quantities to provide a ratio of 40 pounds of crumb rubber per ton of HMA. The point of introduction of the crumb rubber into the manufacturing process was not specified, but would depend on the type of equipment the successful bidding contractor would use--a batch mix facility, a parallel-flow drum mix facility, or a counter-flow drum mix facility.

1.3 Mixes to be Tested.

The MiDOT determined that seven mixes would be tested. Three of those mixes are considered Control Mixes, the other four are considered Rubber Mixes. Six of the mixes were to be manufactured with the same asphalt cement as required for

the asphalt-rubber binder -- an asphalt cement of 200-250 penetration (roughly equivalent to an AC-2.5 asphalt cement). The low viscosity asphalt cement is required in an asphalt-rubber binder because it is believed that the digestion process causes the rubber to absorb substantial amounts of light ends from the asphalt cement. MiDOT chose to use the same asphalt cement throughout the stack testing program to eliminate one variable -- asphalt cement related emissions. The seventh mix, Control Mix 1, was added to the program at a later date as a comparison for a "typical" mix compared to the "rubber" mixes because of the low viscosity asphalt cement used in the rubber mixes. There was concern that there might be emissions reported, particularly with the volatile organic compounds that might be high because of the low viscosity asphalt cement. The mixes are as follows:

Control Mix 1: This mix was to be a typical HMA using an asphalt cement with a penetration of 85-100, which is roughly equivalent to an AC-10 asphalt cement. This mix was included at a later date and was added because of concerns that the asphalt cement specified in the Rubber Mixes was a very soft asphalt and might result in emissions not normally found while producing HMA paving materials with a more viscous asphalt cement. The "typical" mix being produced during the stack testing which could be manufactured with an 85-100 PEN asphalt cement also contained 30% reclaimed asphalt pavement (RAP). This mix was designated as BM13A, Bituminous Mixture 13A -- no Rubber, 30% RAP.

Control Mix 2: This mix was to contain 100% virgin aggregates and asphalt cement with a penetration of 200-250 (roughly equivalent to an AC-2.5 asphalt cement). This mix was designated as MBM01, Modified Bituminous Mixture 01 -- no rubber, no RAP.

Control Mix 3: This mix was to contain 20% "regular" RAP materials. "Regular" as opposed to RAP with an asphalt-rubber binder. There has long been concern on the part of the paving industry as to the recyclability of asphalt pavements produced with an asphalt-rubber binder. Michigan had a roadway paved in the late 1970s with a mix containing an asphalt-rubber binder. The roadway was milled up in order to be used in this testing program. This mix was designated as MBM02, Modified Bituminous Mixture 02 -- no Rubber, 20% RAP.

Rubber Mix 1: The mix was to contain 100% virgin aggregates and an asphalt-rubber binder, manufactured by the WET process. This mix was designated as MBM03, Modified Bituminous Mixture 03 -- **Rubber-WET**, **no RAP**.

Rubber Mix 2: The mix was to contain 20% "rubber-RAP." "Rubber-RAP" because the pavement was originally manufactured with an asphalt-rubber binder. The asphalt cement binder would not be modified with rubber crumb. This mix was designated as MBM05, Modified Bituminous Mixture 05 -- no Rubber, 20% rubber-RAP.

Rubber Mix 3: This mix was to contain 20% "rubber-RAP" and an asphalt-rubber binder, manufactured by the WET process. This mix was designated as MBM06, Modified Bituminous Mixture 06 -- **Rubber-WET**, 20% rubber-RAP.

Rubber Mix 4: The mix was to contain rubber, manufactured by the DRY process, with 100% virgin aggregates. This mix was designated as MBM04, Modified Bituminous Mixture 04 -- **Rubber-DRY**, no RAP.

1.4 Development of the Stack Testing and Worker Exposure Assessment Program.

MiDOT consulted with the National Asphalt Pavement Association (NAPA) as to what environmental and worker exposure measurement approaches should be taken. They then consulted with the Michigan Department of Natural Resources Air Quality Division (MiDNR) about NAPA's recommendations. NAPA provided MiDOT with a copy of the stack testing protocol they had developed for their own stack testing program and the worker exposure sampling protocol for asphalt-rubber binder mixes that NAPA had also developed, in conjunction with the Asphalt Institute. Also, the protocol was distributed around the country for review, primarily to USEPA branches and some state air quality agencies. The additions were based on their feed back, and on MiDNR's practices and requirements. The worker exposure sampling and analytical procedures recommended by NAPA are provided in Table 1.

1.5 Description of the Paving Site at which the Worker Exposure Sampling was Conducted.

The paving site was a two-lane roadway designated as Michigan Route 50 (M-50). It was approximately nine miles long, running east/west, and is the main thoroughfare between Eaton Rapids, Michigan and Charlotte, Michigan. The paving work involved installing wedging along the curves of the roadway and several overlays of a base course pavement mixture and a surface course pavement mixture.

1.6 Description of the Personnel Positions for which Worker Exposure Sampling was Conducted and how Sampling was Conducted.

Five personnel positions were sampled at the paving site: Paver Operator, Roller Operator, Screedman, Luteman, and Laborer. At the Hot Mix Asphalt facility, the Quality Control Worker (in this case the QC Manager) position was sampled.

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Most of the workers that were sampled were smokers. When a smoking break was desired, the industrial hygienist conducting the worker exposure sampling would turn off the pumps and cap the tubes until the smoking break was completed. This was done to eliminate the possible contamination of the samples from cigarette smoke. Cigarette smoke is known to contain some of the same PAHs for which the worker exposure assessment was being conducted.

Each worker was equipped with two sampling pumps. One pump was attached to the sampling equipment for collecting the Particulate Matter (PM), Benzene Soluble Organics (BSO), and Polynuclear Aromatic Hydrocarbons (PAHs) samples, and the other pump was attached to a tri-flow adapter to which the tubes for the 1,3-butadiene, BTEX/Styrene, and the Nitrosamine samples were connected. Each pump was operated for a minimum of 6 hours to a maximum of 8 hours each day. The inlets of the tubes were pinned to the front chest clothing as close to the breathing zone as possible without interfering with the workers' performance at their positions. The pumps were calibrated for specified flow rates, depending on the sampling being conducted—the PM/BSO/PAH pump was calibrated to draw 2 liters per minute, and the other pump was calibrated to draw 0.2 liters per minute.

1.6.1 Paver Operator Position Exposure.

The paver operator essentially steers the paving machine during paving operations. The operator sits on the top of the platform that is centered between the unloading hopper and the screed hopper. The operator's seat was located on the platform closest to the screed hopper. Because of the configuration of the seat, the pumps were affixed to the paver steering column so as not to interfere with the operator's operation of the paving machine.

1.6.2 Roller Operator Position Exposure.

The roller operator was centrally located between the front and back rollers. The exhaust pipe vented below the operator's platform. The roller was operated several hundred feet behind the paving machine. Based on the proximity to the asphalt paving materials and the temperature of the paving materials at time of exposure, the roller operator experiences the least exposure to asphalt fumes of all the paving crew positions.

1.6.3 Screedman Exposure.

The screedman stands over the screed hopper to ensure smooth feeding of the hot mix asphalt paving materials. The screedman also operates the screed extensions that set the width of the pavement mat placed by the paving machine. Based on proximity to the asphalt paving materials and the temperature of the paving materials at time of exposure, the screedman experiences the "worst-case" exposure to asphalt fumes of all the paving crew positions.

1.6.4 Luteman Exposure.

The luteman uses a rake-like device that has a flat board where the rake prongs would be to smooth out rough spots, clear away asphalt paving materials from manhole covers, and generally move asphalt paving materials according to need. The luteman works several feed behind the paving machine and works on the mat after it has been placed by the paving machine.

1.6.5 Laborer Exposure.

The laborer uses a shovel to move asphalt paving materials around on an as needed basis. The laborer can work several feet behind the paving machine, alongside the luteman, or alongside the screed-using the shovel to break up large chunks of asphalt paving materials in front of the screed extension, before it passes over the materials and forms them into the mat.

1.6.6 Quality Control Worker Exposure.

The quality control worker gets into the bed of the truck hauling the asphalt paving materials, on top of the paving materials to check the temperature of the materials in the truck and to collect a sample of the paving materials for QC procedures. The sample that is collected is generally a composite of asphalt paving materials from various spots in the truck bed, thus requiring the QC worker to walk along the length of the truck bed on top of the asphalt paving materials at least once. The QC worker works with the collected sample, first at a heated table to apportion it into several smaller samples. The worker then carries out several QC procedures on the various smaller samples. These procedures would include: pavement density determination, asphalt content determination (the asphalt cement is removed from the aggregate using a solvent), aggregate voids determination, etc.

1.7 Other Samples Collected.

Background samples were collected each day that worker exposure sampling was conducted. The background samples was situated upwind of the paving site so as not to be affected by emissions from the paving site. Field blanks were also collected. Since there were two days of sampling conducted for each mix type, one blank was set up at the paving site, generally on the first day of sampling, and one blank was set up at the Hot Mix Asphalt facility, generally on the second day of sampling. Table 2 provides a list of the field blanks indicating the sample number, the field blank location for each date of worker exposure sampling, and whether anything was detected on the blank.

2.0 WORKER EXPOSURE ASSESSMENT SAMPLING PROCEDURES AND COMPOUNDS TO BE ANALYZED AND QUANTITATED.

2.1 Measurements of Worker Exposure to 1,3-Butadiene in HMA Paving Material Fumes.

Samples for 1,3-Butadiene measurements were collected because 1,3-Butadiene is a part of the rubber polymer. OSHA Method 56 was used to collect and analyze this sample for 1,3-Butadiene. Two tubes of tert-butyl catechol coated charcoal were used, with the second tube acting as a backup for break-through determinations. The two tubes were to be analyzed separately.

2.2 Measurements of Worker Exposure to Particulate Matter and Benzene Soluble Organics in HMA Paving Material Fumes.

Particulate matter and Benzene Soluble Organics measurements were conducted according to NIOSH Methods 0500 and 5023, respectively. However, they were modified by using a pre-extracted 37 mm silver-membrane filter instead of a polyvinylchloride filter. The silver-membrane filter was used because of problems with artifacts from the polyvinylchloride filter dissolving in the benzene solvent extraction procedure and resulting in BSO results higher than the Particulate Matter results. The silver-membrane filter is recommended by Henry (Henk) Brandt of Shell Oil-Netherlands from research he has conducted, and has been used by NAPA and the Asphalt Institute in recently conducted worker exposure assessment studies.

2.3 Measurements of Worker Exposure to Polynuclear Aromatic Hydrocarbons in HMA Paving Material Fumes.

NIOSH Method 5506 was to be conducted for the collection and analysis of the 17 PAH compounds listed in the method. The silver-membrane filter was backed by a pre-extracted 100/50 mg XAD-2 sorbent tube. The two sections of XAD-2 sorbent being separated by glass wool. The 17 PAHs for which analysis was conducted are:

Acenaphthene Acenaphthylene Anthracene

Benz(a)anthracene Benzo(a)pyrene

Benzo(e)pyrene

Benzo(g,h,i)perylene Benzo(j)fluoranthene Benzo(k)fluoranthene

Chrysene

Dibenzo(a,h)anthracene

Fluoranthene

Fluorene

Indeno(1,2,3-cd)pyrene

Naphthalene Phenanthrene

Pyrene

2.4 Measurements of Worker Exposure to Several Volatile Organic Compounds in HMA Paving Material Fumes.

NAPA's Worker Exposure Assessment Protocol recommended measurement of Benzene, Toluene, Ethylbenzene, all isomers of Xylene (BTEX), and styrene. Styrene was specified because it is part of the rubber polymer.

2.5 Measurements of Worker Exposure to Several Nitrosamine Compounds in HMA Paving Material Fumes.

Measurement of nitrosamines was also recommended by NAPA in their Worker Exposure Assessment Protocol.

3.0 FIELD WORK.

The worker exposure sampling was carried out during the latter half of September 1993 and the first few days of October 1993 (9/15 through 10/5). Swanson Environmental, Inc. of Farmington Hills, Michigan, performed the worker exposure sample collection, under the direction of Henry Phillips, CIH. The analytical work for the worker exposure assessment samples was carried out by Data Chem Laboratories of Salt Lake City, Utah, except for the nitrosamines analyses. These analyses were performed by Thermedics Detection Inc. of Woburn, Massachusetts. The stack testing and worker exposure sampling were overseen by Kathryn O'C. Gunkel, P.E. of WILDWOOD Environmental Engineering Consultants, Inc. Ms. Gunkel also oversaw collection of process materials samples, recordation of operating data, and recordation of process materials moisture content. There were some delays--mostly weather related. One major delay was caused by delivery problems with the 1/4 inch rubber crumb and the project had to be carried over another weekend.

3.1 Worker Exposure Sampling Problems.

Thermedics Detection Inc. was unable to provide the required number of tubes with back-up sorbent traps prepared for the nitrosamines sample collection and analysis. Therefore, the original sampling protocol had to be modified somewhat. Originally, two field blanks were to be collected--one at the paving site and one at the HMA facility site. This was modified so that a field blank was collected for each mix sampled (which involved two days of sample collection)--one day at the paving site and the next day at the HMA facility site. Another modification was that only the first day of sampling for each mix had back-up Nitrosamines sorbent traps.

Because of the weather delays that occurred several times in the early morning, some worker exposure samples barely met the minimum six hours of sampling criteria. For the most part, the sample collection time averaged around seven hours. Also, because of the number of smokers on the paving crew, the smokers were accommodated by turning off their pumps and capping the tubes/cassettes during a smoking break to prevent contamination from cigarette smoke, as previously discussed.

3.2 Visible Emission Observations.

It was reported by various individuals that visible vapors from the asphalt paving materials seemed worse with the rubber mixes. However, as there is no method for evaluating fugitive visible emissions from a paving operation, some subjectivity would have to be factored in with these reports.

3.3 Paving Worker Complaints.

On Monday morning, October 4, 1993, Ms. Gunkel received reports that workers had complained of adverse health affects over the weekend following several consecutive days of paving with asphalt-rubber binders. One worker was reported to have complained to the paving superintendent about chest pains and constrictions in breathing over the weekend. Ms. Gunkel went out to the paving site to interview the workers. The paver operator, roller operator, and the laborer were interviewed prior to commencement of paving operations. The paver operator and roller operator reported no problems, while the laborer reported breathing difficulties. In following up with the paving superintendent, Ms. Gunkel learned that it was the paver operator that had originally complained about chest pains, the discrepancy in his report to the paving superintendent and his interview with Ms. Gunkel was not resolved. Ms. Gunkel also learned that the laborer was new to paving, the 1993 paving season being *her* first job on a paving crew. It was felt that her complaints were primarily due to this newness on the job and not having fully developed the physical conditioning that occurs when working in an intensely manual job, such as this.

4.0 DISCUSSION OF RESULTS.

The results of the worker exposure samples are grouped together by job category and by method conducted, where applicable. The data table are grouped together at the end of the report beginning at page 15. The reported detection limit for each compound is provided in the line just above the results for the samples for each worker position. The detection limit concentrations were calculated using the average of all the sample volumes collected for each worker position.

4.1 Sampling and Analytical Results for Particulate Matter and Benzene Soluble Organics (BSO).

The catch weight results of the Particulate Matter and Benzene Soluble Organics (BSO) samples are presented in Table Set I. The concentrations in units of mg/m^3 are also presented in Table Set I.

4.1.1 Particulate Matter Results.

The ACGIH Threshold Limit Value (TLV) for asphalt fumes is as total particulate matter--5 mg/m³. The results of the sampling showed that exposure to total particulate matter, for all positions and mixes, is well below the TLV value.

4.1.2 Benzene Soluble Organics Results.

A substantial number of the BSO results were higher than the total particulate matter results of which the BSO is a fraction. Data Chem reported that after following the extraction procedures of NIOSH Method 5023, a gelatinous residue remained. It is believed that a chemical reaction occurred between the benzene and the filter or between the benzene and the materials captured on the filters that caused this residue to form. Furthermore, it is also believed that this residue is the reason many of the BSO sample results were higher than the total particulate matter results. As stated previously, using a pre-extracted silver-membrane in the cassette was to mitigate the problem of the BSO sample results being higher than the total particulate matter results.

4.2 Sampling and Analytical Results for 17 PAH Compounds.

The catch weight results of the PAH sampling and analysis are presented in Table Set II. The concentrations in mg/m³ are presented in Table Set III. The concentrations in PPB are presented in Table Set IV.

The compound Acenaphthene was detected in all of the samples, including the background sample. Naphthalene was found in three of the background samples and in virtually all the worker samples (three roller operator samples did not report Naphthalene, one luteman sample did not report Naphthalene, and one quality control manager sample did not report Naphthalene). Acenaphthylene and Fluorene were found in virtually all the worker samples, while not in any of the background samples. Phenanthrene was found in most of the samples collected for each worker position except the roller operator, and not in any of the background samples. Anthracene was reported in 13 samples among the paver operator, screedman, and luteman samples. Of the 13 samples in which Anthracene was detected, 10 of the samples were collected while paving with rubber mixes--RBR 1, RBR 2, or RBR 3. Fluoranthene was reported in one paver operator sample (RBR 3--2nd day) and in one screedman sample (RBR 4--1st day). The rest were reported as "Not Detected." Of the detected compounds, only Naphthalene has an exposure level, as follows:

NAPHTHALENE:

NIOSH--10 PPM

OSHA--10 PP*M*

NIOSH--50 mg/m³

OSHA--50 mg/m³

The Naphthalene results were in the ug/m³ range and in the PPB range. Therefore, all of the workers were exposed to levels of Naphthalene significantly below the allowable eight-hour time weighted average concentration.

4.2.1 Problems with the Analytical Procedures Conducted for the PAH Analysis.

NIOSH Method 5506, which was specified by the MDOT Project Specifications, requires that the benzene extract from the filter (from NIOSH Method 5023) be analyzed for PAHs, as well as the extract from the XAD-2 resin in the glass sorbent tube, and uses high pressure liquid chromatography (HPLC) for the analysis. The method clearly stipulates that the filter extract is to be analyzed for PAH separately from the XAD-2 resin extract. The filter extract was not analyzed for PAHs by Data Chem. Their explanation for this omission was that they had originally only quoted for one PAH analysis, that most of their customers have the filter extract combined with the XAD-2 extract for a single analysis. Furthermore, they claim that they went by the Chain-of-Custody sheets which only listed particulate and benzene soluble organics (despite the work-orders which indicated that the PAH analysis was to be performed on the filter extract, and despite the fact that the method calls for analysis of the filter extract). Another problem that occurred was that Data Chem used NIOSH Method 5515 for the analysis, which uses gas chromatography, instead of NIOSH Method 5506. They claim it was because the samples were "dirty" and they routinely use gas chromatography for analysis of "dirty" samples.

4.3 Sampling and Analytical Results for Several Volatile Organic Compounds.

The catch weight results for the volatile organics sampling and analysis are presented in Table Set V. The concentrations as mg/m³ are presented in Table Set VI. The concentrations as PPB are presented in Table Set VII.

Very few of the samples had reported results above the detection limits. In the case of Benzene, there were five samples with reported results above the detection limit of 1 ug/sample--one Paver Operator sample (RBR 3--2nd day), three Screedman samples (RBR 2--1st day, RBR 4--both days), and one Luteman sample (RBR 4--2nd day). In the case of Xylene, there were five samples with reported results above the detection limit of 10 ug/sample--one Paver Operator sample (RBR 3--2nd day), two Screedman samples (RBR 2--1st day, RBR 4--1st day), and two Luteman samples (RBR 1--1st day, RBR 2--1st day). The concentrations for the detected samples ranged from 3.06 PPB to 22.22 PPB for Benzene and from 24.40 PPB to 69.51 PPB for Xylene. The allowable exposure levels for these two compounds are as follows:

BENZENE: NIOSH--100 PPB; OSHA--1,000 PPB XYLENE: NIOSH--100 PP*M*; OSHA--100 PP*M* 435 mg/m³

Styrene was not detected in any of the samples above the detection limit of 10 ug/sample.

4.4 Sampling and Analytical Results for 1,3-Butadiene.

The catch weight results and concentrations in mg/m³ and PPB are provided in Table Set VIII. 1,3-Butadiene was found in one Background sample (RBR 4--1st day) and not in any of the Roller Operator samples. This compound was found in all the RBR 4 samples for all the other worker positions and in a significant number of the various RAP mix samples (in 22 of 35 RAP mix samples collected for all the worker positions combined except the Roller Operator position). 1,3-Butadiene was found in the virgin control mix of the Screedman position and in the virgin rubber mix of the Quality Control Manager.

OSHA has a PEL for 1,3-Butadiene of 1,000 PPM (2,200 mg/m³), while ACGIH has a TLV of 10 PPM (22 mg/m³). NIOSH does not provide an REL for 1,3-Butadiene because it classifies this compound as a carcinogen and, thus, its recommendation is to reduce worker exposure to the "lowest feasible concentration." ACGIH also classifies this compound as a carcinogen. ALL of the sample results for 1,3-Butadiene were significantly less than both the OSHA PEL and the ACGIH TLV--being at the PPB level. In fact, 23 of the 36 samples that reported detected levels of 1,3-Butadiene were at or below 0.1% of the ACGIH TLV and at or below 0.001% of the OSHA PEL.

4.5 Sampling and Analytical Results for Various Nitrosamines Compounds.

The catch weight results for various Nitrosamines compounds are presented in Table Set IX. The concentrations in ug/m^3 are presented in Table Set X, and the concentrations in PPB are provided in Table Set XI.

N-nitrosodimethylamine was detected in one background sample (CTRL 3--1st day) and N-nitrosodibutylamine was detected in one paver operator sample (CTRL 3--2nd day). Other than these two samples, nitrosamine compounds were not detected any of the samples collected and analyzed during the worker exposure sampling. N-nitrosodimethylamine is the only nitrosamine compound which is listed by OSHA, NIOSH, and ACGIH. All three organizations list this compound as a carcinogen and do not provide any exposure levels. However, since this compound was not detected in any of the worker samples, only the background sample, it should not be an issue with respect to worker exposure.

5.0 CONCLUSIONS.

The results of this worker exposure assessment project do not indicate a clear pattern that would suggest that asphalt-rubber binders or crumb rubber mixes increase a paving worker's exposure to hazardous compounds in asphalt fumes. The results also demonstrate that, for all samples and all mixes involved in the project, paving workers' exposures to the compounds looked at are significantly below exposure levels established by two governmental agencies and one nationally recognized voluntary organization.

TABLE 1. WORKER EXPOSURE SAMPLING AND ANALYTICAL PROCEDURES FOR MICHIGAN DEPARTMENT OF TRANSPORTATION'S ASPHALT-RUBBER BINDER STACK TESTING PROJECT

Compound	Analytical Procedure	Method Designation
Total Particulate	Gravimetry	Modified NIOSH Method 0500
Benzene-soluble organics	Benzene extraction followed by gravimetry	NIOSH Method 5023
PAHs (Semi- volatiles)	Benzene extraction, HPLC-fluorescence detector	NIOSH Method 5506
Benzene, Toluene, Ethyl-benzene, Xylene, Styrene	GC/FID	NIOSH Method 1501
1,3-Butadiene	GC/FID	OSHA 56
Nitrosamines (7 species)	GC/TEA	OSHA Method 27

NOTES:

Total Particulate Matter: The sample train shall include a pre-extracted and tared 37 mm silver membrane filter.

Benzene-Soluble Organics: The silver membrane filter used for the Particulate Matter determination shall be used for this procedure.

PAHs (semi-volatiles): The sample train shall include a pre-extracted and tared 37 mm silver membrane filter, followed by a glass tube containing 400 mg of XAD-2 resin separated from 200 mg of XAD-2 resin with glass wool. The glass tube shall be situated in the sample train such that the gas stream will pass through the 400 mg of XAD-2 resin first, then through the 200 mg of XAD-2 resin AFTER passing through the particulate filter cartridge.

TABLE 2. LIST OF FIELD BLANKS--SAMPLE NUMBERS AND LOCATION FOR EACH DAY OF WORKER EXPOSURE SAMPLING

			NAV 10		חלקד סב		NIV IS
MOLTATION	SAMPI ING	COMPOUND	SAMPLE NO.	LOCATION	SAMPLING	COMPOUND	SAMPLE NO.
Paving Site	16-Sep-93	1,3-Butadiene	091693-B1	HMA Facility	16-Sep-93	1,3-Butadiene	091693-B2
0	-	втех	091693-A1			втех	091693-A2
١		Particulate/BSO Filter	091693-C1			Particulate/BSO Filter	ŀ
		PAHsXAD-2 resin	091693-C2			PAHsXAD-2 resin	091693-C3
		Nitrosamines	E55808			Nitrosamines	:
Daving Site	17-Sep-93	1,3-Butadiene	091793-C+D	HMA Facility	18-Sep-93	1,3-Butadiene	091893-C+D
))		BTEX	091793-A+B	×1301-10		BTEX	091893-A+B
		Particulate/BSO Filter	091793-E+F		-	Particulate/BSO Filter	091893-E+F
		PAHsXAD-2 resin	ţ			PAHsXAD-2 resin	ı
		Nitrosamines	E55923+E55884			Nitrosamines	E55931+E55932
Daving Site	20-Sep-93	1.3-Butadiene	092093-C+D	HMA Facility	21-Sep-93	1,3-Butadiene	092193-C+D
		BTEX	092093-A+B			втех	092193-A+B
		Particulate/BSO Filter	092093-E+F			Particulate/BSO Filter	092193-E+F
		PAHsXAD-2 resin	;			PAHsXAD-2 resin	1
		Nitrosamines	E55795			Nitrosamines	E55797
HMA Facility	22-Sep-93	1,3-Butadiene BTEX	092293-C+D 092293-A+B	Paving Site	23-Sep-93	1,3-Butadiene BTEX	092393-C+D 092393-A+B
		Particulate/BSO Filter	092293-E+F			Particulate/BSO Filter	092393-E+F
		PAHsXAD-2 resin	1			PAHsXAD-2 resin	
		Nitrosamines	:				20400
Paving Site	24-Sep-93	1,3-Butadiene	092493-C+D 092493-A+B	HMA Facility	25-Sep-93	1,3-Butadiene BTEX	092593-C+D 092593-A+B
		Particulate/BSO Filter	092493-E+F			Particulate/BSO Filter	092593-E+F
		PAHsXAD-2 resin	!			PAHsXAD-2 resin	1
		Nitrosamines	E56400+E56401			Nitrosamines	E56431+E56432
Paving Site	28-Sep-93	1,3-Butadiene	092893-C+D	HMA Facility	29-Sep-93	1,3-Butadiene	092993-C+D
)	•	втех	092893-A+B	on the second of the		втех	092993-A+B
		Particulate/BSO Filter	092893-E+F			Particulate/BSO Filter	092993-E+F
y		PAHsXAD-2 resin	1			PAHsXAD-2 resin	
· ·		Nitrosamines	E56420			Nitrosamines	E56416
Daving Site	01-Oct-93	1.3-Butadiene	093093-C+D	HMA Facility	04-Oct-93	1,3-Butadiene	100493-C+D
	•	BTEX	093093-A+B			втех	100493-A+B
		Particulate/BSO Filter	093093-E+F			Particulate/BSO Filter	100493-E+F
		PAHsXAD-2 resin	1 6	. •		PAHsXAD-2 resin	
		Nitrosamines	E56801			Millosamines	E30302

Table Set I Particulate Matter and Benzene Soluble Organics Worker Exposure Results

Catch Weight Results as ug/sample Results as mg/m³

TABLE SET 1.

PARTICULATE MATTER AND BENZENE SOLUBLE ORGANIC FRACTION SAMPLING AND ANALYTICAL RESULTS

(Units: ug/sample and mg/m³)

Mix	Sampling	Sample	Sample	Particulate	Benz. Sol Org	Particulate	Benz Sol Or
Туре	Date	Number	Volume	Вn	ng	mg/m3	mg/m3
Detection	Detection Limits >>		Liters		900		900000
CTRL 1	16-Sep-93	23 B	804.1	009	QN	0 746	
CTRL 2	17-Sep-93	24 B	0.999	40	2	0.060	
CTRL 2	18-Sep-93	24 B	836.9	60	8	0.060	
CTRL 3	20-Sep-93	24 B	698.4	30	QN	0.043	
CTRL 3	21-Sep-93	24 B	595.6	50	150	0.084	0.252
RBR 1	22-Sep-93	24 B	8.418	20	09	0.025	0.061
RBR 1	23-Sep-93	24 B	779.9	10	180	0.013	0.231
RBR 2	24-Sep-93	24 B	883.1	30	QN	0.034	
RBR 2	25-Sep-93	24 B	887.0	70	650	0.079	0.733
RBR 3	28-Sep-93	24 B	766.4	30	ND	0.039	
RBR 3	29-Sep-93	24 B	828.8	20	50	0.024	0.060
RBR 4	01-Oct-93	24 B	949.7	20	10	0.021	0.011
RBR 4	04-Oct-93	24 B	760.5	30	100	0.039	0.131
NOTE: Shade	NOTE: Shaded rows indicate mixes with	nixes with		Blanks indicate c	Blanks indicate compound not detected in sample	cted in sample.	

Background Sample

171	
CIE. Siladed IOMS IIIGICATA IIIKAS WIII	100% virain aggregates.
2000	100%
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Daver Operator

ate Benz. Sol. Org.	0.00006		0.059	5 1.154	1 0.507	0.095	6.	7 0.097	090'0	3 0.149	090'0	0.210	-ejau
Particulate mg/m3		0.159	0.014	0.115	0.184	0.071	0.192	0.207	0.036	0.298	0.108	0.168	ected in sen
Benz. Sol. Org. Ug	0.05	QN	ON 20	700	330	08 08	QN	80	50	130	- 20	150	Blanks indicate compound not detected in semple
Particulate ug		130	10 90	70	120	09 09	170	170	30	260	06	120	Blanks indicate c
Sample Volume	Liters	816.4	699.1 844.2	606.4	651.0	9'99 <i>1</i> 1'99'	884.6	820.6	831.6	871.2	831.6	712.8	
Sample Number		8.8	4B 4B	4 B	4 B	8 7	4 B	4 B	4 B	4 B	0	48	nixes with
Sampling Date	Detection Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93	04-Oct-93	JOTE: Shaded rows indicate mixes with
Mix	Detection	CTRL 1	CTRL 2 CTRL 2	CTRL 3	CTRL 3	RBR 1 RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4	RBR 4	IOTE: Shadec

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Benz. Sol. Org. mg/m3 0.00006

Particulate mg/m3

Benz. Sol. Org.

Particulate

Sample

Sample

Sampling

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0.05 2 22 Page 18

(continued)

Table Set I.

0.099

0.234

88

0.056

0.078

გ 2

8 S 140 2 2 5 8 8 6 8 5 70 270 g Volume 807.5 888.5 634.8 661.5 872.9 811.2 773.8 Liters 789.1 806.0 913.5 894.4 825.8 Number 20 B 20 B 20 B 20 B 22 20 20 20 20 B 20 B 20 B 20 B 20 B 20 B 4 B 17-Sep-93 18-Sep-93 22-Sep-93 23-Sep-93 24-Sep-93 25-Sep-93 20-Sep-93 16-Sep-93 21-Sep-93 28-Sep-93 29-Sep-93 01-Oct-93 04-Oct-93 Detection Limits >> Date RBR 1 RBR 1 CTRL 2 CTRL 3 CTRL 3 CTRL 1 RBR 4 RBR 2 RBR 2 RBR 3 RBR 3 RBR 4 Type

0.113

0.090

8 2

0.149

9 9

0.151

0.121

윤원

0.087 0.012 0.158

> NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Blanks indicate compound not detected in sample

Screedman

Mix	Sampling	Sample	Sample	Particulate	Benz. Sol. Org.	Particulate	Benz. Sol. Org.
Type	Date	Number	Volume	бn	Ď	mg/m3	mg/m3
Detection	Detection Limits >>		Liters		0.05		0.00006
CTRL 1	16-Sep-93	16 B	790.0	06	QN	0.114	
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	8 8 8	673.2 813.5	260 170	130 ND	0.386	0.193
CTRL 3	20-Sep-93	12 B	647.5	110	200	0.170	0.309
CTRL 3	21-Sep-93	12B	668.5	100	300	0.150	0.449
RBR 1	22-Sep-93 23-Sep-93	12 B 12 B	880.5 752.6	08 08	400	0.091	0.464
RBR 2	24-Sep-93	12 B	853.6	190	QN	0.223	
RBR 2	25-Sep-93	12 B	842.0	90	ND	0.107	
RBR 3	28-Sep-93	12 B	756.6	400	400	0.529	0.529
RBR 3	29-Sep-93	12B	938.8	480	330	0.511	0.351
RBR 4	01-0:1-93		964.3	250	150	0.259	0.156
707 4	04-Oct-93	12.6	705.6	650	500	0.921	0.709
NOTE: Shade	NOTE: Shaded rows indicate mixes with	nixes with	i i	Blanks indicate c	Blanks indicate compound not detected in sample.	ected in sample.	

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Table Set I.

(continued)

	shoot in comete	Dionic is between the particular of solitor of solitors	Blonks indicate		nivoe with	NOTE: Shaded rows indicate mixes with	NOTE: Shade
0.211	0.240	160	170	709.8	168	04-Oct-93	RBR 4
200 000 0000000000000000000000000000000	CANAL TO SELECTION			0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			
0.140	0.313	130	290	926.3	16 B	29-Sep-93	RBR 3
0.065	0.142	50	110	774.2	16 B	28-Sep-93	RBR 3
:	0.136	ND	110	811.3	16 B	25-Sep-93	RBR 2
	0.244	QΝ	200	818.9	16 B	24-Sep-93	RBR 2
1.347	0.067	1000	50	742.1	16 B	23-Sep-93	RBR 1
0.012	960.0	- 10	80	829.8	9	22-Sep-93	8 8 7
0.125	0.219	80	140	638.5	16 B	21-Sep-93	CTRL 3
0.152	0.061	100	40	659.6	16 B	20-Sep-93	CTRL 3
	0.149	2	120	804.1	16 B	18-Sep-93	CTRL 2
	0.227	2	160	705.6	128	17-Sep-93	CTRL 2
	0.138	QN	110	794.8	12 B	16-Sep-93	CTRL 1
900000		0.05		Liters		Detection Limits >>	Detection
mg/m3	mg/m3	В'n	б'n	Volume	Number	Date	Type
Benz. Sol. Org.	Particulate	Benz. Sol. Org.	Particulate	Sample	Sample	Sampling	Mix

haded rows indicate mixes with 100% virgin aggregates.

		V												
Benz. Sol. Org.	mg/m3	0.00006	0.060		0.202		0.115				0.102	0.151	0.205	: :
Particulate	mg/m3		0.226	0.228	0.155	090.0	0,231 0.065	0.104	0.104	0.052	0.327	0.101	0.178	acted in sample.
Benz. Sol. Org.	ōn	0.05	50	an an	130	Q.	100 80	QN	ND	QN	100	150	180	Blanks indicate compound not detected in sample
Particulate	ân		190	110 180	100	40	200 50	06	90	40	320	100	130	Blanks indicate c
Sample	Volume	Liters	838.9	482.2 784.4	644.1	669.3	867.2 766.3	865.7	861.7	771.6	979.7	993.8	130.6	
Sample	Number		20 B	16 B 12 B	8.8	8 B	8 B 8 B	8 B	8 B	88	8 B	ш с ⇔ •		nixes with tes.
Sampling	Date	Detection Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93	U4-OCE-34	NOTE: Shaded rows indicate mixes with 100% virgin aggregates.
Mix	Type	Detection	CTRL 1	CTRL 2 CTRL 2	CTRL 3	CTRL 3	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	A S C	KBK 4	NOTE: Shaded

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Table Set I. (continued)

	Cuality	Quality Control Manager	Manage				
Mix	Sampling	Sample	Sample	Particulate	Benz. Sol. Org.	Particulate	Benz. Sol. Org.
Type	Date	Number	Volume	fin	g	mg/m3	mg/m3
Detection	Detection Limits >>		Liters		0.05		0.00006
CTRL 1	16-Sep-93	25 B	807.5	70	QN	0.087	
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	28 B 28 B	675.1 737.3	90 120	22	0.133 0.163	
CTRL 3	20-Sep-93	28 B	716.4	140	Q	0.195	
CTRL 3	21-Sep-93	28 B	722.4	220	90	0.305	0.138
RBR 1 RBR 1	22-Sep-93 23-Sep-93	28 B 28 B	806.0 777.4	100 170	00*	0.124	0.099
RBR 2	24-Sep-93	28 B	846.1	210	12250	0.248	14,478
RBR 2	25-Sep-93	28 B	825.1	420	80	0.509	0.097
RBR 3	28-Sep-93	28 B	7.457	230	QΝ	0.305	
RBR 3	29-Sep-93	28 B	935.1	170	50	0.182	0.053
RBR 4	01-Oct-93	28 B	954.5	180	150	0.189	0.157
RBR 4	04-Oct-93	28 B	931.2	190	150	0.204	0.161
TE: Shade	NOTE: Shaded rows indicate mixes with	mixes with		Blanks indicate c	Blanks indicate compound not detected in sample.	ected in sample.	

100% virgin aggregates.

Table Set II Polynuclear Aromatic Hydrocarbon Worker Exposure Results

Results as ug/sample

TABLE SET II.

POLYNUCLEAR AROMATIC HYDROCARBON SAMPLING AND ANALYTICAL RESULTS

(Units: ug/sample)

	SOLINE C	Serente of the serente bet	ne							
Mix	Sampling	Sample	Sample	Naphthalene	Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
Туре	Date	Number	Volume	бn	бn	δ'n	бn	Бn	δn	бn
Detection	Detection Limits >>		Liters	0.5	0.5	0.5	0.5	0.5	0.5	5.0
CTRL 1	16-Sep-93	23 B	804.1			4.8				
CTRL 2	17-Sep-93	24 B	666.0			3.3				
CTRL 2	18-Sep-93	24 B	838.9	0.6		8.9				
CTRL 3	20-Sep-93	24B	698.4	9.0		2.3				
CTRL 3	21-Sep-93	24 B	595.6			3.6				
RBR 1	22-Sep-93 23-Sep-93	24 B 24 B	814.8			6.9				
RBR 2	24-Sep-93	24 B	883.1			4.7				
RBR 2	25-Sep-93	24 B	887.0			6:1			•	
RBR 3	28-Sep-93	24 B	766.4			9:1				
RBR 3	29-Sep-93	24 B	828.8			1.9				
RBR 4	01-Oct-93	248	949.7	-		2.3				
RBR 4	04-Oct-93	24 B	760.5	0.5		2.1				
NOTE: Shade	NOTE: Shaded rows indicate mixes with	mixes with		Blanks indicate	Blanks indicate compound not detected in sample	detected in sem	ple.			

Blanks indicate compou	
haded rows indicate mixes with	100% virgin aggregates.

	うるので									
Mix	Sampling	Sample	Sample	Naphthalene	Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
Туре	Date	Number	Volume	бn	fn	бn	Вn	ng	ng	бn
Detection	Detection Limits >>		Liters	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CTRL 1	16-Sep-93	88	816.4	4.2	2.0	7.7	4.3	0.0		
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	4 4 00 03	699.1 844.2	3.4	3.3	16.0 5.0	7.4	0.8		
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	4 B B	606.4 651.0	4.6	2.7	12.0 6.0	3.9	8.0 7.0		-
RBR 1		8 9	844.4 756.6	1.9	1.3	4.1	2.7	0.8	9.0	
RBR 2 RBR 2	24-Sep-93 25-Sep-93	4 4 8 8	884.6 820.6	12.0 9.2	6.7	12.0 27.0	8.6 17.0	2.6	1.0	·
RBR 3 RBR 3	28-Sep-93 29-Sep-93	4 B 8 B	831.6 871.2	1.5 9.3	1.3 7.7	4.0	2.2 15.0	1.1		0.5
RBR 4	01-Oct-93 04-Oct-93	4 4 0 0	831.6 712.8	2.3	2.2	6.3	4.2			

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Blanks indicate compound not detected in sample.

Table Set II. (continued)

	Roller Operator	perator					•			
Mix	Sampling	Sample	Sample	Naphthalene	Naphthalene Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Ī
Туре	Date	Number	Volume	ug	Вn	ğ	бn	5n	5	
Detection	Detection Limits >>		Liters	9.0	9.0	0.5	0.5	0.5	0.5	
CTRL 1	16-Sep-93	4 B	789.1	0.7		3.0	0.7			l
주 고 교	17-Sep-93	208	807.5		•	3.0	1.0			1979
C LOT	20 55 05	2 (2.420	**	0.7	ī.	2.			
CTRLS	24-Sep-93	208	5.4.8 6.4.8		1	4, 4 W. C	9.0			
	21-3ch-33	20.5	C. 100	S.	/:0	4.2	1.5			
787	22-Sep-93	8	888.5			4.6	1.1			
RBR 1	23-Sep-93	20 B	806.0	1.0	6:0	7.4	22			
RBR 2	24-Sep-93	20 B	872.9	4.5	2.2	12.0	4.5			l
RBR 2	25-Sep-93	20 B	913.5	1.7	1.3	5.6	3.3			
RBR 3	28-Sep-93	20 B	894.4	1.5	6.0	4.4	16			
RBR 3	29-Sep-93	20 B	825.8	3.6	1.3	3.5	2.0			
RBR 4	01-Oct-93	Z0 B	811.2	1.1	7:0	5.9	1.7			
RBR 4	04-Oct-93	20 B	773.8	83 83	9.0		6.0		1000 1000 1000 1000 1000 1000 1000 100	
NOTE: Shade	NOTE: Shaded rows indicate mixes with	nixes with		Blanks indicate	Blanks indicate compound not detected in sample	fetected in sam	ole.			1

100% virgin aggragates.

	screedman.									
Mix	Sampling	Sample	Sample	Naphthalene	Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Finoranthene
Type	Date	Number	Volume	nd	Б'n	ອີກ	ßn	67	bn	οn
Detection	Detection Limits >>		Liters	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CTRL 1	16-Sep-93	16 B	790.0	3.3	1.6	8.9	3.2	9.0		
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	& & B B	673.2 813.5	3. 8. 8. 8.	8.1 3.8	23.0 13.0	14.0 8.6	8.0	**	
CTRL 3	20-Sep-93	128	647.5	3.8	2.4	7.3	4.2	0.7		
CIRLS	21-Sep-93	12 B	668.5	3./	2.4	10.0	5.1	6.0		inima.
RBR 1 RBR 1	22-Sep-93 23-Sep-93	2 2 8 8	880.5	3.4	1.7 3.0	8.0	8.00 0.00	9.0 0.9	20	
RBR 2	24-Sep-93	12 B	853.6	20.0	11.0	26.0	15.0	3.2	1.5	
RBR 2	25-Sep-93	12B	842.0	3.1	2.8	9.1	6.7		1.0	
RBR 3	28-Sep-93	12 B	756.6	7.8	6.2	22.0	14.0	1.7	0.8	
RBR 3	29-Sep-93	12 B	938.8	8.5	7.0	23.0	14.0	2.0		
RBR 4	01-Oct-93	12B	964.3	6.5	9'.	27.0	18.0	2.6		0.5
RBR 4	04-Oct-93	12 B	705.6	6.8	7.1	20.0	15.0	4.		
IOTE: Shaded rows indi		sate mixes with		Blanks indicate	Blanks indicate compound not detected in sample.	detected in sam	ple.			

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Table Set II. (continued)

	Fluoranthene	bn	0.5											X
	Anthracene		0.5				9.0	3.0	0.8					
	Phenanthrene	бn	0.5	9.0	0.7		1:1	1.0				6.0	9.0	
	Fluorene	бn	0.5	2.6	9.1	3.0	7.3	8.0	15.0	5.1	3.7	6.7	7.7	1
	Acenaphthene	Бn	0.5	5.1	22.0 11.0	8.2	14.0	18.0	28.0	9.7	7.0	14.0	13.0	defected in sem
	Acenaphthylene Acenaphthene	ng	0.5	1.2	8.2	1.6	3.6	4.0	9.9	2.2	2.2	3.9	3.5	Blanks indicate compound not detected in sample
	Naphthalene	Вn	6.0	2.6	6.6	2.9	4.9	5.7 5.8		2.6	3.1	6.9	3.8	Blanks indicate
	Sample	Volume	Liters	794.8	705.6 804.1	659.6	638.5	829.8 742.1	818.9	811.3	774.2	926.3	941.9 709.8	
	Sample	Number		12B	12 B 16 B	16 B	16 B	16 B	16 B	16 B	16 B	16 B	16 B	nixes with
Luteman	Sampling	Date	Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93 04-Oct-93	rows indicate r
	Mix	Туре	Detection Limits >>	CTRL 1	CTRL 2 CTRL 2	CTRL 3	CTRL 3	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	88 8 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	NOTE: Shaded rows indicate mixes with

naded rows indicate mixe 100% virgin aggregates.

	و		<u> </u>		335000	Ī		Uilleania		·			Magazia.	1
	Fluoranthene	В'n	0.5											
	Anthracene	В'n	0.5											
	Phenanthrene	δn	0.5	0.8	9,0	0.7		9.0	9.0			6.0	9.0	
	Fluorene	В'n	0.5	3.4	2.1	3.7	1.7	2.1	4.0	3.8	1.3	5.6	10 ₹=	ple.
	Acenaphthene	ug	0.5	6.3	7.5	10.0	4.6	8.6	11.0	0.6	4.1	11.0	11.0	detected in sam
	Acenaphthylene Acenaphthene	ρū	0.5	1.4	1.1	2.2	9.0	1.2	2.1	1.7	8.0	3.0	2.5	compound not (
	Naphthalene	δ'n	0.5	3.0	1.3	3.1	1.2	4.6:	2.8	1.7	1.0	4.5	3.0	Blanks indicate compound not detected in sample.
	Sample	Volume	Liters	838.9	482.2 784.4	644.1	669.3	867.2 766.3	865.7	861.7	771.6	979.7	993.8 730.8	
	Sample	Number		20 B	16 B 12 B	8 B	8 B	8 B 8 B	8.8	8 B	8 B	88	88 88	nixes with fes.
Laborer	Sampling	Date	Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93 04-Oct-93	naded rows indicate mixe 100% virgin aggregates.
	Mix	Type	Detection Limits >:	CTRL 1	CTRL 2 CTRL 2	CTRL 3	CTRL 3	RBR 1 RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4 RBR 4	NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

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Table Set II. (continued)

	Fluoranthene	bn	0.5											
	E		_	L				777717						
	Anthracene	_	0.5				,							
	Phenanthrene	őn	0.5									0.7		
	Fluorene	бn	0.5	1.3	1.0	0 7	o. 7:	4.5	1.9	2.2	1.9	1.7	1.1	ple.
	Acenaphthene	бn	0.5	2.3	7.2	8 U	7.8	2.3	11.0	3.5	7.7	14.0	10.0	detected in sam
	Naphthalene Acenaphthylene Acenaphthene	Ď	0.5			8.0	0.0	9.0	0.8	6.0	6.0	0.7	0.5	Blanks indicate compound not detected in sample.
	Naphthalene	Бn	0.5	8.3	•	A 7	5.3	8. E.	3.4	16.0	3.7	5.7	3.2	Blanks indicate
Mamag	Sample	Volume	Liters	807.5	675.1	716.4	722.4	806.0	846.1	825.1	7.457	935.1	954.5 931.2	
Quality Control Manage	Sample	Number		25 B	28 8 8 8 8	28.0	78 B	28 B 28 B	28 B	28 B	28 B	28 B	28 B 28 B	mixes with
Cuality	Sampling	Date	Detection Limits >>	16-Sep-93	17-Sep-93	20-Sen-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93 04-Oct-93	trows indicate
	Mix	Туре	Detection	CTRL 1	CTRL 2	CTRI 3	CTRL 3	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4	NOTE: Shaded rows indicate mixes with

Table Set III Polynuclear Aromatic Hydrocarbon Worker Exposure Results

Concentrations as mg/m^3

Background Sample

TABLE SET III.

POLYNUCLEAR AROMATIC HYDROCARBON SAMPLING AND ANALYTICAL RESULTS

(Units: mg/m³)

¥ ¥	Sampling	Sample	Sample		Naphthalene Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
2	200	TARRIED ST	AOIMING	(ING/III)	mg/ms	ന്മ്യന്താ	mg/m3	mg/m3	mg/m3	mg/m3
etection	Detection Limits >>		Liters	9000.0	9000.0	0.0006	9000.0	90000	9000.0	90000
CTRL 1	16-Sep-93	23 B	804.1			09000				
2 78 5	17-649-93	878	0.880			0.0060				
CIRL 2	16-Sep-83	248	836.8	90000		80100				
CTRL 3	20-Sep-93	24 B	698.4	0.0011		0.0033				
CTRL 3	21-Sep-93	24 B	585.6			0.0060				
RBR1	22.8ap.83	248	814.8			27000				
RBR 1	23-Bep-65	248	8.822			0.0022				
RBR 2	24-Sep-93	24 B	883.1			0.0053				
RBR 2	25-Sep-93	24 B	887.0			0.0021				ood day,
RBR 3	28-Sep-93	24 B	766.4			0.0021				
RBR 3	29-Sep-93	24 B	828.8			0.0023			**************************************	
RBK 4	81-Oct-93	248	2.075			12000				
RBR 4	04-Oct-93	248	780.8	0.0007		0.0028				
Shaded	NOTE: Shaded rows indicate mixes with	nixes with		Blanks indicate	Blanks indicate compound not detected in sample.	detected in sam	ole.			

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CIONS INCIDED HIXOS WILL	X virgin economicales
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<u>≭</u>	Sampling	Sample	Sample	Naphthalene	Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
Туре	Date	Number	Volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3
Detection	Detection Limits >>		Liters	9000.0	0.0006	900000	9000'0	9000:0	9000'0	9000.0
CTRL 1	16-Sep-93	88	816.4	0.0051	0.0024	0.0094	0.0053	0.0011		
CTRL 2	17.Sep.83	8)	1.888	6700'0	2,000	82300	0.0106	11000	0.0016	
CTRL 2	18-Sep-83	48	544.2	0.0028	0.0018	9500.0	0.0038			
CTRL 3	20-Sep-93	4 B	606.4	0.0076	0.0045	0.0198	0.0078	0.0013		
CTRL 3	21-Sep-93	4 B	651.0	0.0049	0.0029	0.0092	0900.0	0.0011		
RBR 1	22-Sep-83	80	846.6	0.0023	8100.0	89000	2600.0			
RBR1	22-Sep-91	00	198.6	0.0042	1+000	0.0159	0.0085	0.0011	0.0008	
RBR 2	24-Sep-93	4 8	884.6	0.0136	0.0076	0.0136	0.0097	0.0029	0.0011	
RBR 2	25-Sep-93	48	820.6	0.0112	0.0088	0.0329	0.0207		0.0028	
RBR 3	28-Sep-93	4 B	831.6	0.0018	0.0016	0.0048	0.0026			
RBR 3	29-Sep-93	48	871.2	0.0107	0.0088	0.0275	0.0172	0.0013		0.0006
RBR4	01-Oct-83	8	621.5	0,0028	0.0028	0,0078	1500.0			
RBR	Serection 5	6	712.8	0.0021	0.0020	0.0104	0.0032			
NOTE: Shadex	NOTE: Shaded rows indicate mixes with	nixes with		Blanks indicate	Blanks indicate compound not detected in sample.	defected in sam	ple.			
		S								

CTRL 1 = 85/100 PEN AC, 30% RAP ₩ CTRL 2 = No RBR, No RAP ₩ CTRL 3 = No RBR, 20% RAP

Table Set III. ····· (continued)

	Roller Operator	perator.								
X E	Sampling	Sample	Sample	CONTRACTOR OF THE PARTY.	Naphthalene Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fliorentheo
Type	Date	Number	Volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	ma/m3	ma/m3
Detection	Detection Limits >>		Liters	9000.0	9000.0	9000.0	90000	90000	0 0006	9000
CTRL 1	16-Sep-93	48	789.1	0.0009		0.0038	0 000	NATIONAL PROPERTY.		2000
CTRL 2	30,000,00	8								
CTRL 2	18-845-43	8		21000	0,000	0.0073	Y ()			
CTRL 3	20-Sep-93	20 B	634.8			0.0068	0000			
CTRL 3	21-Sep-93	20 B	661.5	0.0029	0.0011	0.0063	0.0023		- Constant	
RBR	22.586.62	802	2 600			0.0000	0.000			
RBRI	23-Sep-03	802	0.909	0.0012	11000	0.000	20000			
RBR 2	24-Sep-93	208	872.9	0.0052	0.0025	0.0137	0.0052			
RBR 2	25-Sep-93	20 B	913.5	0.0019	0.0014	0.0061	0.0036			
RBR 3	28-Sep-93	20 B	894.4	0.0017	0.0010	0.0049	0 0018			
RBR 3	29-Sep-93	20 B	825.8	0.0044	0.0016	0.0042	0.0024			
RBR	01-05-93	807	2343	11000	90000	0.0073	16000			
RBR4	04-0-43	208	773.8	0.0045	90000	0,0040	0,0012			
NOTE: Shaden	NOTE: Shaded rows indicate mixes with	nixes with		Blanks Indicate	Blanks Indicate compound not detected in sample.	Selected in samp	ple.			

100% virgin aggregates.

Z.	Sampling	Sample	Sample	Naphthalene	Naphthalene Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
Туре	Darte	Number	Volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3
Detection Limits	n Limits >>		Liters	0.0006	9000.0	0.0006	9000'0	9000.0	90000	0.0006
CTRL 1	16-Sep-93	16 B	790.0	0.0042	0.0020	0.0086	0.0041	0.0010		
CTRL 2	17-Sep-93	88	673.2	98000	0.0091	2000	0.0208		2,000.0	
CTRL 2	18-Sep-#1	88	613.6	0.0059	0.0047	0.010.0	80100	0.000		
CTRL 3	20-Sep-93	12 B	647.5	0.0059	0.0037	0.0113	0.0065	0.0011		
CTRL 3	21-Sep-93	12B	668.5	0.0055	0.0036	0.0150	0.0076	0.0013		
RBR 1	22-Bern-83	12.8	97098	7000 B	81000	0.0091	5,00,0	0.0007		
RBR 1	23-83-0-82 23-83-0-82	42.8	9 2 3	0.0045	0.0040	00186	0.0088	0.0012	80000	
RBR 2	24-Sep-93	12 B	853.6	0.0234	0.0129	0.0305	0.0176	0.0037	0.0018	
RBR 2	25-Sep-93	12 B	842.0	0.0037	0.0033	0.0108	0.0080		0.0012	
RBR 3	28-Sep-93	12 B	9.952	0.0103	0.0082	0.0291	0.0185	0.0022	0.0011	
RBR 3	29-Sep-93	12B	938.8	0.0091	0.0075	0.0245	0.0149	0.0021		
	01-Oct-83	12.8	2.996	0.0087	0.0078	0.0280	0.0187	0.0027		0.000
RBR4	04.00(168)	12.8	708.6	0.0096	0,0101	0.0283	0.0213	0.0020		
NOTE: Shaded rows ind	d rows indicate n	scate mixes with		Blanks indicate	Blanks indicate compound not detected in semple.	fetected in sem	ple.			
8	<i>ාගන හැඳුන අතු</i> දුක්තුය(මෙන	9				٠				

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Table Set III. (continued)

Fluoranthen mg/m3 0.0006 0,000 Anthracene mg/m3 0.0010 0.0006 0,003 0.000 Phenanthrene mg/m3 0.0000 8,00.0 0.0006 0.0008 0.0012 0.0010 0.0017 9000 92300 0.0087 0.0131 0.0006 0.0033 0.0045 0.0114 88000 0.0183 0.0048 mg/m3 0.0072 0.0063 0.0258 0.0312 0.0100 0.0006 0.0064 0.0137 0.0124 0.0219 50217 0.0342 0.0120 0.0090 mg/m3 8000 Acenaphthylen 0,0059 8 0,0068 0.0015 mg/m3 0.0006 0.0024 8700'0 0.0028 0.0037 0.0081 0.0027 0.0040 Naphthalene mg/m3 16000 0.0006 0.0033 0.0044 8888 3 8700.0 0.0032 0.0040 0.0074 Sample Volume 659.6 638.5 Liters 794.8 811.3 818.9 774.2 926.3 Š 742.4 Sample Number 12 B 2 2 2 2 3 3 8 B 16 B 16 B 16 B 16 B 16 B 16 B NOTE: Shaded rows indicate mixes with Luteman 17-Sep-92 CO-CO-CO Sampling 22.Sep. 83 01-00-82 20-Sep-93 24-Sep-93 28-Sep-93 16-Sep-93 21-Sep-93 22-5ep-83 25-Sep-93 29-Sep-93 18 Cast 21 Date Detection Limits >> RBR4 RBR (CIRL 2 CIRC. CTRL 3 RBR 1 RBR 1 CTRL 1 CTRL 3 RBR 2 RBR 2 RBR 3 RBR 3 Mix Type

Blanks Indicate compound not detected in sample.

100% virgin aggragates.

Laborer

Fluoranthene mg/m3	90000													
 	-													
• Anthracene mg/m3	0.0006								**************************************					
Phenanthrene mg/m3	0.0006	0.0010		0.0008	0.0011		80000	0.0007			0.0009	0.0008		
Fluorene mg/m3	90000	0.0041	0.0044	0.0084	0.0057	0.0025	8900 0 0 0058	0.0046	0.0044	0.0017	0.0057	0.0055	90000	s)C.
Acenaphthene mg/m3	0.0006	0.0075	0.0156	0.0102	0.0155	0.0069	0.0157	0.0127	0.0104	0.0053	0.0112	0.0111	0.0000	defected in sam
Acenaphthylene Acenaphthene mg/m3	0.0006	0.0017	0.0023	0.0025	0.0034	0.0012	0.0027	0.0024	0.0020	0.0010	0.0031	0.0025	0.00	compound not
Naphthalene mg/m3	9000:0	0.0036	22000	0.0031	0.0048	0.0018	0.0016	0.0032	0.0020	0.0013	0.0046	0.0030	0.0018	Blanks indicate compound not detected in semple
Sample Volume	Liters	838.9	2.207	786.6	644.1	669.3	587.2 786.3	865.7	861.7	771.6	979.7	9889	330.6	
Sample Number		20 B	891	12.8	8 B	8 B	88	89 BB	8.8	88	8 B	88	88	te mixes with
Sampling Date	Limits >>	16-Sep-93	17-Sep-63	18-Sep-83	20-Sep-93	21-Sep-93	22 Sep-83 22-Sep-83	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01.00.63	28-100-90	
Mix Type	Detection Limits >>	CTRL 1	CTRL 2	OTRL 2	CTRL.3	CTRL 3	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR4	RBRA	NOTE: Shaded rows indice

NOTE: Sheded rows indicate mixes with 100% virgin aggregates.

Table Set III.

(continued)

	Cuality	Quality Control Manager	9							
Type	Sampling Date	Sample Number	Sample Volume	Naphthalene mg/m3	Naphthalene Acenaphthylene Acenaphthene mg/m3 mg/m3 mg/m3	Acenaphthene mg/m3	Fluorene mg/m3	Phenanthrene mg/m3	Anthracene mor/m3.	Fluoranthene
Detection	Detection Limits >>		Liters	9000.0	9000.0	90000	9000.0	90000	90000	90000
CTRL 1	16-Sep-93	25 B	807.5	0.0103		0.0028	0.0016			
CIRL 2	17-Sep-92 18-Sep-93	258	237.3	0.0058		0.0107	0.0016			
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	28 B 28 B	716.4 722.4	0.0066 0.0073	0.0011	0.0092 0.0108	0.0025			
RBR 1		288	808.0 777.4	0.0048 0.0042	0.0007	0.0050	0,0030			
RBR 2 RBR 2	24-Sep-93 25-Sep-93	28 B 28 B	846.1 825.1	0.0040	0.0009	0.0130	0.0022			
RBR 3 RBR 3	28-Sep-93 29-Sep-93	28 B 28 B	754.7 935.1	0.0049	0.0012	0.0102	0.0025	0.0007		
RBR 4 RBR 4	01-Dec-93 04-Dec-93	28 B 28 B	57128 82128	0.008	90000	00106	0.0012			
TE: Shade	NOTE: Shaded rows indicate mixe.	S K	1	Sienks indicate	Blenks indicate compound not detected in sample	efected in sam	ole.			

Table Set IV Polynuclear Aromatic Hydrocarbons Worker Exposure Results

Concentrations as PPB

TABLE SET IV.

POLYNUCLEAR AROMATIC HYDROCARBON SAMPLING AND ANALYTICAL RESULTS

(Units: PPB)

04-Oct-93 24 B 760.6 0.123	PPB 0 075	Anthracene P P B 0 085	Phenanthrene PPB 0 085	PPB 0 092	Acenaphthene PPB 0 099 0 0931 1.659 0.514 0.943 0.340 0.336 0.358 0.358 0.378 0.431	PPB 0 100	O.119 0.112 0.215 0.215 0.123	Sample Volume Liters 804.1 666.0 836.9 698.4 595.6 814.8 779.9 883.1 887.0 766.4 828.8	24 B	Sampling Date Limits >> 16-Sep-93 17-Sep-93 20-Sep-93 21-Sep-93 22-Sep-93	Mix Type Detection CTRL 1 CTRL 2 CTRL 2 CTRL 3 CTRL 4 RBR 1 RBR 2 RBR 2 RBR 2 RBR 2 RBR 3 RBR 3 RBR 3 RBR 3 RBR 4 RBR 4 RBR 4
				ple.	detected in sam	Blanks indicate compound not detected in sample.	Blanks indicate		mixes with tes.	NOTE: Shaded rows indicate mixes with 100% virgin aggregates.	NOTE: Shadeo
					0.378		. •	949.7	24 B	01-Oct-93	RBR 4
01-Oct-93 24 B 949.7					0.358			828.8	24 B	29-Sep-93	RBR 3
29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.326			766.4	24 B	28-Sep-93	RBR 3
28-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.334			887.0	24 B	25-Sep-93	RBR 2
25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.830			883.1	24 B	24-Sep-93	RBR 2
24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.340			779.9		23-Sep-93	RBR 1
23-Sep-93 24 B 778.9 24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					1,130			814.8		22-Sep-93	RBR 1
22.Sep-93 24 B 814.8 23.Sep-93 24 B 779.9 24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.943			595.6	24 B	21-Sep-93	CTRL 3
21-Sep-93 24 B 595.6 22-Sep-93 24 B 814.8 23-Sep-93 24 B 83.1 24-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0.514		0.215	698.4	24 B	20-Sep-93	CTRL 3
20-Sep-93 24 B 698.4 0.215 21-Sep-93 24 B 595.6 23-Sep-93 24 B 814.8 24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7	- Year		70000-C		1.669		0.112	836.9	24 B	18-Sep-93	CTRL2
18-Sep-93 24 B 836.9 0.112 20-Sep-93 24 B 698.4 0.215 21-Sep-93 24 B 595.6 0.215 22-Sep-93 24 B 814.8 1779.9 24-Sep-93 24 B 883.1 188.7 25-Sep-93 24 B 887.0 166.4 29-Sep-93 24 B 766.4 166.4 29-Sep-93 24 B 828.8 166.4 29-Sep-93 24 B 828.8 166.4					0.773			0.999	24 E	17-Sep-93	CTRL 2
17-Sep-93 24 B 666.0 18-Sep-93 24 B 698.4 0.112 20-Sep-93 24 B 698.4 0.215 21-Sep-93 24 B 814.8 23-Sep-93 24 B 83.1 24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 26-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7					0 931			804.1	23 B	16-Sep-93	CTRL 1
16-Sep-93 23 B 804.1 17-Sep-93 24 B 666.0 18-Sep-93 24 B 698.4 0.112 20-Sep-93 24 B 698.4 0.215 21-Sep-93 24 B 814.8 23-Sep-93 24 B 883.1 24-Sep-93 24 B 883.1 25-Sep-93 24 B 887.0 28-Sep-93 24 B 766.4 29-Sep-93 24 B 828.8 01-Oct-93 24 B 949.7	0 0 75	0 085	0 085	260 0	0 099	0 100	0 119	Liters		Limits >>	Detection
16-Sep-93 24 B 66.0 0.215 0.514 0.031 0.095 0.085 0.085 17-Sep-93 24 B 68.4 0.215 0.773 0.773 0.514 0.514 20-Sep-93 24 B 698.4 0.215 0.514 0.514 0.514 21-Sep-93 24 B 694.8 0.215 0.514 0.543 0.544 22-Sep-93 24 B 614.8 0.215 0.340 0.334 0.334 23-Sep-93 24 B 883.1 0.334 0.334 0.334 0.334 28-Sep-93 24 B 885.0 0.035 0.336 0.336 0.336 28-Sep-93 24 B 828 B 0.035 0.336 0.336 0.336 29-Sep-93 24 B 949.7 0.358 0.378 0.378 0.378		PPB	PPB	PPB	PPB	PPB	PPB	Volume	Number	Date	Туре
Date Number Volume PPB PPB PPB PPB PPB PPB 16-Sep-93 23 B 804.1 0.119 0.100 0.099 0.092 0.065 0.065 16-Sep-93 24 B 666.0 0.112 0.773 0.773 0.065 0.065 20-Sep-93 24 B 698.4 0.215 0.943 0.943 0.943 0.943 21-Sep-93 24 B 883.1 0.0830 0.934 0.934 0.934 22-Sep-93 24 B 883.1 0.0830 0.340 0.934 22-Sep-93 24 B 887.0 0.334 0.334 28-Sep-93 24 B 766.4 0.334 0.336 28-Sep-93 24 B 867.0 0.334 0.356 28-Sep-93 24 B 867.0 0.334 0.356 28-Sep-93 24 B 968.7 0.356 0.356 29-Sep-93 24 B 968.7 0.356 0.356	\vdash	Anthracene	Phenanthrene	Fluorene	Acenaphthene	Acenaphthylene	Naphthalene	Sample	Sample	Sampling	Mix
Sampling Date Sample Number Sample Number Naphthalene PPB Acenaphthylene PPB Acenaphthylene PPB Acenaphthylene PPB PPB<								me	und San	Backero	
Sample Sample Date Number Number Number Nolume PPB Acenaphthylene Acen									•	•	

	Daver Operator	perator								
Mix	Sampling	Sample	Sample	Naphthalene	Acel	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthe
Туре	Date	Number	Volume	PPB	РРВ	PPB	РРВ	PPB	PPB	PPB
Detection	Detection Limits >>		Liters	0.120	0.101	0.100	0.092	0.086	0.086	0.076
CTRL 1	16-Sep-93	8 B	816.4	996.0	0.387	1.471	0.762	0.149		
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	4B 4B	699.1 844.2	0.913 0.634	0.746 0.281	3.570 0.924	1.532 0.549	0.154	0.212	
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	4 B	606.4 651.0	1.424	0.704	3.087	1.122	0.178		
RBR 1	22-Sep-93 23-Sep-93	4 4 Ø Ø	844.4	0.422	0.243	0.757	0.463	0.143	0.107	
RBR 2 RBR 2	24-Sep-93 25-Sep-93	4 B 8 B	884.6 820.6	2.546	1.197	2.116 5.132	1.407	0.397	0.153	
RBR 3 RBR 3	28-Sep-93 29-Sep-93	4 B 4 B	831.6 871.2	0.339	0.247	0.750	0.383	0.170		0.068
RBR 4 RBR 4	01-Oct-93 04-Oct-93	4B 4B	831.6 712.8	0.519 0.395	0.418 0.310	1.182	0.731			
OTE: Shade	OTE: Shaded rows indicate mixes with	nixes with		Blanks indicate	Blanks indicate compound not detected in sample	detected in sam _i	ple.			

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Table Set IV.

Roller Operator

(continued)

53 0.083 0.074								t these types		
0.083							-			
0.089		0.128	0.179	0.137	0.179	0.746	0.259	0.351	0.303 0.168	nole
	0.096	0.593	0.580 1.136	1.057 0.990	0.808	2.144	0.767	0.661	1.136 0.625	detected in sen
	0.098		0.151	0.167	0.176	0.398	0.159	0.249	0.136 0.102	Blanks indicate compound not detected in sample
2	0.116	0.166	0.314	0.539	0.233	0.968	0.315	0.818	0.254	Blanks indicate
	Liters	789.1	807.5 837.9	634.8 661.5	888.5 806.0	872.9	894.4	825.8	811.2 773.8	
Number		4B	20 B 20 B	20 B 20 B	20 B 20 B	20 B	20 B	20 B	20 B 20 B	nixes with
Date	Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93 21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93 04-Oct-93	NOTE: Shaded rows indicate mixes with
Туре	Detection Limits	CTRL 1	CTRL 2 CTRL 2	CTRL 3 CTRL 3	RBR 1 RBR 1	RBR 2 RBR 2	RBR 3	RBR 3	RBR 4 RBR 4	NOTE: Shaded

Shaded rows indicate mixes 100% virgin aggregates.

	Screeding									
Mix	Sampling	Sample	Sample	Naphthalene	Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
Туре	Date	Number	Volume	PPB	PPB	PPB	PPB	PPB	PPB	PPB
Detection	Detection Limits >>		Liters	0.119	0.100	0.099	0.091	0.085	0.085	0.075
CTRL 1	16-Sep-93	16B	790.0	0.784	0.320	1.343	0.586	0.137		
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	8B 8B	673.2 813.5	1.617 1.107	1.432 0.738	5.329 2.493	3.010 1.530	0.133	0.361	
CTRL 3	20-Sep-93	12 B	647.5	1.101	0.586	1.759	0.939	0.146		
CTRL 3	21-Sep-93	12B	668.5	1.039	0.567	2.333	1.104	0.182		
880 800 1	22-Sep-93	12 B	880.5	0.448	0.305	215.1	0.641	260.0	2000	
אםע ו	23-dac-62	14.0	0,70	0.040	20.0	۲.50٪	1.203	. Jo	0.125	
RBR 2	24-Sep-93	12B	853.6	4.397	2.037	4.751	2.543	0.506	0.237	
RBR 2	25-Sep-93	12B	842.0	0.691	0.526	1.686	1.152		0.160	
RBR 3	28-Sep-93	12 B	756.6	1.935	1.295	4.536	2.678	0.303	0.143	
RBR 3	29-Sep-93	12B	938.8	1.699	1.178	3.821	2.158	0.288		
RBR 4	01-Oct-93	128	964.3	1.265	1.246	4.368	2.701	0.364		0.062
RBR 4	04-Oct-93	12 B	708.6	1.809	1.590	4.421	3.076	0.268		

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Blanks indicate compound not detected in sample.

Table Set IV. (continued)

Fluoranthene 0.076 PPB Anthracene 0.086 0.081 PPB 0.127 Phenanthrene 0.13 0.086 0.086 0.102 0.163 PPB 0.233 0.131 1.866 1,395 0.093 0.473 0.658 1.655 0.910 0.692 1.047 1.183 PPB 2.651 Acenaphthene 2.134 0.100 1.09 1.939 3.384 5.334 1.865 1.410 2.153 1.560 PPB 2.358 Acenaphthylene 1.075 0.239 0.762 0.937 0.383 0.891 0.449 0.101 1.274 0.429 0.687 0.445 Naphthalene 1.756 1.289 0.120 1.004 0.825 1.440 0.752 0.757 PPB 0.614 0.601 1.398 Sample Volume 794.8 941.9 709.8 705.6 804.1 659.6 638.5 829.8 742.1 818.9 811.3 774.2 Liters 926.3 Sample Number 16 B 12B 2 6 8 8 16 B 16 B 16 B 16 B 16 B 16 B a a a Shaded rows indicate mixes with Sampling 17-Sep-93 22-Sep-93 28-Sep-93 01-Oct-93 16-Sep-93 18-Sep-93 20-Sep-93 23-Sep-93 24-Sep-93 25-Sep-93 21-Sep-93 29-Sep-93 04-Oct-93 Detection Limits >> Date RBR 4 CTRL 2 CTRL 3 CTRL 3 RBR 1 RBR 1 RBR 2 RBR 2 RBR 3 CTRL 1 RBR 3 RBR 4 **Type** ĭ Z NO TE:

Luteman

Blanks indicate compound not detected in sample.

100% virgin aggregates.

	Laborer									
Mix	Sampling	Sample	Sample	Naphthalene	Naphthalene Acenaphthylene Acenaphthene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene
i ype	Date	Number	volume	מלב ל	97.6	844	APB.	PPB	ььв	РРВ
Defection	Detection Limits >>		Liters	0.119	0.100	0.099	0.092	0.086	0.086	0.075
CTRL 1	16-Sep-93	20 B	838.9	0.671	0.264	1.171	0.587	0.129		
CTRL 2	17-Sep-93	16 8	782.2	909'0	0.361	2.426	0.630			
CTRL 2	18-Sep-93	128	784.4	0.574	0.403	1.69.1	0.922	0.086		
CTRL 3	20-Sep-93	80 ED	644.1	0.903	0.540	2.422	0.831	0.147		
CTRL 3	21-Sep-93	8 B	669.3	0.336	0.189	1.072	0.368			
RBR 1 RBR 1	22-Sep-93 23-Sep-93	88	867.2 766.3	0.303	0.219	1,547	0320	0,106		
RBR 2	24-Sep-93	8.8	865.7	0.607	0.383	1.982	0.669	0.094		
RBR 2	25-Sep-93	88	861.7	0.370	0.312	1.629	0.638			
RBR 3	28-Sep-93	8 B	771.6	0.243	0.164	0.829	0.244			
RBR 3	29-Sep-93	8 B	979.7	0.862	0.484	1.751	0.827	0.124		
RBR 4	01-Oct-93	თ. თ თ . თ	993.8	0.567	0.398	1.727	0.801	0.081		

Blanks indicate compound not detected in sample. NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Table Set IV. ····· (continued)

	riuoranthene	2,00	r												
		200												See Every	
Dhenstring	a do	0.084										0.101			
Fluorene	PPB	060 0	1120	277	\$ L ₹ .	0.364	0.301	0.251	0.00	0.386	0.364	0.263	0.167	0.280	ple.
Acenaphthene	9	0 097	0 444	4 66.6	4 6 6	1437	1.684	0.871	2000	0.662	1.592	2.335	1.634	1.558	letected in sam
Acenaphthylene Acenaphthene	PPB	0 098				0.176	0.153	0.118	0 140	0.172	0.188	0.118	0.083	0.119	componed not a
Naphthalene	PPB	0 116	1 929		1.044	1.231	1.377	0.908	0.754	3.639	0.920	1.144	1.662	0.645	Blenks indicate compound not detected in sample.
Sample	Volume	Liters	807.5	678.1	737.3	716.4	722.4	806.0	846 1	825.1	754.7	935.1	964.5	931.2	
Sample	Number		25 B	28 B	28 28	28 B	28 B	28 B 28 B	28 B	28 B	28 B	28 B	28 B	28 B	idicate mixes with aggregates.
Sampling	Date	Limits >>	16-Sep-93	17-Sep-93	18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct-93	04-Oct-93	naded rows indicate mix 100% virgin aggregates.
Mix	Type	Detection Limits	CTRL 1	CTRL 2	CTRL 2	CTRL 3	CTRL 3	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4	RBR 4	NOTE: Shaded rows in 100% virgin s

Quality Confrol Manage

Table Set V Benzene, Toluene, Ethylbenzene, Xylene, and Styrene Worker Exposure Results

Results as ug/sample

Blanks indicate compound not detected in sample

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

TABLE SET V.

VOLATILE ORGANIC COMPOUNDS SAMPLING AND ANALYTICAL RESULTS

(Units: ug/sample)

	Background Sample	ind Sampl	<u>e</u>					
Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
Туре	Date	Number	Volume	gn	Б'n	Б'n	מ	bn
Detection	Detection Limits >>		Liters	1	10	10	10	5
CTRL 1	16-Sep-93	21 A & B	88.0					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	21 A & B	69.9 92.4					
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	21 A & B 21 A & B	77.8 66.3					
RBR 1 RBR 1	22-Sep-93 23-Sep-93	21 A & B 21 A & B	90.7 84.2					
RBR 2 RBR 2	24-Sep-93 25-Sep-93	21 A & B 21 A & B	99.9 92.6					
RBR 3 RBR 3	28-Sep-93 29-Sep-93	21 A & B 21 A & B	90.3 94.6					
RBR 4 RBR 4	01-Oct-93 04-Oct-93	21 A & B	90.3 83.9					
NOTE: Shade	NOTE: Shaded rows indicate mixes with	ces with		Blanks indicate	Blanks indicate compound not detected in sample.	detected in sam	ple.	

100% virgin aggregates.

	Daver Operator	erator						
, Mix	Sampling	Sample	Sample	Benzene	EthyiBenzene	Toluene	Xylene	Styren
lype	Date	Number	Volume	δ'n	б'n	nd	ĥ	gn
Detection	Detection Limits >>		Liters	-	10	10	10	10
CTRL 1	16-Sep-93	5A&B	85.0					
CTRL 2	17-Sep-93	1 A & B	49.9					
CTRL 2	18-Sep-93	1A&B	82.1					
CTRL 3	20-Sep-93	1A&B	58.0					
CTRL 3	21-Sep-93	1 A & B	72.1					
X X X X	22-Sep-93 23-Sep-93	1 A & A L	91.3 80.2					
RBR 2	24-Sep-93	1A&B	85.3					
RBR 2	25-Sep-93	1A&B	92.7					
RBR 3	28-Sep-93	1A&B	67.1					
RBR 3	29-Sep-93	1A&B	100.7	1		1	10	
RBR 4	01-0ct-93 04-0ct-93	 소 소 유 약 교 교	102.4 76.3					

Table Set V. (continued)

	Roller Operator	erator						
Mix Type	Sampling Date	Sample Number	Sample Volume	Benzene UG	EthylBenzene	Toluene	Xylene	Styrene
Detection	Detection Limits >>		Liters	1	10	10	10	10
CTRL 1	16-Sep-93	1A&B	85.7					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	17 A & B	47.9 81.6					
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	17 A & B	69.7					
RBR 1	22-Sep-93 23-Sep-93	17 A & B	92.5 81.2					
RBR 2 RBR 2	24-Sep-93 25-Sep-93	17 A & B 17 A & B	67.3					
RBR 3 RBR 3	28-Sep-93 29-Sep-93	17 A & B 17 A & B	78.2 71.8					
RBR 4 RBR 4	01-Oct-93 04-Oct-93	17 A & B 17 A & B	97.4					
NOTE: Shadec 100%	NOTE: Shaded rows indicate mixes with 100% virgin aggregates.	es with		Blanks indicate	Blanks indicate compound not detected in sample	detected in sam	ıρle.	

Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xvlene	Styrene
Type	Date	Number	Volume	бn	δ'n	5	, bi	5
Detectio	Detection Limits >>		Liters	_	9	9	10	9 2
CTRL 1	16-Sep-93	13 A & B	81.6					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	5 A & B	71.5 50.8					
CTRL 3	20-Sep-93	9 A & B	68.1					
RBR 1	22-Sep-93 23-Sep-93	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	87.6					
RBR 2 RBR 2	24-Sep-93 25-Sep-93	9 A & B 9 A & B	88.6 85.5	2			20	
RBR 3 RBR 3	28-Sep-93 29-Sep-93	9 A & B 9 A & B	82.5 95.9					
RBR 4 RBR 4	01-Oct-93 04-Oct-93	9A&B 9A&B	83.1	6 0			Q.	
JOTE: Shade 100	NOTE: Shadad rows indicata mixas with 100% virgin aggragates.	(es with		Blanks indicate	Blanks indicate compound not detected in semple	detected in sam	ple.	

CTRL 1 = 85/100 PEN AC, 30% RAP ♣ CTRL 2 = No RBR, No RAP ♣ CTRL 3 = No RBR, 20% RAP RBR 1 = RBR-WET, No RAP ♣ RBR 2 = No RBR, 20% Rbr RAP ♣ RBR 3 = RBR-WET, 20% Rbr RAP ♣ RBR 4 = RBR-DRY, No RAP Table Set V. (continued)

	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
٦	Date	Number	Volume	ug	ug	ug	ĥ	бn
io	Detection Limits >>		Liters	1	10	10	10	10
Г	16-Sep-93	9A&B	81.2					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	8A&B 13A&B	72.4 86.1					
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	13 A & B 13 A & B	70.0 72.2					
	22-Sep-93 23-Sep-93	13A&B 13A&B	92.9 84.3				e.	
	24-Sep-93 25-Sep-93	13 A & B 13 A & B	86.7 86.8				10	
	28-Sep-93 29-Sep-93	13 A & B 13 A & B	77.2					
RBR 4 RBR 4	01-Oct-93 04-Oct-93	13 A & B 13 A & B	97.9 61.5					
3dec	NOTE: Shaded rows indicate mixes with	res with		Blanks indicate	сотроипа поt	Blanks indicate compound not detected in sample	ple.	

100% virgin aggregates.

	Laborer							
Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
Defection	Defection Limits >>		Lifers	§ -	3 C	3 5	g C	g C
CTRL 1	16-Sep-93	17 A & B	56.9					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	13 A & B 9 A & B	68.8 86.1					
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	5 A & B	63.1					
RBR 1	22-Sep-93 23-Sep-93	5 A A	93.0					
RBR 2 RBR 2	24-Sep-93 25-Sep-93	5 A & B 5 A & B	94.4 85.3					
RBR 3 RBR 3	28-Sep-93 29-Sep-93	5 A & B 5 A & B	76.4 97.0					
RBR 4	01-Oct-93 04-Oct-93	5 A & B 5 A & B	98.4 72.0					
NOTE: Shaded	NOTE: Shaded rows indicate mixes with	res with		Blanks indicate	compound not	Blanks indicate compound not detected in sample	.pje.	

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Table Set V. (continued)

	Г				- diggraph		## 15				1
	Styrene	9	9								
	Xvlene	nd	9								ıple.
	Toluene	5	5								detected in san
	EthylBenzene	6n	10								Blanks indicate compound not detected in sample.
	Benzene	Ď	1								Blanks indicate
	Sample	Volume	Liters	84.2	81.2 88.6	72.7	72.1	85.1 89.1	87.7	79.6 97.9	
Dinterol A4a	Sample	Number		22 A & B	25 A & B 25 A & B	25 A & B 25 A & B	25 A & B 25 A & B	25 A & B 25 A & B	25 A & B 25 A & B	25 A & B 25 A & B	es with
Cuality Control Manager	Sampling	Date	Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93 21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93 25-Sep-93	28-Sep-93 29-Sep-93	01-Oct-93 04-Oct-93	NOTE: Shaded rows indicate mixes with 100% virgin addregates
	Mix	Type	Detection Limits >>	CTRL 1	CTRL 2	CTRL 3 CTRL 3	RBR 1	RBR 2 RBR 2	RBR 3 RBR 3	RBR 4	NOTE: Shaded

Table Set VI Benzene, Toluene, Ethylbenzene, Xylene, and Styrene Worker Exposure Results

Concentrations as mg/m^3

TABLE SET VI.

VOLATILE ORGANIC COMPOUNDS SAMPLING AND ANALYTICAL RESULTS

(Units: mg/m³)

	SACKOLOU	Backeround Sample	6				•	
Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
Туре	Date	Number	Volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3
Defection	Detection Limits >>		Liters	0.0116	0.1160	0.1160	0.1160	0.1160
CTRL 1	16-Sep-93	21 A & B	88.0					
CTRL 2	17-Sep-93 18-Sep-93	21 A & B	69.8 92.4					
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	21 A & B 21 A & B	77.8					
RBR 1	22-Sep-93 23-Sep-93	21 A & B	90.7					
RBR 2 RBR 2	24-Sep-93 25-Sep-93	21 A & B 21 A & B	99.9 92.6					
RBR 3 RBR 3	28-Sep-93 29-Sep-93	21 A & B 21 A & B	90.3 94.6					
RBR 4	01-Oct-93 04-Oct-93	21 A & B	90.3 83.9					
NOTE: Shadec	NOTE: Shaded rows indicate mixes with	(es with		Blanks indicate c	Blanks indicate compound not detected in sample.	cted in sample.		

100% virgin aggregates.

	Daver Operator	erator						
Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
lype	Date	Number	volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3
Defection	Detection Limits >>		Liters	0.0125	0.1246	0.1246	0.1246	0.1246
CTRL 1	16-Sep-93	5A&B	85.0					
CTRL 2	17-Sep-93	7 A A A A A A A A A A A A A A A A A A A	49.9 R2.1					
CTRL 3	20-Sep-93	1 A & B	58.0					
CTRL 3	21-Sep-93	1 A & B	72.1					
RBR 1 RBR 1	22-Sep-93 23-Sep-93	1 A & B	91.3 80.2					
RBR 2	24-Sep-93	1A&B	85.3					
RBR 2	25-Sep-93	1A&B	92.7					
RBR 3	28-Sep-93	1A&B	67.1					
RBR 3	29-Sep-93	1A&B	100.7	6600.0			0.0993	
RBR 4 RBR 4	01-Oct-93 04-Oct-93	1A&B 1A&B	102.4 76.3					
OTE: Shade	NOTE: Shaded rows indicete mixes with	ces with		Blanks indicate co	Blanks indicate compound not detected in sample	scfed in sample.		

NOTE: Shaded rows indicete mixes with 100% virgin aggregates.

Table Set VI. (continued)

Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Tolliene	Yulone	3
Туре	Date	Number	Volume	mg/m3	mg/m3	mg/m3	ma/m3	ma/m;
Detection	Detection Limits >>		Liters	0.0132	0.1321	0.1321	0.1321	0.1321
CTRL 1	16-Sep-93	1A&B	85.7					
CTRL 2 CTRL 2	17-Sep-93 18-Sep-93	17 A & B	47.9 81.6					
CTRL 3	20-Sep-93	17 A & B	69.7					
CTRL 3	21-Sep-93	17 A & B	68.5					
RBR 1	22-Sep-93 23-Sep-93	17 A & B 17 A & B	92.5 81.2					
RBR 2	24-Sep-93	17 A & B	67.3					
RBR 2	25-Sep-93	17 A & B	9.79					
RBR 3	28-Sep-93	17 A & B	78.2					
RBR 3	29-Sep-93	17 A & B	71.8					
R R R A A A A A A A A A A A A A A A A A	01-Oct-93 04-Oct-93	17 A \$ 8 B	97.4					
NOTE: Shaded	NOTE: Shaded rows indicate mixes with	es with		Blanks indicate c	Blanks indicate compound not detected in sample.	cted in sample.		

radad rows indicate mixes with the compound no 100% virgin aggregates.

	ine Styrene mg/m3						57		88	
	Xylene mg/m3						0.2257		0.1203	ole.
	Toluene mg/m3	0.1277								etected in sam
	EthylBenzene mg/m3	0.1277								Blanks indicate compound not detected in sample.
	Benzene mg/m3	0.0128					0.0226		0.0722	Blanks indicate
	Sample Volume	Liters	81.6	71.5 50.8	68.1	87.6	88.6 85.5	82.5 95.9	83.1	
	Sample Number		13 A & B	5 A & B 6 A & B	9 A & B	9 A & B	9 A & B 9 A & B	9 A & B 9 A & B	9 A & B 9 A & B	res with s.
Screedman	Sampling Date	Detection Limits >>	16-Sep-93	17-Sep-93 18-Sep-93	20-Sep-93 21-Sep-93	22-Sep-93 23-Sep-93	24-Sep-93 25-Sep-93	28-Sep-93 29-Sep-93	01-Oct-93 04-Oct-93	NOTE: Shadad rows indicata mixas with 100% virgin aggregates.
	Mix Type	Detection	CTRL 1	CTRL 2 CTRL 2	CTRL 3 CTRL 3	RBR 1	RBR 2 RBR 2	RBR 3 RBR 3	RBR 4 RBR 4	NOTE: Shade 1009

Table Set VI. (continued)

		ected in sample.	Blanks indicate compound not detected in sample	Blanks indicate o		ces with	NOTE: Shaded rows indicate mixes with	NOTE: Shade
				0.0163	61.5	13 A & B	04-Oct-93	RBR 4
	. 7				97.9	13 A & B	01-Oct-93	RBR 4
					95.8	13 A & B	29-Sep-93	RBR 3
					. 77.2	13 A & B	28-Sep-93	RBR 3
					86.8	13 A & B	25-Sep-93	RBR 2
	0.1154		•		86.7	13 A & B	24-Sep-93	RBR 2
					84.3	13 A & B	23-Sep-93	RBR 1
	0.1076	¥ 75 - 27 5			92.9	13 A & B	22-Sep-93	RBR 1
		:			72.2	13 A & B	21-Sep-93	CTRL 3
					70.0	13 A & B	20-Sep-93	CTRL 3
					86.1	13 A & B	18-Sep-93	CTRL 2
-					72.4	8 A & B	17-Sep-93	CTRL 2
					81.2	9A&B	16-Sep-93	CTRL 1
0.1221	0.1221	0.1221	0.1221	0.0122	Liters		Detection Limits >>	Detection
mg/m3	mg/m3	mg/m3	mg/m3	mg/m3	Volume	Number	Date	Туре
Styrene	Xylene	Toluene	EthylBenzene	Benzene	Sample	Sample	Sampling	Mix
								l

100% virgin aggregates.

Σ×	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrene
Туре	Date	Number	Volume	mg/m3	mg/m3	mg/m3	mg/m3	mg/m3
Detection	Detection Limits >>		Liters	0.0125	0.1255	0.1255	0.1255	0.1255
CTRL 1	16-Sep-93	17 A & B	56.9					
CTRL 2	17-Sep-93	13 A & B	68.8					
CTRL 2	18-Sep-93	9 A & B	86.1					
CTRL 3	20-Sep-93	5 A & B	63.1					
CTRL 3	21-Sep-93	5 A & B	69.7					
RBR 1	22-Sep-93	8 A & B	93.0					
RBR 1	23-Sep-93	5 A & B	75.1		1.			
RBR 2	24-Sep-93	5 A & B	94.4					
RBR 2	25-Sep-93	5A&B	85.3					
RBR 3	28-Sep-93	5 A & B	76.4					
RBR 3	29-Sep-93	5 A & B	97.0					
RBR 4	01-Oct-93	5A&B	98.4					19 - 1 14 - 1
RBR 4	04-Oct-93	6 A & B	72.0				<u> </u>	

Table Set VI.

(continued)

	Cuality (Cuality Control Manager	E.					
Mix	Sampling	Sample	Sample	Benzene	EthylBenzene	Toluene	Xylene	Styrana
1 X Pag	Date	Number	Volume	mg/m3	mg/m3	mg/m3	ന്മൃഷ്ട	€ய/வ
Defection	Defection Limits >>		Liters	0.0123	0 1231	0 1231	0 1231	17210
CTRL 1	16-Sep-93	22 A & B	84.2					
CTRLZ	17-Sep-92	26 A & B	2					
CTRL 2	18-Sep-93	26ABB	80.8					
CTRL 3	20-Sep-93	25 A & B	72.7					
CTRL 3	21-Sep-93	25 A & B	64.6					
RBR1	22-Sep-95	26A&B	72.1					
RBR 1	23-Sep-83	25AAB	72.1					
RBR 2	24-Sep-93	25 A & B	85.1					
RBR 2	25-Sep-93	25 A & B	89.1					
RBR 3	28-Sep-93	25 A & B	87.7					
RBR 3	29-Sep-93	25 A & B	81.0		_			
RBR.4	01-0-4-83	ZSA&B	78.8					
RBR 4	04-Oct-93	25 A A B	67.9					
NOTE: Sheden	NOTE: Shaded rows Indicate mixes with	ixes with		Blanks indicate co	Blanks indicate compound not detected in sample.	ected in semple.		

Table Set VII Benzene, Toluene, Ethylbenzene, Xylene, and Styrene Worker Exposure Results

Concentrations as PPB

TABLE SET VII.

VOLATILE ORGANIC COMPOUNDS SAMPLING AND ANALYTICAL RESULTS

(Units: PPB)

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Mix PP8	Sampling Date	Sample Number	Sample Volume	Benzene PPB	Ethy/Benzene PPB	Toluene	Xylene PPB	Styrene
efection	Detection Limits >>		Liters	3.84	28.24	32.54	28.25	28.79
CTRL 1	16-Sep-93	5A&B	85.0				Marine Marine Company	
CTRL 2	17-Sep-43	1448	49.8					
	2000	ING D	1.70					
CTRL 3	20-Sep-93	1A&B	58.0					
CTRL 3	21-Sep-93	1 A & B	72.1					
RBR 1	22-8ep-93	1A4B	21.3					
RBR1	25-Sep-83	TABB	202					
RBR 2	24-Sep-93	1A&B	85.3					
RBR 2	25-Sep-93	1A&B	92.7	-		•		
RBR 3	28-Sep-93	1A&B	67.1					
RBR 3	29-Sep-93	1 A & B	100.7	3.06			22.51	
RBR 4	01-0-5-83	1888	102.4					
RBR 4	04-0-0-81	884.	76.3					
Shade	NOTE: Shaded rows indicate mixes with	res with		Blanks indicate	Blanks indicate compound not detected in sample	defected in sam	90	
,								

Table Set VII. (continued)

Mix	Sampling	Sample	Sample					
Туре	Date	Number	Volume	PPB	EthylBenzene PPB	Toluene	Xytene	Styrene
Detection	Detection Limits >>		Liters	4.07	29.94	34.50	29.95	30.52
CTRL 1	16-Sep-93	1A&B	85.7					70.00
CTRL	17-Sep-83	TAGE	47.8					
CTRL 2	18-Sep-63	TALB	81.8					
CTRL 3	20-Sep-93	17A&B	69.7					
CTRL 3	21-Sep-93	17 A & B	68.5					
RBR 1	22.5mp.83	17 A & B	92.5					
RBR 2	24-Sen-93	17 A & B	67.3					
RBR 2	25-Sep-93	17 A & B	9.79		100			
RBR 3	28-Sep-93	17 A & B	78.2					
RBR 3	29-Sep-93	17 A & B	71.8					
RBK 4	01-0-1-83	17 A & B	27.4					
RBR 4	04-0-(-63	TABB	74.4					
VOTE: Shaden	VOTE: Shaded rows indicate mixes with	es with		Slanks indicate	compound not	Blanks indicate compound not detected in sample	0/6	
					•			

Roller Operator

100% virgin aggregates.

a 3.93 28.94 33.34 28.95 a 3.93 28.94 33.34 28.95 b 6.95 69.51	¥	Sampling	Sample	Sample	Benzene	EthylBenzene	Tolivene	Yolene	Change
16-Sep-93 13 A&B 14ers 3.93 28.94 33.34 28.95 16-Sep-93 5 A&B 81.6 33.34 28.95 17-Sep-83 5 A&B 68.1 68.1 80.8 21-Sep-93 9 A&B 66.5 81.7 81.7 24-Sep-93 9 A&B 88.6 6.95 89.51 24-Sep-93 9 A&B 82.5 82.5 82.5 28-Sep-93 9 A&B 82.5 82.27 29-Sep-93 9 A&B 83.1 24.25 29-Sep-93 9 A&B 83.1 24.25 29-Sep-93 9 A&B 85.5 83.5	Type	Date	Number	Volume	РРВ	РРВ	PPB	PPB	PPB
16-Sep-83 13 A & B 81.6 81.6 17-Sep-83 \$A & B 71.6 82.5 20-Sep-83 9 A & B 68.1 86.5 86.5 21-Sep-83 9 A & B 86.5 87.6 87.6 22-Sep-83 9 A & B 88.6 6.95 69.51 24-Sep-93 9 A & B 85.5 85.5 69.51 28-Sep-93 9 A & B 82.5 82.5 82.5 29-Sep-93 9 A & B 83.1 22.22 29-Sep-93 9 A & B 83.1 22.22 29-Sep-93 9 A & B 83.1 22.22	Defection	n Limits >>		Liters	3.93	28.94	33.34	28.95	29.50
17.Sep-83 \$A&B 71.6 20-Sep-83 9A&B 68.1 21-Sep-83 9A&B 66.5 22-Sep-83 9A&B 66.5 22-Sep-83 9A&B 87.7 24-Sep-93 9A&B 88.6 6.95 25-Sep-93 9A&B 85.5 85.5 28-Sep-93 9A&B 82.5 82.5 29-Sep-93 9A&B 82.5 82.5 29-Sep-93 9A&B 87.5 87.22 04-Octest 9A&B 71.6 72.22	CTRL 1	16-Sep-93	13 A & B	81.6					
18-Sep-83 56 & B.1 50.8 20-Sep-93 9 A & B 68.1 21-Sep-83 9 A & B 66.5 22-Sep-83 9 A & B 87.7 24-Sep-93 9 A & B 88.6 6.95 25-Sep-93 9 A & B 85.5 85.5 28-Sep-93 9 A & B 82.5 82.5 28-Sep-93 9 A & B 82.5 82.5 28-Sep-93 9 A & B 82.5 82.5 29-Sep-93 9 A & B 83.1 82.5	OTRI. 2	17-Sep-03	SAAB	71.8					
20-Sep-93 9A&B 68.1 21-Sep-93 9A&B 66.5 22-Sep-93 8A&B 88.6 6.95 24-Sep-93 9A&B 88.6 6.95 25-Sep-93 9A&B 82.5 28-Sep-93 9A&B 82.5 29-Sep-93 9A&B 82.5 20-Sep-93 9A&B 82.5	CTRL 2	18 Sep-83	5448	8.03					
21-Sep-93 9 A & B 66.5 66.5 22-Sep-93 9 A & B 84.7 6.95 24-Sep-93 9 A & B 88.6 6.95 25-Sep-93 9 A & B 85.5 85.5 28-Sep-93 9 A & B 82.5 82.5 29-Sep-93 9 A & B 95.9 82.5 29-Sep-93 9 A & B 82.5 82.5 29-Sep-93 9 A & B 83.7 74.8 10-Octal 8 A & B 71.8 71.8	CTRL 3	20-Sep-93	9 A & B	68.1					
22-Sep-93 9 A & B 87.7 24-Sep-93 9 A & B 88.6 6.95 25-Sep-93 9 A & B 85.5 85.5 28-Sep-93 9 A & B 82.5 82.5 29-Sep-93 9 A & B 95.9 82.5 29-Sep-93 9 A & B 83.7 22.22 04-Oct 24 9 A & B 71.6 17.65	CTRL 3	21-Sep-93	9 A & B	66.5		,			
24-Sep-93 9A&B 88.6 6.95 25-Sep-93 9A&B 85.5 85.5 28-Sep-93 9A&B 82.5 29-Sep-93 9A&B 95.9 01-0x421 #A&B 71.8 04-0x431 #A&B 71.8	RBR 1	22.Sep.93	SAKB	87.8					
25-Sep-93 9 A & B 85.5 28-Sep-93 9 A & B 82.5 29-Sep-93 9 A & B 95.9 01-Oct81 B A & B 71.6 04-Oct83 B A & B 71.6	RBR 2	24-Sep-93	9 A & B	88.6	6.95			69 51	
28-Sep-93 9A&B 82.5 29-Sep-93 9A&B 95.9 01-Octe1 PA&B 83.1 22.22 04-Octe3 PA&B 71.6 12.89	RBR 2	25-Sep-93	9 A & B	85.5				2	
29-Sep-93 9A&B 95.9 P.C. P.C. P.C. P.C. P.C. P.C. P.C. P.	RBR 3	28-Sep-93	9 A & B	82.5					
01-0x4-81 8.8.15 22.22 04-0x4-81 9.8.8 71.8 12.89	RBR 3	29-Sep-93	9 A & B	95.9					
04-0ct#1 9A#B 718 12.89	RBR4	01-0-1-03	PAAS	53.1	22.22			37.03	
	888.6	04.0040	8448	81.2	12.59				

Table Set VII. (continued)

Styrene PPB 28.98

	Luteman							
Mix Type	Sampling Date	Sample Number	Sample Volume	Benzene PPB	EthylBenzene PPB	Toluene PPB	Xylene PPB	Styrene
Defection	Detection Limits >>	-	Liters	3.76	27.66	31.87	27.67	28.20
CTRL 1	16-Sep-93	9A&B	81.2					
CTRL 2 CTRL 2	17-Sep-63 18-Sep-63	SA&B 13A&B	72.4					
CTRL 3	20-Sep-93	13 A & B	0.07					
CTRL 3	21-Sep-93	13 A & B	72.2					
RBR1	22.Sep-93 23.Sep-93	SARB SARB	82.8 84.3				24.40	
RBR 2	24-Sep-93	13 A & B	86.7				26.15	
RBR 2	25-Sep-93	13 A & B	8.98					
RBR 3	28-Sep-93	13 A & B	77.2					
RBR 3	29-Sep-93	13 A & B	95.8					
RBR 4	04.001.83	日間をおり	81.8	3.68				
VOTE: Sheden	NOTE: Shaded rows indicate mixes with	es with		Blanks indicate	Blanks indicate compound not detected in semale.	defected in sem	ole.	

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

ixes with Blanks indicate compound not detected in sample.

	Laborer						
Mix Type	Sampling Date	Sample Number	Sample Volume	Benzene	EthylBenzene PPB	Toluene PPB	Xylene PPB
Defection	Detection Limits >>		Liters	3.86	28.43	32.76	28.44
CTRL 1	16-Sep-93	17 A & B	6.95				
CTRL 2 CTRL 2	17-Sep-83 18-Sep-83	13ALB Baab	88.8 88.1				
CTRL 3	20-Sep-93	5 A & B	63.1				
CTRL 3	21-Sep-93	5A&B	69.7				
RBR1	25.Sep-03	5A48	76.1				
RBR 2	24-Sep-93	5 A & B	94.4				
RBR 2	25-Sep-93	5A&B	85.3				
RBR 3	28-Sep-93	5 A&B	76.4				
RBR 3	29-Sep-93	5A&B	97.0				
RDRA	01-0:4-83	5848	95.4				
4000	18 PO 10	0 3 4 6					

| RBK& | PA-KKKW | DR.C.th | FA.W. NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Blanks indicate compound not detected in sample.

Table Set VII. (continued)

	Quality Control Manager	ontro! Ma	nagei.					
Mix Type	Sampling Date	Sample Number	Sample Volume	Benzene PPB	Ethy/Benzene PPB	Toluene	Xytene	Styrene
Defection	Detection Limits >>		Uters	3 79	27 90	32.15	27.91	28.44
CTRL 1	16-Sep-93	22 A & B	84.2	The second secon				
CTRL 2 CTRL 2	17 Sep 83 18-Sep 83	25 A & B	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2					
CTRL 3	20-Sep-93	25 A & B	72.7					
CTRL 3	21-Sep-93	25 A & B	9.49					
RBR 1 RBR 1	22 Sept 83 23 Sept 83	25 A & B 25 A & B	72.1					
RBR 2	24-Sep-93	25 A & B	85.1					
RBR 2	25-Sep-93	25 A & B	89.1					
RBR 3	28-Sep-93	25 A & B	87.7					
RBR 3	29-Sep-93	25 A & B	81.0					
RBR 4 RBR 4	04.0ct.83	25.4.8.B 26.4.8.B	9.8. 8.79					
NOTE: Shade	NOTE: Shaded rows indicate mixes with	es with		Slanks indicate	Blanks indicate compound not detected in sample.	fetected in sem	ple.	

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Table Set VIII 1,3-Butadiene Worker Exposure Results

Results as ug/sample Concentrations as mg/m³ Concentrations as PPB TABLE SET VIII.

1,3-BUTADIENE SAMPLING AND ANALYTICAL RESULTS (Units: ug/sample, mg/m³, and PPB)

	Background Sample	nd Sampl	بو			
Mix Type	Sampling Date	Sample Number	Sample Volume	1.3-Butadiene Ug	1,3-Butadiene PPB	1,3-Butadler mg/m3
Defection	Detection Limits >>		Liters	-	5.86	0.0132
CTRL 1	16-Sep-93	22 A & B	80.4	ΩN		The second secon
CTRL 2	17-Sep-93	23.A.S.B	78.5	QΝ		
C BIO	18-Sep-83	23.4 & B	84.4	9		
CTRL 3	20-Sep-93	23 A & B	6.07	Q		
CTRL 3	21-Sep-93	23 A & B	60.5	9		
RBRI	22.Sep-83	23 A & B	82.7	ΩV		
RBRI	23-Sap-93	23 A & B	76.8	Ð		
RBR 2	24-Sep-93	23 A & B	91.7	QN		
RBR 2	25-Sep-93	23 A & B	85.0	QN		
RBR 3	28-Sep-93	23 A & B	85.3	QN		
RBR 3	29-Sep-93	23 A & B	89.3	Q		
RBR 4	01-0-193	Z3A&B	85.3	3	15.65	0.0352
RBR 4	04-Oct-93	23 A & B	79.2	ð		
VOTE: Shader	VOTE: Shaded rows indicate mixes with 100% virnin econocates	os with		Blanks indicate o	Blanks indicate compound not detected in sampl	cted in sempl

	Daver Operator	erator	:			
Mix Type	Sampling Date	Sample	Sample	1,3-Butadlene Ud	1,3-Butadiene	1,3-Butadlene
Defectio	Detection Limits >>		Liters	-	6.32	0.0142
CTRL 1	16-Sep-93	7A&B	81.2	QN		
CTRL2 CTRL2	17-Sep-83 18-Sep-83	3448	41.4	QN		
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	3 A & B 3 A & B	59.3 72.4	- Q	7.50	0.0169
RBR 1 RBR 1	22.Sep.93 23.Sep.93	3A&B 3A&B	87.2 76.8	QN QN		
RBR 2 RBR 2	24-Sep-93 25-Sep-93	3 A & B 3 A & B	89.6 85.0	1 2	4.96	0.0112
RBR 3 RBR 3	28-Sep-93 29-Sep-93	3 A & B 3 A & B	69.5 93.6	8 -	4.75	0.0107
RBR4 RBR4	01-0ct-93 04-0ct-93	3A&B 3A&B	85.Z 70.9		4.67	0.0105
VOTE: Shade	NOTE: Shaded rows indicate mixes with	es with	7	Blanks indicate compound not detected in sample.	ompound not dete	cted in sample.

Table Set VIII. · · · · · · · · (continued)

	Roller Operator	erator				
Mix Type	Sampling Date	Sample Number	Sample Volume	1,3-Butedlene UKD	1,3-Butadlene	1,3-Butadlen
Defection	Detection Limits >>		Liters	1	5.80	0.0130
CTRL 1	16-Sep-93	3A&B	70.5	QN		And in case of the last of the
CTRL2	17.Sep.93	8888	2.49	QN.		
C IOTO	20.00	GBVA	780	Q.		
CTRL 3	21-Sep-83	19 A & D	71.8	2 9		
	2000	0 5 0 0	0.00	QN.		
RBR	23.880.83	1988B	85.3 8.48	9		
RBR 2	24-Sep-93	19 A & B	0 99	CN		
RBR 2	25-Sep-93	19 A & B	66.3	2		·
RBR 3	28-Sep-93	19 A & B	82.9	QV		
RBR 3	29-Sep-93	19 A & B	74.4	2		
RBR 4	01-0-493	19 A & B	183	QN		
RBR 4	D4-Oct-93	BARB	, 20 20 20	ND		
NOTE: Shadec 1009	NOTE: Sheded rows indicate mixes with 100% virgin eggregates.	es with	1	Blanks indicate c	Blanks indicate compound not detected in sample	ded in sample

Elenks indicate compound not detecte	
SCRIO TRADS WITH	ggregates.

Mix Type	Sampling Date	Sample	Sample	1,3-Butedlene	1,3-Butadlene	1,3-Butadiene
Defection	Detection Limits >>		Liters	-	6.36	0.0143
CTRL 1	16-Sep-93	15 A & B	89.2	4	19,93	0.0448
CTRL 2	17-Sep-93	7AAB	51.3	j	8.68	0.0195
	10.200783	CAGO	0.23	9	63.50	0.1628
CTRL 3	20-Sep-93	11 A & B	65.1	9	41.00	0.0922
CTRL 3	21-Sep-93	11 A & B	74.2	_	5.99	0.0135
RBR 1	ZZ-Sep-93	11888	1.78	GN		
RBR 1	23-Sep 93	11888	79.8	S		
RBR 2	24-Sep-93	11 A & B	89.5	-	4.97	0.0112
RBR 2	25-Sep-93	11 A & B	89.9	QV		!
RBR 3	28-Sep-93	11 A & B	76.6	2		
RBR 3	29-Sep-93	11 A & B	101.7	QN		
RBR 4	01-0:493	11 A & B	199	2	10.33	0.6932
RBF.4	04-004-84	HARB	76.0	ď	17.56	0.0395
OTE: Shade	NOTE: Shaded rows indicate mixes with 100% virgin acceptant	os with		Blanks indicate o	Blanks indicate compound not detected in sample.	cted in semple.
	romanda Man ingila o					

Table Set VIII.

(continued)

Mix	Sampling	Sample	Sample	1,3-Butadlene	1,3-Butadlene	1,3-Butadiene
Туре	Date	Number	Volume	ug	рРВ	mg/m3
Defection	Detection Limits >>		Liters	1	5.79	0 0 1 3 0
CTRL 1	16-Sep-93	11 A & B	888	2	10 01	0 0225
CTRL 2 CTRL 2	17.Sep 93 18.Sep 93	11 A A B 15 A & B	69.1 70.8	0 Q		The continues of the co
CTRL 3 CTRL 3	20-Sep-93 21-Sep-93	15 A & B 15 A & B	70.4 68.0	ON 3	19.62	0.0441
RBR 1 RBR 1	22.5ap.93 23.5ap.93	15A&B 15A&B	93.4 7.47	QN		
RBR 2 RBR 2	24-Sep-93 25-Sep-93	15 A & B 15 A & B	88.0 87.7	- Q	5.05	0.0114
RBR 3 RBR 3	28-Sep-93 29-Sep-93	15 A & B 15 A & B	79.5 98.7	1 2	5.59 9.01	0.0126
RBR 4	01-04-93 04-001-93	15A&B 15A&B	103.8 63.7		4.28 6.98	0.00%
NOTE: Shadex	NOTE: Shaded rows indicate mixes with	es with		Blanks indicate c	Blanks indicate compound not detected in semple	ded in semple.

Lufeman

100% virgin aggregates.

Mix Type	Sampling Date	Sample Number	Sample Volume	1,3-Butadlene ug	1,3-Butadlene PPB	1,3-Butadiene mg/m3
fection	Detection Limits >>		Liters	1	6.57	0.0148
CTRL 1	16-Sep-93	19 A & B	47.1	2	18.89	0.0425
CTRL 2 CTRL 2	17-Sep-83 18-Sep-83	15A&B	61.8	Q		
CTRL 3	20-Sep-93	7A&B	70.4	Q		
CTRL 3	21-Sep-93	7A&B	71.8	QV		
RBR 1 RBR 1	ZZ Sep 93 23.56p-93	SAA7	83.7	GN GN		
RBR 2	24-Sep-93	7 A & B	9.98	QV.		
RBR 2	25-Sep-93	7A&B	9.98	7	35.95	0.0808
RBR 3	28-Sep-93	7 A & B	77.5	Q		
RBR 3	29-Sep-93	7A&B	98.5	-	4.52	0.0102
RBR 4	01-0:4-93	7A&B	6'68	- 2	8.91	0.0200
RBR 4	04-04-83	7A&B	73.1	1	6.09	5,0137
Shade	TE: Shaded rows indicate mixes with	es with		Blanks indicate co	Blanks indicate compound not detected in sample	cted in semple.
}						

Table Set VIII.

	Cuality Control Acadage	Distinct Add	Indeed			
Mix	Sampling	Sample	Sample	1,3-Butadiene	1.3-Butadlene	1 3-Ruttadlana
Туре	Date	Number	Volume	5	РРВ	ma/m3
Defection	Defection Limits >>		Liters	-	5.83	0.0131
CTRL 1	16-Sep-93	24 A & B	60.4	Q		
CTRL 2	17.Sep.93	27 A A B	88.6	QN		
Z Z Z	10.000	27.A. & B	86.7	ND		
CTRL 3	20-Sep-93	27 A & B	74.9	1	5.94	0.0134
CTRL 3	21-Sep-93	27 A & B	75.5	7	11.78	0.0265
RBR	22.Sep-93	27.A.&.B	73.7	9	38.20	7,800
RBR	23-Seb-83	27 A & B	73.7	10	60.33	0.1387
RBR 2	24-Sep-93	27 A & B	83.0	3	16.08	0.0361
RBR 2	25-Sep-93	27 A & B	86.9	30	153.62	0.3454
RBR 3	28-Sep-93	27 A & B	85.1	1	5.22	0.0117
RBR 3	29-Sep-93	27 A & B	78.6	е	16.97	0.0382
RBR	01-04-93	27.4.8.8	77.2	*	23 04	GANIA
RBR 4	D4-Oct-93	27.A.&.B	85.0	-	4.63	0.0108
NOTE: Shedec	NOTE: Sheded rows indicate mixes with	ss with		Blanks indicate o	Blanks indicate compound not detected in sample	cted in sample

Table Set IX Nitrosoamine Worker Exposure Results

Results as ug/sample

TABLE SET IX.

NITROSAMINE SAMPLING AND ANALYTICAL RESULTS (Units: ug/sample)

	Backgroun	Fround Sample								
M M M	Sampling	Sample		N-nitroso-	-оводін-N	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-oitroso-
Туре	Date	Number	Volume	dimethylamine	Bed	dipropylamine	dibutylamine	piperidine	pyrrolldine	morpholine
				β'n	Ğ'n	- Bn	Ŝ	ĝ	5	3
Defection	Detection Limits >>		Liters	0.005	900.0	0.008	0.010	0.008	0.008	0.008
CTRL 1	16-Sep-93	25 A	82.1							
CTRL 2	17. Sep. 83	55590	712							
CTRL 2	18-Sep-93	226933	288							
CTRL 3	20-Sep-93	E55934	71.3	0.007						
CTRL 3	21-Sep-93	E55803	8.09							
RBR 1	22-Sep-83	E55942	83.2							
RBR 1	23 Sep 93	E55847	77.2							
RBR 2	24-Sep-93	E56411	20.7							
RBR 2	25-Sep-93	E56398	84.2							
RBR 3	28-Sep-93	E56425	82.7							
RBR 3	29-Sep-93	E56413	86.7							
HBH.4	01:04:83	186353	128							
RBR 4	04-00-93	E58382	8.92							
VOTE: Shadek	VOTE: Shaded rows indicate mixes with	es with		Blanks indicate	compound not	Blanks indicate compound not detected in semple	alor.			
/00007										

100% vingin aggragates.

Daver Opera	erator								
Sampling Date	Sample	Sample Volume	Y E	N-nitroso- dethylamine	N-ntroso- dipropytemine	N-nitroso- dibutylamine	N-nitroso-	N-nitroso- pyrrolidine	N-nitroso- morpholine
		Litera	0.005	0.008	0.008	0.010	ug 0.008	0.008	Ba
16-Sep-93	E55873 & E55885	88.0			-				
17 Sep-83 18 Sep-83	2.A.8.B E55824	50.4 89.9							
20-Sep-93 21-Sep-93	E55936 & 355974 E55802	67.8				970			
22-Sep-93 23-Sep-93	ESS438 & ESS441 ESS948 & ESG941	87.6 77.0				0.010			
24-Sep-93 25-Sep-93	E56405 & E56406 E55393	87.5 84.5							
28-Sep-93 29-Sep-93	E56430 E56417	75.8 92.6							
01 Oct 80 04-0ct 83	E56388 E56381	79.4							
NOTE: Shaded rows indicate mixes with	øs with		Blanks indicate compound not detected in sample.	componed not c	fetected in samy	Jo.			

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Roller Operator

Table Set IX. ······ (continued)

푈	Sampling	Sample	Sample	N-nitroso-	-оводи-N	N-nitroso-	N-nitroso-	N-ritroso-	N-nitroso-	N-oitroso-
- Appe	Date	Number	Volume	dimethylamine	dethytamine	dipropytamine	dibutylamine	piperidine	pyrrolidine	morpholine
				Ď,	Ď'n	5	Bn n	2	5	3
Detection	Detection Limits >>		Liters	0.005	0.008	0.008	0.010	0 008	0.00	0.008
CTRL 1	16-Sep-93	E55881, E55882	86.5		The same of the sa				200.0	0.000
CTRL 2	17 Sep. 83	£55918	39.6							
CTRL2	18-Sep-93	E55925	62.4							
CTRL 3	20-Sep-93	E55935	71.4							
CTRL 3	21-Sep-93	E55800	65.8					*desises		
RBR 1	25-040-22	E55796	8 8							
RBR 1	23-Sep-93	E55949	83.2							
RBR 2	24-Sep-93	E56404	87.0							
RBR 2	25-Sep-93	E56395	87.4				•			
RBR 3	28-Sep-93	E56422	78.6							
RBR 3	29-Sep-93	E56414	81.2			-	-			
BBR 4	01-0-gt	£56391	98.5							
RBR 4	D4-Apr-93	E96378	21.19							
NOTE: Shader	NOTE: Shaded rows indicate mixe	es with		Blanks indicate	Blanks indicate compound not detected in sample.	fetected in sam	ple.			
3	। ୯୯.୮୭ <i>Yıı ପ୍ରମା</i> ଟପ୍ରଫୁଟ ପ୍ରଶାବର									

Stanks indicate compound not detected in sample.	
ğ	
compound	
indicate	
MANKS	

	THE COUNTY OF THE PARTY OF THE									
¥.	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-otroso-	Nailtoso	N-nitroso-	M-offroso-	N-oiftoen
Туре	Date	Number	Volume	dimethylamine	dethylamine	dipropytamine Utg	dibutytamine	piperidine	pyrrolidine	morpholine
Defection	Detection Limits >>		Liters	0.005	0.008	0.008	0.010	0.008	0.008	0000
CTRL 1	16-Sep-93	14 A & B	80.3							200.0
CTRL2 CTRL2	(7.Sep-83 18.Sep-83	E55887 & E55880 E55979	70.0							
CTRL 3	20-Sep-93	E55790 & E55793	65.4							
RBR 1	22.5mp.93 27.5mp.93 27.5mp.93	E85944 & E55939 E85944 & E55939	101.0							
RBR 2 RBR 2	24-Sep-93 25-Sep-93	E56403 & E56412 12 A	95.2 825.1							
RBR 3 RBR 3	28-Sep-93 29-Sep-93	E56424 & E56428 E56426	75.9							
RBR 4 RBR 4	01-0:4-93 04-0:4-93	E58384 E56379	89.1							
VOTE: Shaden	NOTE: Shaded rows indicate mixes with	os with		Stanks indicate	Blanks indicate compound not detected in sample.	letected in sam	ple.			

Table Set IX.

(continued)

	Luteman									
Mk Type	Sampling Date	Sample Number	Sample Volume	N-nitroso- dimethylamine	N-nitroso- dethylamine	N-nitroso- dipropylamine	N-nitroso- dibutytamine	N-ritroso- piperidine	N-nitroso- pyrrolidine	N-nitroso- morpholine
Detection	Detection Limits >>		Litera	0.005	0.008	0.008	0.010	8000	0 008	ng 0 00
CTRL 1	16-Sep-93	E55878, E55877	82.0				And the second second			0000
CIRLO	17-Sep-93	E55917 E55930	74.9							
CTRL 3	20-Sep-93	E55789	72.1							
CTRL 3	21-Sep-93	E55798	72.9							
7034 1 404 1	22.Sep.93	E56807 E56948	95.6							
RBR 2 RBR 2	24-Sep-93 25-Sep-93	E56407 E56399	89.3 93.3							
RBR 3 RBR 3	28-Sep-93 29-Sep-93	E56423 E56415	75.7 93.9							
RBR 4 RBR 4	91-Oct-85 04-Oct-83	E56386 E56380	98.4 79.6							
NOTE: Shedex	NOTE: Shaded rows indicate mix	xes with		Blanks indicate	Blanks indicate compound not detected in sample	Hetected in sam	ole.			

100% virgin aggragates.	Laborer

- Kon L	Number 18 A & B E E E E E E E E E E E E E E E E E E	Volume	dimethytamine	dlethylemine.					
8	1 7	iters			dipropytamine	dibutylamine	piperidine	pyrrolidine	morpholine
8		iters	Š	ĝ.	DÎ)	ďΩ	Ĝ'n	Şî	Ď,
	<u> </u>	2	0.005	0.008	0.008	0.010	800.0	0.008	0.008
		80.5			Maria Cara Cara Cara Cara Cara Cara Cara				
		70.							
	ii ii	3							
_	3 E55792	72.7							
CIKL3 21-Sep-83		71.4							
900 t	CERCOLS	0.00							
		•							
RBH 1 23-Sep-93	088899	88.5							
RBR 2 24-Sep-93	E56410	86.1							
RBR 2 25-Sep-93		87.9							
RBR 3 28-Sep-93	E56427	80.2							
RBR 3 29-Sep-93		101.9							
RBH 01:04.83	E56387	103.3							
		- 58							
ded rows indica 20% virgin eggr	mixes with		Blanks indicate	Blanks indicate compound not detected in semple	detected in sem	ple.			
3									

Table Set IX.

Quality Control Adminster

····· (continued)

至	Sampling	Sample	Sample	Noitroep	Sa Chicago					
Туре	Date	Number	Volume	dimethylamine		dipropylamine	dibutytemine	N-riffroso- piperidine	N-nitroso- pyrrolidine	N-nitroso- morpholine
				3	ĝ.	3	3	5	3	3
Defection	Detection Limits >>		Litera	0 005	800 0	8000	0 0 10	0 008	8000	0.00
CTRL 1	16-Sep-93	24	82.5			a majoritori de l'amino de l'amin				
CTR 2	17.Sep.83	E55918 & E65920	82.0							
CTRL 3	20-Sep-93	E55701 & E55011	7.15						1000	
CTRL 3	21-Sep-93	E55804 & E55805								
RBR 1 RBR 1	22:Sep. 83 23:Sep. 93	E55940 & E55945 E55955 & E55954	22.2							
RBR 2	24-Sep-93	E54709	88.2							
RBR 2	25-Sep-93	E56396	92.3							
RBR 3	28-Sep-93	E56421 & E56429	86.9							
RBR 3	29-Sep-93	E56418	80.2				-			
RBR.4 RBR.4	01-0:d-83 04-0:d-83	E56383	78.8							
NOTE: Shader	NOTE: Shaded rows indicate mixes	ŧ	1	Blanks indicate	compound not	Blanks indicate compound not detected in semple	2/6			

Table Set X Nitrosoamine Worker Exposure Results

Concentrations as ug/m³

TABLE SET X.

NITROSAMINE SAMPLING AND ANALYTICAL RESULTS (Units: µg/m³)

					>>> Chita are a Michograms per meterno <><	言でなりなる	was per meter	۲^3 <<<		
五五	Sampling	Sample	Sample	N-otoso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-
Type	Date	Number	Volume	dimethylamine	dlethylamine	dpropytamine	dibutytamine	piperidine	pyrroldine	morpholine
7				ug/m3	ng/m3	ug/m3	ng/m3	ng/m3	ng/m3	ug/m3
Defection	Detection Limits >>		Liters	0.063	0.100	0.100	0.125	0.100	0.100	0.100
CTRL 1	16-Sep-93	25 A	82.1			The same and the s				
CTRL 2	17-Sep-93	05653	71.4							
CIRLZ	18-Bep-93	226933	288.2							
CTRL 3	20-Sep-93	E55834	71.3	960.0						
CTRL 3	21-Sep-93	E55803	8.09							
RBR (ZZ-Sep-93	555542	83.2							
RBR :	25-Sep 83	E88947	77.2							
RBR 2	24-Sep-93	E58411	90.7							
RBR 2	25-Sep-93	E56398	84.2							
RBR 3	28-Sep-93	E58425	82.7							
RBR 3	29-Sep-93	E58413	86.7							
RBR	01-00-63	E80901	82.7							
VOTE: Shaded	VOTE: Shaded rows indicate mixes			Blanks indicate co	Blanks indicate compound not detected in sample.	ded in semple.				

100% virgin aggregates.

	Daver Operator	perator			>>> Units are in MICROgrams per meter^3 <<<	In MICROGE	uns per mete	r^3 <<<		ļ
Mix	Sampling	Sample	Sample	N-nitroso-	N-otoso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-
Type	Date	Number	Volume	dimethylamine	dethylamine	dipropytamine	dibutylamine	plperidine	pyrrolidine	morpholine
				ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
Defection	Detection Limits >>		Liters	0.062	0.099	0.099	0.124	0.099	0.099	0.099
CTRL 1	16-Sep-93	E55873 & E55885	98.0							
CTRL 2	17.Sep-93	28.5	80.4							
CTRL 2	18-Sep-93	£55924	89.9							
CTRL 3	20-Sep-93	E55936 & 355974	67.8							
CTRL 3	21-Sep-93	E55802	74.2				0.243			
RBR1	22-Sep-93	199523 7 809523	87.6							
RBR 1	23-Sep-93	100533 8 830553	77.0							
RBR 2	24-Sep-93	E58405 & E56408	87.5							
RBR 2	25-Sep-93	E55383	84.5							
RBR 3	28-Sep-93	E58430	75.8							
RBR 3	29-Sep-93	E56417	92.6							
RSR4	01-04-93	585363	296							
7 000		recons	* **		L	-			•	

Blanks indicate compound not detected in sample.

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

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	N-nitroso	morpholine	ng/m3	0.100																		Natioso	morpholine	0.067	7.00												
	M-nitroso-	pyrrolidine	ug/m3	0.100																		-Osobit-N	pyrrolidine tkg/m3	0.057	0.0												
YY ? Hall be min to your many	N-nitroso-	pperidine	ug/m3	0.100																, Y	1	-OSCIPILIOS	piperidine U/m3	0.057													
	N-ntroso-	dibutylamine	ug/m3	0.126																electric services	10		dibutytamine UQ/m3	0.072													
	N-nitroso-	dipropylamine	ug/m3	0.100																ded in sample.	Malfroso	200	upropyumine ug/m3	0.057					_								
	N-nitroso-	dethylamine	ug/m3	0.100										- February						ompound not detected in sample.	N-oitroso-		-	0.057													
	N-ntroso-	dimethylamine	ug/m3	0.063																dains indicate compound not detected in sample.	N-nitroso-	dimethylamine	ug/m3	0.036					n								
	Sample	Noume		Liters	86.5	000	62.4	71.4	2.1.0	03.0	8.30	3.5	0.28	87.4	78.5	2.5		95.5	88.7	3	Sample	Volume		Liters	80.3	777)	65.4	76.6	1010	55.5	05.2	825.1	75.9	8.	89.1	84.8
	Sample	Mumber			E55881, E55882	ERSOIR	E55925	F55935	ESSBOO	2000	E55796	E55949	E56404	E56395	E56422	E56414			E20.5/8		Sample	Number			14 A & B		E55007 a E3380U	E55790 & E55793	E55807 & E55806	E55944 & F55939	E55953 & E55952	E56403 & E56412	12 A	E56424 & E56428	E56426	E56384	E56370
0	Sampling	3		Delection Limits >>	16-Sep-93	17.50m.03	18-Sep-93	20-Seo-93	21-Sep-93		22:Sep-83	23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93		2 (2000	100% virgin eggregates. Screedinan	Sampling	Date		Limits >>	16-Sep-93		Target 63	20-Sep-93	21-Sep-93	22-540-93	23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-Oct #3	04.0501
717	¥ 5	2	;	Delection	CTRL 1	C E	CTRL 2	CTRL 3	CTRI 3		RBR (RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	* 000		4 Vidio	1009	RIX	Type		Detection Limits >>	CTRL 1	د اقلاع	- C EEO	CTRL 3	CTRL 3	RBR 1	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	HBH 4	RBR

	Γ.	ble	7			1	·	· ·	•	···		<u>·</u>	• •	<u>.</u>	•	•	•	 1	• •	<u> </u>		•	•	· ·	·	-	· ·	• •	-		(C	oni	tin	ued	<u>i)</u>
	Naitroso	morpholine	£W/Bn	0 094				_												Noitroe	morpholine	mg/m3	0.094												
	Natroso	pyrrolidine	ng/m?	0 094				_	-											N-ottroso-	pyrrolidine	ug/m3	9 60.0								WAPPEN AND AND AND AND AND AND AND AND AND AN				-
هرسع <<<	N-otroso-	piperidine	SE OF	0 094				777											۳۶	N-nitroso-	piperidine	ug/m3	0.094								.,,				-
ams per met	М-литово-	dibutylamine	2110	0 118															ans per mete	N-nitroso-	dibutytamine	ug/m3	0.117												
by MICROG	N-nitroso-	dipropytemine	2	0 094	-													ected in semple.	In MICROA	N-altroso-	dipropylamine	ug/m3	0.094												
>>> Units are in MICROgrams per meter ^a 3 <<<	N-nitroso-	dlethylamine	2	0 094			1000 1000 1000 1000 1000 1000 1000 100											empound not dete	>>> Units are in MICROgrams per metern3 <>>	N-atroso-	dethylamine	ug/m3	0.094												
	N-nitroso-	dimethylamine txq/m3	B	0.059														Blanks indicale compound not detected in sample		N-nitroso-	dimethylamine	ug/m3	0.059												
	Sample	Volume		Luera	820	74.9	98.9	72.1	72.9	95.6	26.7	89.3	93.3	75.7	93.9	98.4	79.6	,		Sample	Volume		Liters	80.5	75.2	7.78	72.7	*: /	DE 24	86.1	87.9	80.2	101.9	5501	
	Sample	Number			E55878, E55877	£18993	E55930	E55789	E55798	655837	E55948	E56407	E56399	E56423	E56415	E56388	E58380	os with		Sample	Number			18 A & B	E56982	226933	E55792	E33733	FESSES	E56410	E56394	E56427	E56419	E56387	23000
	Sampling	Date	f family as	Delection Layers //	16-Sep-93	17.Sep-83	18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-93	23 Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01-04-93	04-00-93	NOTE: Shaded rows indicate mixes with 100% virgin aggregates.	Laborer	Sampling	Date		Limits >>	16-Sep-93	17-Sep-93	18-Sep-93	20-Sep-93	21-395-12	24.000.EX	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	01.004.83	TREAT WOOD
	M,	ed.	1		CTRL 1	CIRL 2	CIRL 2	CTRL 3	CTRL 3	RBR	RBR 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4	RBR#	NOTE: Shadec 100%		Mix	Туре		Defection Limits >>	CTRL 1	CIRL 2	CIRL 2	CTRL 3	S TIME S	HBP 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR4	T. WORL

Table Set X. (continued)

	Cuality C	Cuality Control Manager			>>> Units are in MICROgrams per metern3 <<<	h MICROAL	ama per mete	y^3 <<<		
M.	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-
<u> </u>	o ate	Number	Volume	dimethytamine	dethylamine	dipropylamine	dibutytemine	piperidine	Dvrrolidine	morpholine
				ug/m3	ug/m3	ng/m3	ug/m3	ug/m3	ua/m3	ua/m3
Defection	Detection Limits >>		Liters	090.0	960:0	960.0	0.119	960 0	9600	9000
CTRL 1	16-Sep-93	24	82.5						222.2	20.0
CIRL 2	17.549.83	E56819 & E55920	82.0							
CTRL 3	20-Sep-93	E55791 & E55933	74.5							
CTRL 3	21-Sep-93	E55804 & E55805	86.1							
RBR 1	25.00 £3	ESSOAD & ESSOAS ERROSES E ERRORE	84.2							
RBR 2	24-Sep-93	E54709	88.2							
Z Z Z	25-Sep-93	E56396	92.3						***************************************	
RBR 3	28-Sep-93	E56421 & E56429	86.9							
RBR 3	29-Sep-93	E56418	80.2		W.J. v. ib		-			
RBR 4	01-00493	E56383	78.8							
		2000	2.78							
NOTE: STROKE	NOTE: Shaded rows indicate mixes with	es with	•	Blanks indicate co	Blanks indicate compound not detected in sample	cled in semole				

Shaded rows indicate mixes with 100% virgin aggregates.

Table Set XI Nitrosoamine Worker Exposure Results

Concentrations as PPB

TABLE SET XI.

Background Sample

NITROSAMINE SAMPLING AND ANALYTICAL RESULTS (Units: PPB)

		W	-						nė para							111			-															
N-nitroso- morpholine	2 6	0.021																	Nothorn	morpholine	0.021													
N-nitroso- pyrrolidine PPR	700	*20.0																	N-offroso-	pyrroldine	0.024													
N-nitroso- piperidine PPB	0 021	170.0																	N-nitroso-	piperidine	0.021													
N-nitroso- dibutytamine PPB	0 019					Ç									-/	, des			N-nitroso-	dibutytamine	0.019	Karata Maria			1000	0.03/								e.
N-nitroso- dipropylamine PPB	0.019														Blanks indicate compound by detacted in seconds	IIBS III DAIDAIDO			N-nitroso-	dpropytamine PPB	0.018													blanks indicate compound not defected in sample.
N-nitroso- diethylamine PPB	0.024														to paracator	bil pilipodiuo			N-nitroso-	dethylamine	0.023													эмропид иок а
N-nitroso- dimethylamine PPB	0.020				0.032										Blanks indicate				N-nitroso-	dimethylamine PPB	0.020													YOU'KS INCRESSO
Sample Volume	Liters	82.1		8 :	71.3	60.8	83.2	77.2	90.7	84.2	82.7	86.7	62.7	78.8					Sample	Volume	Liters	0.88	709	88.8	67.8	0.00	0.77	87.5	84.5	8'5'	92.6	256		ų
Sample Number		25 A	EKKROM	E55927	E55934	E55803	E55942	E55947	E56411	E56398	E56425	E56413	E56391	E56362	s with			rator	Sample	Number		E55873 & E55885	2A48	E55824	E55936 & 355974 E55802	CKKAND & CERAN	E55948 & E55941	E56405 & E56406	E55393	E56430	E56417	E56388	TOOM TO	(I) M
Sampling Date	Detection Limits >>	16-Sep-93	17.5000.00	18-Sep-93	20-Sep-93	21-Sep-93	22-Sep-83	23-Sep-93	24-Sep-93	25-Sep-93	28-Sep-93	29-Sep-93	58-90-10	04-04-93	NOTE: Shaded rows indicate mixes with	100% virgin aggragates.	1	Daver Opera	Sampling	ege ege	Detection Limits >>	16-Sep-93	17-Sep-93	18-Sep-93	20-Sep-93 21-Sep-93			-		28-Sep-93	29-Sep-93	01-04-94		100% virgin aggragatos.
Mix Type	Detection	CTRL 1	e Bio	OTRL 2	CTRL 3	CTRL 3	RBR 1	RBH 1	RBR 2	RBR 2	RBR 3	RBR 3	RBR 4	RBR 4	NOTE: Shade	1009			M	Туре	Detection	CTRL 1	CTRL 2	CTRL 2	CTRL 3) and	RBR1	RBR 2	RBR 2	RBR 3	RBR 3	R89.4	CALCAS CALCAS	100%

Table Set XI. ····· (continued)

¥	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-itroso-	N-itroso	N-ottroeo-	Moitroep	N office
Туре	Date	Number	Volume	ਚ	6	dipropylamine	dibutylamine	piperidine	pyrrolidine	morpholine
				٥	מאק	778	ВЫ	8	BPB	80
Detection	Detection Limits >>		Liters	0.020	0.024	0.019	0.019	0.021	0.024	0.021
CTRL 1	16-Sep-93	E55881, E55882	86.5							170.0
S NO	17-500-83	E55918	39.8							
CTRL 2	18-949-93	E55825	82.4							
CTRL 3	20-Sep-93	E55935	71.4							
CTRL 3	21-Sep-93	E55800	65.8							
RBRI	\$8.4 4 85.23	E55796	848							
RBR 1	23-Sep-93	E55949	83.2							
RBR 2	24-Sep-93	E56404	87.0							
RBR 2	25-Sep-93	E56395	87.4							
RBR 3	28-Sep-93	E56422	78.6							
RBR 3	29-Sep-93	E56414	81.2						***************************************	
HBR	01.04.83	180993	558							
RBR 4	04-404-93	E56378	21.10							
NOTE: Shader	NOTE: Shaded rows indicate mixes	os with		Blanks indicete	Blanks indicate compound not detected in semple.	detected in sem	ple.			
3	। ୧୯୬୭ ହାନ୍ତ୍ରମ ଅନୁକ୍ର ଅନୁକ୍ର ଓଟ	-4								

Roller Operator

ected in semple.
ર્કે
ğ
compound
indicate
Blanks

Mix	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-ntroso-	N-nitrose-	N-nitroso-	N-nitroso-	N-nitroso-
adk -	Date	Number	Volume	dmethylamine PPB	dettytemine PPB	dipropytamine PPB	dibutytamine PPB	piperidine PPB	pyrrolidine PPB	morpholine
Defection	Detection Limits >>		Liters	0.012	0.014	0.011	0.011	0.012	0.014	0.012
CTRL 1	16-Sep-93	14A&B	80.3			-	No. of Concession, Name of Street, or other Persons, Name of Street, Name of S			
CIRL2	17-Sep-83	E55887 & E55880	70.0							
CHES	16-Sep-93	E55529	71.8							
CTRL 3	20-Sep-93	E55790 & E55793	65.4							
CTRL 3	21-Sep-93	E55807 & E55806	9'92							
RBR	22.545-93	E55944 & E55939	0.101							
RBR 1	Z3-Sep-93	E55953 & E55852	85.5							
RBR 2	24-Sep-93	E56403 & E56412	95.2							
RBR 2	25-Sep-93	12 A	825.1							
RBR 3	28-Sep-93	E56424 & E56428	75.9							
RBR 3	29-Sep-93	E56426	4 .96	-						
RBR 4	01-04-63	E56384	1.68							
RBR 4	04-04-93	E56379	8.5							
NOTE: Shade	NOTE: Shaded rows indicate mixes wit	05 With		Blanks indicate	Blanks indicate convolud not detected in semple	tetected in sem	afo			
\$	100% vimin econocies				Sur Primadina	CONTRACTOR OFFICE	į			

NOTE: Shaded rows indicate mixes with 100% virgin aggregates.

Screedman

Table Set XI. (continued)

Mix	Sampling	Sample	Sample	N-nitroso-	N-oltroso-	N-nitroso-	Naitroso	N-pitroso-	Noitroep	N other
Туре	Date	Number	Volume	dimethylamine	dethylamine	dipropytamine	dibutylamine	piperidina	pyrrolidine	morpholine
				n L	n n	Вии	ВЫВ	PPB	PPB	PPB
Detection	Detection Limits >>		Litera	0 0 1 9	0 022	0 017	0 0 1 8	0 0 0 0	0 023	0.020
CTRL 1	16-Sep-93	E55878, E55877	82.0							
CIMI 2	17.Sep. 93	E55917	24.9				1 1 1		1 2 2 2 3 3 4	
CTRL 2	18 Sep-93	E55930	8							
CTRL 3	20-Sep-93	E55789	72.1							
CTRL 3	21-Sep-93	E55798	72.9							- Anna Car
RBRI	28-080-22	E55837	956							
HBR 1	23-Sep-93	E55948	28.7							
RBR 2	24-Sep-93	E56407	89.3							
RBR 2	25-Sep-93	E56399	93.3							
RBR 3	28-Sep-93	E56423	75.7							
RBR 3	29-Sep-93	E56415	93.9		48					
RBR 4	58-90-10	980993	98.4							
RBR 4	04-04-93	E56350	79.6							
NOTE: Shadec	NOTE: Shaded rows indicate mixes	es with		Blanks indicate	compound not	Blanks indicate compound not detected in sample	afc.			
\$00¢	COOK Winning						Š			

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100% vingin aggregates.

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MK	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-ntroso-	N-Atroso-	N-nitroso-
Туре	Date	Number	Volume	dimethylemine PPB	dethytemine	dipropytemine PPB	dibutylemine PPB	piperidine PPB	pyrrolidine PPB	morpholine PPB
Detection	Detection Limits >>		Liters	0.019	0.022	0.017	0.018	0.020	0.023	0.019
CTRL 1	16-Sep-93	18 A & B	80.5				- The Late of the			
CIRL2 CIRL2	17-Sep-93 18-Sep-93	E55992 E55928	75.2							
CTRL 3	20-Sep-93	E55792	72.7							
CTRL 3	21-Sep-93	E55799	71.4							
RBR 1	23.Sep.90	E85860	86.5							
RBR 2	24-Sep-93	E56410	1.98							
RBR 2	25-Sep-93	E56394	87.9						. '	
RBR 3	28-Sep-93	E56427	80.2							
RBR 3	29-Sep-93	E56419	101.9				-			
RBR 4	DI-Oct-93	E56387	1833							
RBR.4	04-04-99	E58377	1:38							
TE: Shede	TE: Shaded rows indicate mixes wi	es with		Blanks indicate	Blanks indicate compound not detected in sample	tetected in sem	şe			
200	1009 Junio				•					

NOTE: Sheded rows indicate mixes with 100% virgin aggregates.

Table Set XI.

Cuality Control Manager

..... (continued)

¥K.	Sampling	Sample	Sample	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-	N-nitroso-
	Date	Number	Volume	dimethylamine PPB	dettrylamine PPB	dpropytemine PPB	dibutytamine PPB	piperidine PPB	pyrroldine PPB	morpholine
efection	Detection Limits >>		Liters	0.019	0.023	0.018	0.018	0.020	0.023	0.020
CTRL 1	16-Sep-93	24	82.5						A CONTRACTOR OF THE PERSONS ASSESSMENT	
CTRL 2	17 Sep 83	0269937816993	82.0							
A LUCK	10-20-93	079600):16							
CIRLS	20-Sep-93	E55791 & E55933	74.5	,		68 ₉ 0				
CTRL 3	21-Sep-93	E55804 & E55805	66.1						•	
RBR 1	22-5ep-93	E55940 & E55945	84.2							
RBR 1	Z3-Sep-93	E65956 & E55954	2 94							
RBR 2	24-Sep-93	E54709	88.2							
RBR 2	25-Sep-93	E56396	92.3							
RBR 3	28-Sep-93	E56421 & E56429	6.38							
RBR 3	28-Sep-93	E56418	80.2						•	
RBR 4	01-Oct-84	E56383	78.8							
RBR 4	04-04-93	E56384	97.0							
heded	NOTE: Sheded rows indicate mixes wit	es with		Blanks indicate	Blanks indicate compound not detected in sample	defected in sem	9/2			

oneded rows indicate mixes w 100% virgin aggregates.