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Pilot-Scale Evaluation of the Potential for Emissions of Hazardous Air Pollutants from Combustion of Tire-Derived Fuel

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16. ABSTRACT The report gives results of experiments in a 73-kW (250,000-Btu/hr) rotary kiln incinerator simulator to examine and characterize emissions from incineration of scrap tire material. The purposes of the project were to: (1) generate a profile of target analytes for full-scale stack sampling, not statistically defensible emission factors for the controlled combustion of scrap tire material; and (2) where possible, give insight into the technical issues and fundamental phenomena related to controlled combustion of scrap tires. Wire-free crumb rubber, sized at < 0.64 cm (< 1/4 in.), was combusted at two feed rates, two temperatures, and three kiln oxygen (O2) concentrations. Along with continuous emissions monitoring for O2, carbon dioxide, carbon monoxide, nitric oxide, sulfur dioxide, and total hydrocarbons, samples were taken to examine volatile and semi-volatile organics, polychlorinated p-dibenzodioxins and dibenzofurans, and metal aerosols. In addition, a continuous polycyclic aromatic hydrocarbon analyzer was used in all tests. Samples were analyzed with emphasis on the 189 hazardous air pollutants listed in the 1990 Clean Air Act Amendments, but other compounds were also identified, where possible. Overall, except for zinc, potential emissions from tire-derived fuel do not appear to be significantly different from emissions from conventional fossil fuel combustion in a well-designed and well-operated combustion device.

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ABSTRACT

Experiments were conducted in a 73 kW (250,000 Btu/hr) rotary kiln incinerator simulator to examine and characterize emissions from incineration of scrap tire material. The purposes of this project are to: (1) generate a profile of target analytes for full-scale stack sampling efforts, not to generate statistically defensible emission factors for the controlled combustion of scrap tire material; and (2) where possible, give insight into the technical issues and fundamental phenomena related to controlled combustion of scrap tires. Wire-free crumb rubber sized to < 0.64 cm (< 1/4 in) was combusted at two different feed rates, two different temperatures, and at three different kiln oxygen concentrations. Along with continuous emissions monitoring for oxygen (O_2), carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), sulfur dioxide (SO_2), and total hydrocarbons (THCs), samples were taken to examine volatile and semi-volatile organics, polychlorinated p-dibenzodioxins and dibenzofurans (PCDD/PCDF), and metal aerosols. In addition, a continuous polycyclic aromatic hydrocarbon (PAH) analyzer was used in all the tests. Samples were analyzed with an emphasis on the 189 hazardous air pollutants (HAPs) listed in the 1990 Clean Air Act Amendments (CAAA), but other compounds were also identified where possible.

Results indicate that, if burned in a steady-state mode, TDF combustion will result in very low emissions of CO, THCs, volatile and semi-volatile organics, and PCDD/ PCDF. Metal emissions were also very low, with the exception of arsenic (As), lead (Pb), and zinc (Zn). Uncontrolled stack concentrations of As and Pb were 37.16 and 65.96 $\mu g/Nm^3$, respectively. Uncontrolled Zn emissions were considerably higher, at 35,465 $\mu g/Nm^3$. Results also indicate that organic emissions can increase significantly when TDF is fired in a non-steady mode. The continuous PAH analyzer appeared to track transient operation well, and gave concentration results in the same range as those derived using EPA standard semi-volatile organic sampling methodologies.

Overall, it appears that, with the exception of zinc, potential emissions from TDF combustion are not significantly different from emissions from combustion of conventional fossil fuels, when burned in a well-designed and well-operated combustion device. If unacceptable particulate loading occurs due to zinc emissions, then the emissions would have to be controlled by an appropriate particulate control device.

PREFACE

The Control Technology Center (CTC) was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to state and local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

The technical guidance projects, such as this one, focus on topics of national or regional interest that are identified through contact with state and local agencies. In this case, the CTC became interested in examining pollutants emitted from both the controlled and uncontrolled combustion of scrap tires.

Initial tests were conducted to examine the emissions from a simulated tire fire. These simulated open burning tests were completed in 1989 and the final report titled "Characterization of Emissions from the Simulated Open Burning of Scrap Tires" was published as EPA report EPA-600/2-89-054. In 1991, a follow-up to the original open burning study was performed, where the previously sampled organic extracts were subjected to Ames bioassays to determine mutagenic potencies of the extracts, then gas chromatography/mass spectroscopy (GC/MS) analysis to determine which classes of compounds accounted for the mutagenic activity. This report was published as EPA report EPA-600/R-92-127 entitled "Mutagenicity of Emissions from the Simulated Open Burning of Scrap Rubber Tires."

The CTC has also published report EPA-450/3-91-024 entitled "Burning Tires for Fuel and Tire Pyrolysis: Air Implications." This report was a paper study examining the emissions from the use of scrap tires as fuel for processes. Although data on criteria pollutants (CO, SO_x, NO_x, and particulates) were available, little data were available as to the emission of air toxics, including metals and organics. This study was funded in order to help close the data gaps uncovered in the paper study, and to give guidance to state and local air pollution agencies as to which pollutants to measure during sampling tests.

ACKNOWLEDGEMENTS

Portions of this work were conducted under EPA Contract 68-DO-0141 with Acurex Environmental Corporation, and EPA Cooperative Agreement CR-814945-01-0 with University of Arkansas (J.E. Dunn). The author would like to thank: Acurex's Jeff Ryan, who was the Acurex task leader, and coordinated all of the sampling and analytical activities; Marc Calvi, who operated the kiln, tire feeder, and flue gas cleaning system; Mike Bowling, Ed Brown, and Ray Thomas, who operated the sampling equipment; and Hal Buck, who built the tire feeder. Finally, the author would like to thank EPA/AEERL's Frank Briden, who performed the XRD and XRF analyses.

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1. INTRODUCTION

1.1. Scrap Tire Generation Issues

Approximately 240 million vehicle tires are discarded annually in the United States[1]. Viable methods for reclamation exist. Some of the attractive options for use of scrap tires include burning, either alone or with another fuel, such as coal, in a variety of energy-intensive processes, such as cement kilns and utility boilers.[2,3,4] Another potentially attractive option is the use of ground tire material as a supplement to asphalt paving materials. Congress has passed a law, the Intermodal Surface Transportation Efficiency Act of 1991,[5] which mandates that up to 20 percent of all federally funded roads in the United States include as much as 9 kg (20 lb) of rubber derived from scrap tires per 907 kg (1 ton) of asphalt by 1997. In spite of these efforts, less than 25 percent of the total amount of discarded tires are re-used or re-processed, and the remaining 175 million scrap tires are discarded in landfills, above-ground stockpiles, or illegal dumps. In addition, these reclamation efforts do little to affect the estimated 2 billion tires already present in stockpiles.

Many landfills are refusing to accept tires because they present not only disposal but also health-related problems. After burial, tires often float to the surface and become partially filled with water. Cutting the tire in half or in pieces can reduce this tendency. However, it is very costly to cut or shred tires for landfilling purposes, and in any event, many sites lack the necessary equipment. Steel-belted radials, which comprise the majority of the nation's discarded tires, are particularly difficult to cut and/or shred. Often, they are simply stockpiled or illegally dumped. These stockpiles and dumps can become a breeding ground for many insects, especially mosquitoes, where water collects in the tires and creates an ideal breeding habitat. The introduction and spread of several mosquito species has been directly attributed to the presence of refuse tires.[6]

1.2. Tire Fires

The growing incidence of tire fires creates another potential health hazard. More tire stockpiles and illegal dumps are coming into existence, and with them the occurrence of tire fires. These fires, sometimes started by arson, generate a huge amount of heat, making them extremely difficult to extinguish. Some of these tire fires have continued for months. For example, the Rhinehart tire fire in Winchester, Virginia, burned for nearly 9 months,[7] exuding large quantities of potentially harmful compounds. Efforts to identify and quantify compounds emitted during tire fires have been successful. Large quantities of volatile organics, such as benzene, semi-volatile organics, such as polycyclic aromatic hydrocarbons (PAHs), and particulates

are released into the atmosphere during tire fires.[8,9] Emissions from simulated open burning of tires were mutagenic and contained several known carcinogens.[10,11]

1.3. Tire Derived Fuel

The potential dangers of air emissions from tire fires, though, don't necessarily mean that controlled combustion of scrap tires will produce harmful emissions. Tires can be burned whole, or can be shredded or chipped before burning. Tires that have been processed into smaller pieces are called Tire-Derived Fuel (TDF). There are three main industries that utilize either whole tires or TDF either as a sole fuel or a fuel supplement.[3] These industries are:

- Electric utilities that use TDF and whole tires as supplemental feed in power generation. One company is using whole tires as its sole source of fuel in power generation.
- Cement manufacturing companies using tires and TDF to supplement their primary fuel (usually coal) for firing cement kilns. Some of the companies are using tires or TDF directly in the kiln, some are using tires or TDF in the precalciner (prior to the kiln).
- Pulp and paper companies using tires or TDF as supplemental fuel in their waste-wood products boilers.

TDF can be additionally processed to remove the steel belts and the metal bead that surrounds the wheel rim. TDF with the metals removed is termed wire-free, and TDF with the wire remaining is termed wire-in. TDF can be purchased in a variety of size ranges all the way down to < 0.7 cm (< 0.25 in). TDF that is very small is termed crumb rubber. TDF has a higher heating value than coal, and contains about as much sulfur as a medium sulfur coal. Table 1-1 lists a comparative fuel analysis by weight for an average TDF and an average coal.

Table 1-1. Comparative fuel analysis, by weight.[12]

Fuel	Composition (percent)							Heating Value
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Ash	Moisture	kJ/kg
TDF	83.87	7.09	2.17	0.24	1.23	4.78	0.62	7,428
Coal	73.92	4.85	6.41	1.76	1.59	6.23	5.24	6,396

1.4. Air Emissions from TDF Combustion

The main environmental concern of using whole tires or TDF as supplementary fuel is the potential for increased air emissions. Pollutants of concern include criteria pollutants (CO, SO_2, NO_x, and particulates), metals, and unburned organics. Title III of the 1990 Clean Air Act Amendments (CAAA) includes a list of 189 Hazardous Air Pollutants (HAPs) of concern.[13] These include volatile organic species such as benzene, polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene, metal species such as lead, and several individual compounds such as polychlorinated p-dibenzodioxins and polychlorinated dibenzofurans (PCDD/PCDF).

Past field data have shown that, for the most part, emissions of most criteria pollutants are reduced when a fraction of the fuel input is replaced with tires or TDF.[3,4] This includes SO_2 (which drops if the primary fuel is a high sulfur eastern coal), and NO_x (since tires have very little fuel nitrogen). Uncontrolled emissions of particulates have generally increased slightly. In some cases the ash characteristics changed such that the particulate control devices worked better, and overall particulate emissions were reduced, especially for systems containing electrostatic precipitators (ESPs). Emissions data for other pollutants, however, are either very limited or non-existent.

1.5. Project Objective

A significant data gap exists in the database of HAPs that can be formed from combustion of tires or TDF. This makes it difficult for state and local air pollution agencies to grant air quality permits allowing a facility to supplement its fuel with tires or TDF, since stack sampling is quite expensive, especially when a list of target analytes does not exist. It was for this reason that the CTC funded this particular project. The purposes of this project are to: (1) generate a profile of target analytes for full-scale stack sampling efforts, not to generate statistically defensible emission factors for the controlled combustion of scrap tire material; and (2) where possible, give insight into the technical issues and fundamental phenomena related to controlled combustion of scrap tires.

There are several issues that are of concern with the use of TDF in combustion devices:

- The effect on products of incomplete combustion (PICs) of the mode of tire feeding (e.g., whole tires vs. shredded tires).
- The potential for the formation of classes of air toxics not normally found in the stacks of the combustion devices while burning conventional fuels.

- The impact of TDF-generated particulate on operation of existing particulate control devices.
- Potential for operational problems due to differences in feed characteristics.
- Potential operational problems due to differences in the residues that are generated.

This project will attempt to address the first two issues listed above. As much as possible, the last three issues will be eliminated from the scope of the project by: 1) utilizing a very uniform feed so as to enable as close to steady-state operation as possible; and 2) to use a grade of TDF that will not generate significant residue.

2. EXPERIMENTAL

2.1. Experimental Equipment

A single laboratory-scale combustor was used to perform all the tests, and the tests were performed in as wide a range of operating conditions as possible, to simulate the process conditions in a variety of combustion units. In addition, it was decided that the scrap tire material be co-fired with natural gas as the primary fuel, rather than coal or wood waste. By using natural gas as the primary fuel, it was hoped that the effect of the TDF could be isolated, rather than adding the additional experimental complications inherent with burning an additional heterogeneous fuel like coal or wood.

2.1.1. Rotary Kiln Incinerator Simulator

The tests were all performed in the EPA's rotary kiln incinerator simulator (RKIS), located in the EPA's Environmental Research Center in Research Triangle Park, NC. The EPA RKIS has been described in detail previously[14,15]. It has been established that the 73 kW (250,000 Btu/hr) pilot-scale simulator exhibits the salient features of full-scale units with thermal ratings 20 to 40 times larger. The simulator matches the volumetric heat release, gas-phase residence time, and temperature profile of many full-scale hazardous waste incineration units, and yet is flexible enough to allow parametric testing. A schematic drawing of the simulator is presented in Figure 2-1. A small afterburner (43.8 kW; 150,000 Btu/hr) mounted at the base of the secondary combustion chamber served to establish near-isothermal operating conditions throughout the unit. Sample ports are located at various locations.

The effluent from the RKIS is ducted into a dedicated flue gas cleaning system (FGCS) consisting of a 1.1 MW (4,000,000 Btu/hr) afterburner, followed by a spray quench, baghouse, and wet scrubber. The presence of the FGCS enables extremely flexible operation of EPA's research combustors such as the RKIS without venting pollutants into the atmosphere.

Measurements made on the RKIS are not intended to be directly extrapolated to full-scale units. It is, for example, very difficult to scale up some of the important gas-phase mixing phenomena from the simulator, where, for instance, stratification is not a significant factor, to a full scale unit, where stratification is known to be significant[16]. In addition, there are significant differences between kilns and other combustion devices, and this study does not address those issues, although some of the information from this study can be applied to other types of combustors, particularly those that burn TDF in the suspension phase. The purpose of the simulator is to individually examine the fundamental phenomena that occur in full-scale units, and to gain an understanding of the qualitative trends that would be found in a full-scale

rotary kiln. In no way should it be inferred that the concentrations of pollutants from this apparatus would be the same as those from full-scale units.

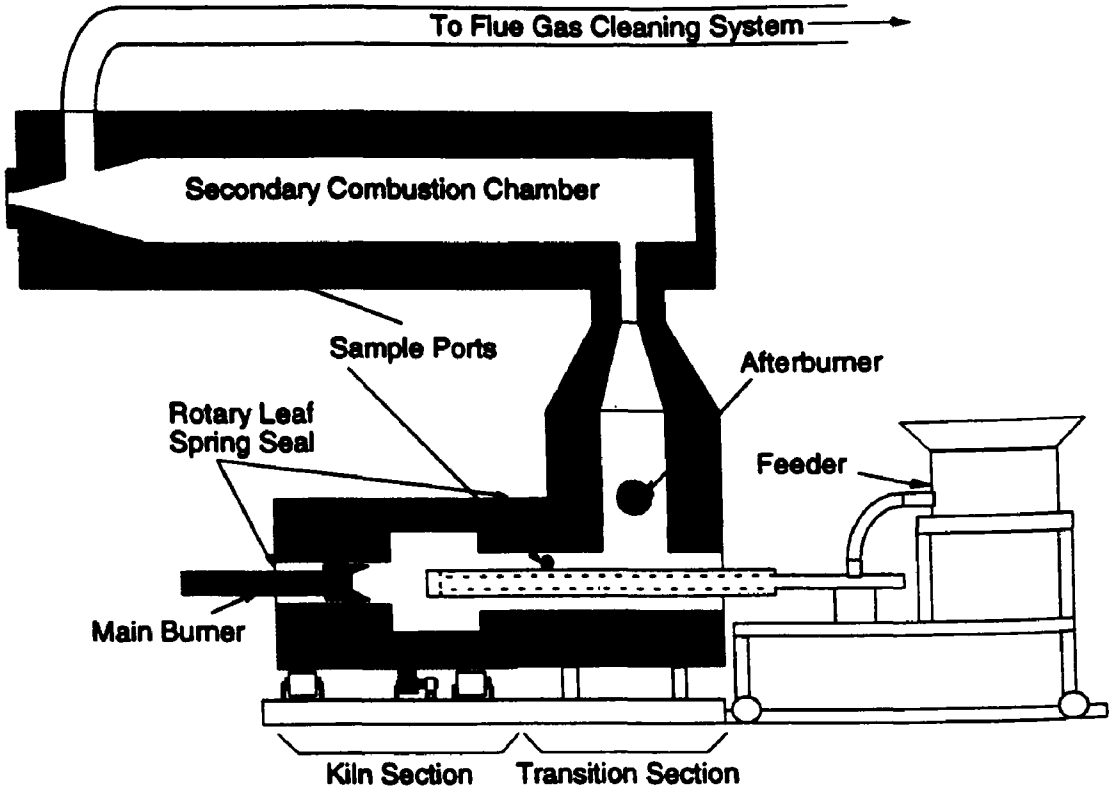

Figure 2-1. Rotary kiln incinerator simulator.

2.1.2. Tire Derived Fuel (TDF)

TDF, consisting of wire-free crumb rubber, sized < 0.64 cm (< 0.25 in), was introduced into the kiln via a vibrating feeder. This feeder (shown in Figure 2-2) consists of an AccuRate screw feeder (model # 604), which dropped a controlled amount of tire material into a stainless steel tube connected to a vibrator (Dyna-Slide model # S0496). The stainless steel tube was inserted through a water jacketed annular tube so that the outlet to the feeder tube lied over the centerline of the kiln's internal recess chamber. Industrial grade nitrogen (N_2) was purged through the feeder to cool and provide an inert atmosphere to prevent the in-transit TDF from combusting or pyrolizing. The feeder enabled feed rates ranging from 0 to 2 kg/hr to be continuously fed into the RKIS.

The TDF material underwent a proximate and ultimate analysis, as well as an analysis for metals, the results of which are tabulated in Table 2-1. TDF contains significant amounts of zinc (Zn), since Zn is extensively used in the tire manufacturing process.

2.1.3. Sampling Equipment

Gases were monitored with continuous emission monitors (CEMs) to measure oxygen (O_2), carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), and total hydrocarbons (THC) both before and after the secondary combustion chamber (SCC), as well as sulfur dioxide (SO_2) at the SCC exit. In addition, a continuous photoelectric polycyclic aromatic hydrocarbon (PAH) analyzer sampled the gases at the stack exit. Table 2-2 lists the gas analyzers used in this study. Figure 2-3 illustrates the sampling locations used for this study.

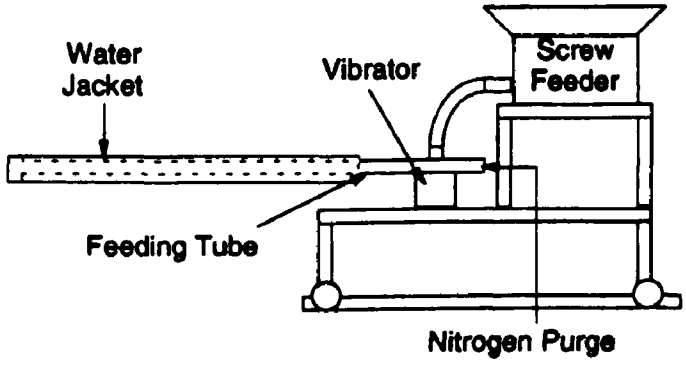

Figure 2-2. TDF feeder.

Table 2-1. Proximate and ultimate analyses of TDF.

Ultimate Analysis	
Moisture	0.84 %
Carbon	76.02 %
Hydrogen	7.23 %
Kjeldahl Nitrogen	0.34 %
Sulfur	1.75 %
Total Halogens (calculated as chlorine)	0.31 %
Ash	7.20 %
Proximate Analysis	
Moisture	0.84 %
Volatile Matter	65.52 %
Ash	7.20 %
Fixed Carbon	26.44 %
Metals	
Cadmium	<5 ppm
Chromium	<5 ppm
Iron	295 ppm
Lead	51 ppm
Zinc	2.14 %
Heating Value	7,666 kJ/kg

Table 2-2. Continuous emission monitors

Analyte	Method	Analyzer
O_2	paramagnetic	Beckman 755, 755R
CO	non-dispersive infrared	Beckman 864
		Horiba PIR-2000
CO_2	non-dispersive infrared	Beckman 864, 880
		Horiba PIR-2000
NO	chemiluminescent	TECO 10A
SO_2*	ultraviolet	Teledyne 611DAMC-X
		TECO 48
		Anacon 207
THC	flame ionization	Beckman 402
PAH	photoelectric	EcoChem PAS 1000e

* the SO_2 analyzers had problems; three different analyzers were tried before reliable operation was attained.

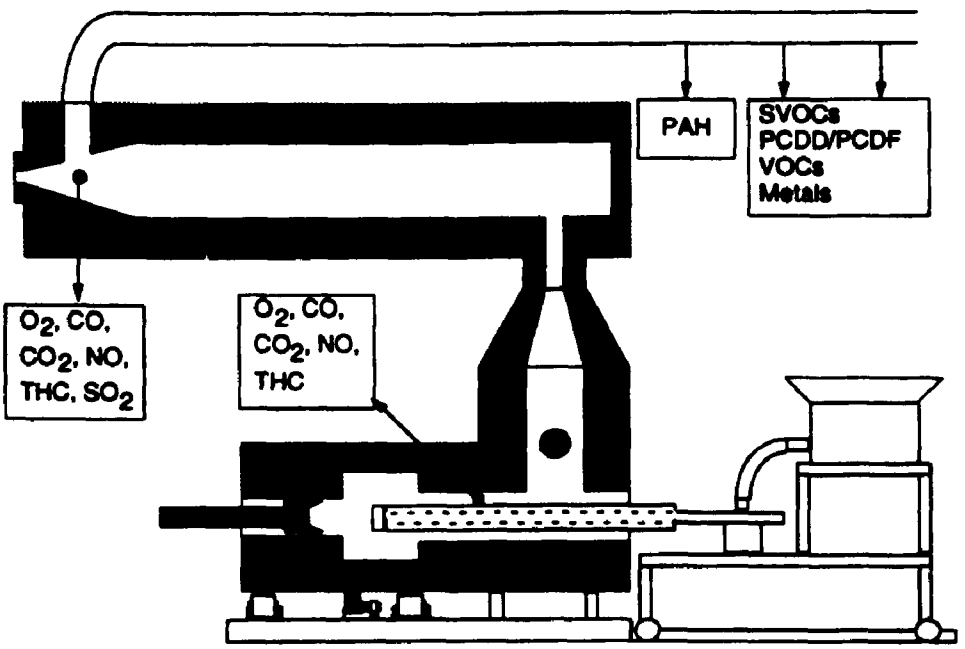

Figure 2-3. Location of sample points.

VOCs were collected by a Volatile Organic Sampling Train (VOST) system[17] located as shown in Figure 2-3. For each run where VOCs were measured, VOST tubes were taken sequentially in triplicate (to judge reproducibility) and each VOST tube was analyzed separately. VOST samples were analyzed using a gas chromatograph/mass spectrometer (GC/MS) system to determine the concentration of 59 separate VOCs, 38 of which are listed under Title III of the CAAAs[18,19]. The majority of these compounds were either very near to or below the detection limits of the equipment. The high frequency of concentrations below the detection limit (BDL) requires that the average concentrations not be reported as precise values. Concentrations below the equipment detection limits should not arbitrarily be assigned the value of zero, nor should they be given the value of the detection limit. Rather, the actual value likely lies between the two extremes. For the purposes of this study, however, if a compound was detected at above the detection limit in one or more of the VOST tubes, then, for averaging purposes, the detection limits were used as the concentrations for the other VOST tubes. All VOC data are presented in Appendix B, however, if a more detailed treatment is required.

Semi-volatile organics and bulk particulate were collected by isokinetic sampling protocols with a Modified Method 5 (MM5) train[20] located as shown in Figure 2-3. The MM5 procedure did not result in multiple samples for each run, as was the case with VOST. Rather, a single integrated sample over the course of the entire run was produced. Collected samples were analyzed using approved analysis procedures[21] for 95 semivolatile organic compounds, 61 of which are listed as hazardous under Title III[13]. Of the 61 listed compounds, 20 are PAHs.

Metal aerosols were collected by the Multiple Metals Train (MMT),[22] with the exception that the potassium permanganate ($KMnO_4$) impinger solution (used for collection of mercury (Hg) from the sample) was omitted. No literature could be found that reported the presence of mercury in tires, and due to the limited funding for this project, mercury analysis was omitted, which made it unnecessary to configure the sampling train for mercury sampling.

PCDD and PCDF were sampled using the MM5 train with the protocols laid out in EPA Method 23[23] and analyzed by high resolution gas chromatography/low resolution mass spectrometry (HRGC/LRMS), using a Hewlett-Packard 5890/5970 Gas Chromatography/Mass Selective Detector (GC/MSD) system and methods that are slight adaptations to EPA Method 23 and RCRA Method 8280[24]. Isotopically labeled internal standards for each congener class are incorporated during the extraction and cleanup phases of the analytical procedures to enhance analytical accuracy. For the GC/MSD analyses, the procedures differed from RCRA Method 8280 only in the number of labeled congeners used to calculate recoveries, i.e.,

congeners containing the 2,3,7,8 substitution positions are avoided as a safety precaution. An internal standard was used that consisted of a $^{13}C_{12}$-labeled congener from each tetra-octa PCDD/PCDF (except for octa-CDF). The recovery standard $^{6}C_{12}$-labeled TCDD is added before injection on the GC. The recovery must be within 40 and 120 percent to be acceptable.

2.1.4. Data Acquisition System

All CEMs and thermocouples are connected to a microcomputer-based data acquisition system which allows on-screen visualization of data, conversion of data to engineering units, and date/time stamping of data for later reference. This system, run on an Apple Macintosh IIcx, uses the Strawberry Tree Workbench Mac software[25]. All files are output in tab-delimited ASCII format for later manipulation. Data were logged to disk every 10 sec. for all input channels.

2.2. Experimental Approach

2.2.1. Experimental Design

A response-surface experimental design[26] was used to reduce the number of tests required. The primary variables of interest (both dependent and independent) are listed in Table 2-3. Note also that some variables are functions of other variables, for example, the feed rate of tires and the gas temperature inherently cannot be totally separated from the oxygen concentration.

Table 2-3. Primary variables of interest.

Independent	
	1) Kiln exit temperature
	2) Kiln O_2 concentration
	3) Tire feed rate
	4) Feed mode (batch vs. continuous)
Dependent	
	1) CO emissions
	2) particulate emissions
	3) metals emissions
	4) PIC emissions (THC, PAH, volatile organics, semi-volatile organics, and PCDD/PCDF)

The test conditions were achieved by varying kiln firing rate, combustion air flow rate, and tire feed rate. Figure 2-4 illustrates a scatter plot the experimental design points achieved with respect to the independent variables No. 1 through 3. For the response-surface methodology to be valid, data must be available over the desired range of values of the independent variables. Variations in independent variable No. 4 (mode of TDF feeding) were achieved by performing two additional tests: one test where the tires were introduced in 300 g batches spaced 10 min. apart; and one test where the kiln air flow rate was ramped up and down every 10 minutes to change the kiln oxygen concentration. Table 2-4 tabulates the run numbers and their respective kiln operating conditions.

2.2.2. Experimental Procedures

Since the feeder is water-cooled, it was removed when experiments were not being performed so that the loss of cooling water would not lead to failure of the water jacket and thermal shock to the kiln's refractory from having water being poured on the refractory once cooling water flow was re-established. Another side effect of the feeder being water cooled was that it provided a heat sink for the hot kiln gases, resulting in cooler operation than is normally found at the identical fuel and air settings without the feeder present. For this reason, the kiln was run at a higher firing rate with the feeder installed so that temperatures could be maintained.

With the exceptions of Runs No. TB8 and TB9, the following test protocol was used. The kiln was allowed to come to thermal equilibrium at a given temperature by setting the main burner and afterburner to the desired air and fuel flow rates. The main flame was then extinguished, and the tire feeder was weighed and installed. Once the feeder was installed, the main flame was re-lit, and the desired run settings were achieved. On blank runs (with 0 kg/hr TDF feed rate), the feeder was installed as well, and the nitrogen purge was maintained; however, no TDF was fed. The desired TDF feed rate was dialed into the feeder control, and the system was allowed to stabilize. Due to the time it took for the TDF to travel down the feeder tube, it took approximately 30 minutes from the initiation of TDF feed before the system stabilized. Once steady-state was achieved, sampling was initiated. For runs where no organic or metals sampling was to be performed, CEMs were operated for 10 minutes, with the CEM results being averaged over the 10 minute run time. For runs where organic or metals sampling was performed, sample duration was determined by the requirements of the sampling methodology being used, which was determined by the requirements that a given volume be pulled through the sample train at isokinetic conditions.

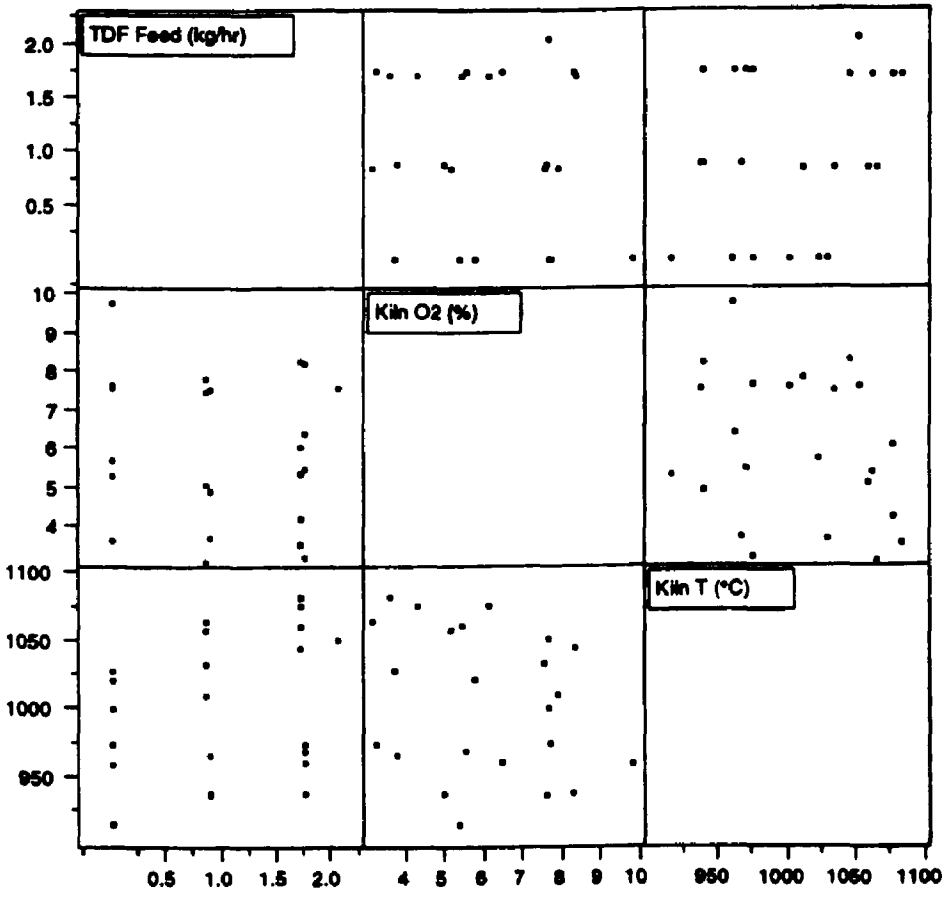

Figure 2-4. Scatter plot matrix of experimental conditions.

Table 2-4. Run conditions.

Run	TDF Feed Rate (kg/hr)	% Total Fuel as TDF	Kiln O_2 (%)	Kiln T (°C)	SCC T (°C)	Other Samples‡
TB1*	0.74	7.23	8.28	1009	896	V
TB2*	1.95	16.95	7.17	1034	924	S
TB3*	2.02	17.14	7.35	1045	962	V, S
TB4*	1.81	15.50	8.51	1030	964	S
TB5*	0.00	0.00	9.23	990	952	V, S
TB6	2.05	17.30	7.64	1052	979	D, M
TB7	0.00	0.00	9.82	959	896	D, M
TB8+	2.31	19.18	6.45	1059	962	V, S
TB9+	1.74	14.97	8.38	1042	918	V, S
TB10	0.00	0.00	7.66	975	824	
TB11	0.00	0.00	3.68	1029	830	
TB12	0.00	0.00	5.71	1022	842	
TB13	0.00	0.00	7.62	1001	857	
TB14	0.85	7.80	7.85	1011	884	
TB15	0.85	7.80	3.10	1065	875	
TB16	0.85	7.80	5.07	1058	886	
TB17	0.85	7.80	7.53	1033	901	
TB18	1.70	14.54	5.40	1061	909	
TB19	1.70	14.54	3.55	1082	910	
TB20	1.70	14.54	8.32	1045	927	
TB21	1.70	14.54	4.24	1077	925	
TB22	1.70	14.54	6.06	1077	931	
TB23	0.00	0.00	5.33	916	860	
TB24	0.88	11.99	4.91	939	871	
TB25	0.88	11.99	7.59	937	879	
TB26	0.88	11.99	3.70	966	872	
TB27	1.75	21.41	3.18	975	884	
TB28	1.75	21.41	6.39	962	887	
TB29	1.75	21.41	8.23	938	889	
TB30	1.75	21.41	5.49	970	887	

‡ V = volatile organics; S = semi-volatile organics; M = metals; D = dioxins

* electrical noise problems on the CEMs.

\+ non-continuous feed tests

After sampling was completed, the kiln flame was extinguished, the feeder removed and re-weighed, and the kiln re-lit. Mass feed rates were calculated based on the weight difference between the feeder at the beginning and at the end of the day (including the mass of TDF added during the day to keep the feeder full). Feed rates were adjusted by an estimate of the amount of TDF that was found to build up in the feeder tube during calibration runs.

For Run No. TB8, the procedure above was performed, with the additional operation of changing the volumetric flow rate of the main burner combustion air back and forth between 140 Nm^3/hr (5000 scfh) and 112 Nm^3/hr (4000 scfh) every 10 minutes to simulate transient operation. For Run No. TB9, an attempt was made to simulate the transient operation that might occur in a system feeding whole tires at periodic intervals rather than feeding TDF continuously. This test was performed by loading 300 g of TDF into a 0.9 L (1 qt) cardboard container and feeding the containers into the kiln every 10 min, by using a manual charging basket/ramrod feeder as described previously[12,13]. Note that isokineticity was not precisely maintained during the transient tests, due to the constantly changing stack gas volumes.

Particulate samples that were found deposited in the sight ports on the TDF feeder were subjected to X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) analysis to determine composition and speciation of the metals in the particulate.

3. RESULTS

3.1. Continuous Emission Monitor Samples

3.1.1. General Observations

All CEM data were averaged over the course of the run to yield a single number. The CEMs were giving extremely noisy responses in runs No. TB1 through TB5. This noise problem was traced to the electrical circuits, and was eliminated in all runs after TB5. For this reason, validity of average responses from many of the CEMs (especially CO, SO_2, PAH) are questionable for runs No. TB1 through TB5. Table 3-1 lists the average values from the CEMs taken at the kiln exit sample port. Table 3-2 lists the average values from the CEMs taken at the exit of the secondary combustion chamber, with the exception of the PAH data, which were taken at the duct sample port shown in Figure 2-3. Other data of importance, such as kiln and afterburner firing rates, flow rates of the gaseous effluent leaving the kiln and secondary combustion chamber (SCC), and relevant temperatures, are listed in Table 3-3. In addition, the NO and SO_2 analyzers were not always behaving as per required Quality Assurance guidelines, due to excessive drift of the responses between initial pre-run calibration and post-run Quality Control checks.

Of particular note is the fact that THC measurements (both at the kiln exit and the SCC exit) were, for all practical purposes (except for Run No. TB9, which will be discussed later), in the range from 0 to 5 ppm, which is of the same order of magnitude as the resolution of the THC analyzer. In addition, CO measurements were always (except, again, in the case of Run No. TB9) less than 100 ppm, indicating that "good" combustion conditions were occurring. This is likely from the steady-state feeding of the TDF, which burned quite well when fed at a constant rate. Also note that for every run performed at steady-state conditions, stack CO measurements were on the order of 20 ppm; even those where no TDF was being burned. This observation would indicate that the SCC was successfully burning residual CO from the kiln down to a lower limit of approximately 20 ppm. Emissions below this limit were not attainable from the apparatus given the fact that the afterburner conditions were fixed for the entire set of runs.

3.1.2. Regression Analysis of CO and PAH Data

Based on these initial observations, it was decided that THC, both at the kiln exit and SCC exit, as well as CO at the SCC exit, would not be appropriate variables to examine with regards to the effect of TDF on emissions. Data were prepared for a regression analysis, with the dependent variables being the emission rates of CO at the kiln exit; and the emission rate of PAH at the stack exit. Data used for the regression analysis are listed in Table 3-4. Note that only the steady-state tests were used in the regression analysis.

Table 3-1. CEM data taken at kiln exit.

Run	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	THC (ppm)
TB1*	8.28	7.33	33	52	3
TB2*	7.17	7.45	36	73	3
TB3*	7.35	7.70	16	58	0
TB4*	8.51	7.14	31	54	1
TB5*	9.23	6.31	44	39	0
TB6	7.64	7.77	20	55	1
TB7	9.82	5.85	17	32	2
TB8+	6.45	8.38	30	60	1
TB9+	8.38	7.32	700	53	43
TB10	7.66	7.09	30	39	-1
TB11	3.68	9.34	38	53	0
TB12	5.71	8.22	36	47	1
TB13	7.62	7.15	35	40	0
TB14	7.85	7.25	35	46	1
TB15	3.10	9.97	42	62	2
TB16	5.07	8.86	40	57	1
TB17	7.53	7.43	35	50	1
TB18	5.40	8.92	44	62	1
TB19	3.55	10.00	48	64	1
TB20	8.32	7.35	41	54	1
TB21	4.24	9.59	47	64	1
TB22	6.06	8.71	43	62	1
TB23	5.33	8.08	28	56	0
TB24	4.91	9.03	50	66	1
TB25	7.59	7.55	45	64	1
TB26	3.70	9.71	51	65	2
TB27	3.18	10.24	59	68	1
TB28	6.39	8.54	54	66	2
TB29	8.23	7.39	54	58	1
TB30	5.49	8.94	53	68	1

* electrical noise problems on the CEMs.

\+ non-continuous feed tests

Table 3-2. CEM data taken at SCC exit.

Run	O_2 (%)	CO_2 (%)	CO (ppm)	NO (ppm)	THC (ppm)	SO_2 (ppm)	PAH (ng/m^3)
TB1*	7.59	8.62	16	49	-2	12	1437
TB2*	5.43	9.44	14	64	-1	81	2278
TB3*	5.62	9.62	12	48	-2	59	2284
TB4*	6.78	9.07	20	62	2	67	3289
TB5*	7.50	8.44	16	52	1	14	1941
TB6	6.06	9.45	15	60	1	51	982
TB7	8.10	7.80	9	42	2	35	429
TB8+	5.20	10.07	18	58	1	76	1957
TB9+	8.85	8.11	70	46	6	26	214000
TB10	6.23	8.86	13	28	0	.	410
TB11	2.82	10.77	17	36	0	.	630
TB12	4.49	9.94	16	35	-1	.	404
TB13	6.17	9.01	16	30	0	.	426
TB14	6.60	8.99	16	35	0	42	767
TB15	2.48	11.18	20	46	0	.	1553
TB16	4.07	10.35	19	44	0	103	1313
TB17	6.28	9.15	17	41	0	106	702
TB18	4.30	10.46	19	50	0	.	1939
TB19	2.61	11.33	20	50	0	96	2364
TB20	7.12	9.00	18	45	0	82	1474
TB21	3.20	11.01	20	50	0	74	1937
TB22	5.01	10.18	20	50	0	78	1734
TB23	4.11	9.94	13	32	-1	7	925
TB24	4.40	10.30	19	36	-1	26	1581
TB25	6.85	9.02	18	37	-1	22	618
TB26	3.68	10.60	20	36	0	42	1550
TB27	3.47	10.83	20	37	0	108	1787
TB28	5.97	9.68	20	39	0	106	1632
TB29	7.36	8.88	20	36	0	100	1130
TB30	5.39	9.93	19	37	0	84	1551

* electrical noise problems on the CEMs.
\+ non-continuous feed tests
. analyzer non-operational

Table 3-3. Burner information for kiln and SCC.

Run	Main Burner Air Flow Rate (Nm^3/hr)	Main Burner Fuel Flow Rate (Nm^3/hr)	Main Burner Firing Rate (kW)	SCC Burner Air Flow Rate (Nm^3/hr)	SCC Burner Fuel Flow Rate (Nm^3/hr)	SCC Firing Rate (kW)	TDF Firing Rate (kW)	Kiln Gas Flow Rate (Nm^3/hr)	SCC Gas Flow Rate (Nm^3/hr)
TB1	146.82	8.64	91.07	36.9	3.43	37.23	9.28	160.36	196.32
TB2	161.55	8.75	92.30	36.9	3.43	37.23	21.96	171.75	208.84
TB3	158.55	8.92	94.02	36.9	3.43	37.23	22.50	148.97	208.92
TB4	165.48	9.03	95.06	36.9	3.43	37.23	20.50	147.56	215.89
TB5	144.59	9.03	95.18	36.9	3.43	37.23	0.00	136.83	194.20
TB6	165.29	8.95	94.22	36.9	3.43	37.23	22.74	172.33	215.69
TB7	152.74	8.98	94.63	36.9	3.43	37.23	0.00	148.12	202.29
TB8	153.00	8.92	93.94	36.9	3.43	37.23	25.16	137.38	203.41
TB9	169.79	9.03	95.02	36.9	3.43	37.23	19.80	177.24	220.16
TB10	135.27	9.15	96.28	36.9	3.43	37.23	0.00	139.77	184.97
TB11	107.60	9.15	96.28	36.9	3.43	37.23	0.00	117.81	157.06
TB12	120.15	9.15	96.28	36.9	3.43	37.23	0.00	128.22	169.78
TB13	134.85	9.15	96.28	36.9	3.43	37.23	0.00	139.77	184.53
TB14	148.18	9.15	96.28	36.9	3.43	37.23	10.42	140.15	197.35
TB15	115.51	9.15	96.28	36.9	3.43	37.23	10.42	118.12	164.46
TB16	127.37	9.15	96.28	36.9	3.43	37.23	10.42	128.60	176.53
TB17	145.80	9.15	96.28	36.9	3.43	37.23	10.42	140.15	194.99
TB18	142.24	9.15	96.28	36.9	3.43	37.23	19.41	140.54	191.09
TB19	129.86	9.15	96.28	36.9	3.43	37.23	19.41	134.86	178.71
TB20	165.94	9.15	96.28	36.9	3.43	37.23	19.41	151.88	214.73
TB21	134.62	9.15	96.28	36.9	3.43	37.23	19.41	140.54	183.47
TB22	146.03	9.15	96.28	36.9	3.43	37.23	19.41	140.54	194.85
TB23	78.32	5.89	62.06	36.9	3.43	37.23	0.00	89.90	124.18
TB24	86.51	5.89	62.06	36.9	3.43	37.23	11.90	90.29	132.35
TB25	98.29	5.89	62.06	36.9	3.43	37.23	11.90	90.29	144.13
TB26	81.61	5.89	62.06	36.9	3.43	37.23	11.90	90.29	127.43
TB27	91.10	5.89	62.06	36.9	3.43	37.23	21.26	90.68	136.89
TB28	106.73	5.89	62.06	36.9	3.43	37.23	21.26	105.13	152.69
TB29	120.63	5.89	62.06	36.9	3.43	37.23	21.26	119.84	166.76
TB30	102.51	5.89	62.06	36.9	3.43	37.23	21.26	105.07	148.47

Table 3-4. Data used for regression analysis.

Run	CO emission rate (g/hr)	Estimated CO emissions (ng/J)	PAH emission rate (mg/hr)	Estimated PAH emissions (ng/J)
TB1*	5.33	16.26	0.28	8.54E-04
TB2*	6.34	19.08	0.48	1.44E-03
TB3*	2.36	6.97	0.48	1.42E-03
TB4*	4.51	13.18	0.71	2.07E-03
TB5*	5.99	17.48	0.38	1.11E-03
TB6	3.56	10.50	0.21	6.19E-04
TB7	2.50	7.34	0.09	2.64E-04
TB8+	4.01	11.86	0.40	1.18E-03
TB9+	125.96	368.26	47.11	1.38E-01
TB10	4.13	11.92	0.08	2.31E-04
TB11	4.32	12.46	0.10	2.89E-04
TB12	4.45	12.84	0.07	2.02E-04
TB13	4.82	13.91	0.08	2.31E-04
TB14	4.85	13.99	0.15	4.33E-04
TB15	4.77	13.76	0.26	7.50E-04
TB16	4.98	14.37	0.23	6.64E-04
TB17	4.84	13.97	0.14	4.04E-04
TB18	6.00	17.31	0.37	1.07E-03
TB19	6.27	18.09	0.42	1.21E-03
TB20	6.20	17.89	0.32	9.23E-04
TB21	6.44	18.58	0.36	1.04E-03
TB22	5.98	17.25	0.34	9.81E-04
TB23	2.47	11.06	0.11	4.92E-04
TB24	4.48	20.05	0.21	9.40E-04
TB25	3.99	17.86	0.09	4.03E-04
TB26	4.48	20.05	0.20	8.95E-04
TB27	5.18	23.19	0.24	1.07E-03
TB28	5.62	25.16	0.25	1.12E-03
TB29	6.53	29.23	0.19	8.50E-04
TB30	5.52	24.71	0.23	1.03E-03

* electrical noise problems on the CEMs.

\+ non-continuous feed tests - not used in regression analysis

The regression analysis was performed using the SAS statistical software package. Parameters examined in the regression analysis (and their definitions) are listed in Table 3-5. The RSQUARE option in SAS procedure REG was used to optain the best fitting models using R**2 (multiple R-squared) as a selection criterion. An attempt was made to model the variation in each of the response variables taken in each of three forms, namely its actual value, its logarithm, and its reciprocal. The available predictor set initially consisted of KFEEDPCT, KILNT, KILNO2, and either KILNGAS or KILNFUEL, where use of each form of the latter was used separately. In addition, all squares and two-factor products of the four predictors were made available for selection. Once the highest R^2 models were obtained in this way, then reciprocals and

logarithms of KILNO2, KILNT, and either KILNGAS or KILNFUEL were made available for switches among the predictors, using the MAXR option, with the goal of obtaining an improved fit (higher R^2) while maintaining the original number of predictors. The ultimate criterion for choosing a final model was that all predictors in the model were significant, and no other predictor could be added from within the excluded list of predictors which attained significance when added to the model. A significance level of $p \leq 0.01$, indicating the probability level that the partial effect of a predictor is significantly different from zero, was chosen as the acceptance criterion.

Table 3-5. Parameters examined in regression analysis.

Parameter	Definition
Dependent variables	
KFEEDPCT	% of kiln fuel as TDF
KILNO2	kiln O_2 (%)
KILNT	kiln T (°C)
KILNAIR	kiln combustion air (Nm^3/hr)
KILNFUEL	kiln natural gas fuel (Nm^3/hr)
KILNGAS	kiln exhaust flow rate (Nm^3/hr)
Response variables	
COEMISFAC	CO emissions (ng/J total heat input)
PAHEMISFAC	PAH emissions (ng/J total heat input)

Table 3-6 lists the model predictors for the regression model. By multiplying the predictor by the value of the coefficient and summing this total for all coefficients, the predicted value of the result can be derived. Note that certain models require this total must be exponentiated after being calculated. The simplest model for COEMISFAC involves only KFEEDPCT and KILNFUEL. This is attributed to the fact that COEMISFAC was so reactive every time KILNFUEL underwent a change. The list of KILNGAS values are relatively noisy by comparison. Model-1 and Model-2 apply almost identically to the prediction of ln(COEMISFAC). Estimated regression coefficients (R^2) are shown for each model. p-values associated with tests of the partial effects of each of the terms in the models were universally ≤ 0.0001. The best model based on KILNGAS rather than KILNFUEL provides a direct prediction of COEMISFAC (without exponentiation) and is characterized below in terms of its estimated coefficients as Model-3. Again, p-values associated with tests of the partial effects of the individual terms in the model were all ≤ 0.0001. This model involves three of the four pre-selected predictor variables, KILNO2 having no significant effect in the model. Furthermore, these predictors are specific to the untransformed response, COEMISFAC. By contrast, R^2 drops to 0.9005 when the same predictors are used to predict ln(COEMISFAC). The single difficulty with use of either Model-1 or Model-2, is that they both seriously underestimate the observed response for Run TB29.

Table 3-6. Model predictors.

Predictor	Model-1*	Model-2*	Model-3
COEMISFAC	R2 = 0.95189	R2 = 0.95193	R2 = 0.9374
intercept	55.69512	-417.507	26.888
KFEEDPCT	0.019876	0.0198886	0.383806
KILNFUEL	-14.822410	•	•
KILNFUEL^2	0.984505	•	•
ln(KILNFUEL)	•	139.523	•
1/KILNFUEL	•	1016.867	•
KILNT^2	•	•	-8.706E-5
KILNGAS^2	•	•	-4.93807E-3
KILNT x KILNGAS	•	•	1.210081E-3
PAHEMISFAC	R2 = 0.9206	R2 = 0.9778	R2 = 0.9410
Intercept	3.7475E+00	7.1829E+01	-1.3428E-02
KFEEDPCT	•	-2.8505E-01	-2.2349E-04
KILNO2	•	•	-3.0193E-04
KILNT	•	-4.4491E-02	•
KILNGAS	•	-5.1808E-01	•
KFEEDPCT^2	-1.5930E-03	-1.4292E-03	
KILNO2*KFEEDPCT	-1.0619E-02	•	•
KILNT*KFEEDPCT	•	3.7836E-04	2.5232E-07
KILNT*KILNO2	•	-1.0769E-03	•
KILNGAS*KFEEDPCT	1.3552E-03	•	•
KILNGAS*KILNO2	•	8.1143E-03	2.0806E-06
KILNGAS*KILNT	-5.5331E-05	3.4782E-04	6.1586E-08
KILNGAS^2	•	•	-3.0212E-07
1/KILNGAS	-6.2066E+02	-1.7409E+03	•
1/KILNT	•	•	1.0991E+01

* - model requires exponentiation of result to convert to predicted COEMISFAC and PAHEMISFAC.

A complete list of the residuals, i.e., [observed - fitted], for all 3 models can be found in Table F-2 in Appendix F. Of course, the residuals shown there for Models 1 and 2 are not actually the residuals of the least squares fit. The latter were the basis for the fit in the logarithmic scale; the former were obtained by exponentiating the predicted logarithms and subtracting the result from the observed.

By varying individual parameters from the model while holding everything else constant, it is possible to visualize the individual effects of predictors. Figure 3-1 illustrates the effect of TDF feed fraction on emissions of CO (in ng/J total heat input), using nominal values of KILNT = 1000 °C, KILNGAS = 140 Nm^3/hr, KILNFUEL = 9.1Nm^3/hr, and KILNO2 = 7%, for each of Models 1 through 3. Notice that Models 1 and 2 are virtually indistinguishable from each other. Predicted COEMISFAC was insensitive to kiln temperatures and oxygen concentrations, and did not even exhibit a significant effect of TDF feed rate. Note that only the steady-state tests were used for all of the regression analysis. The model would only

predict an increase in CO emissions from a minimum of 10.3, to a maximum of 18.8 [ng/J total kiln fuel input] while increasing TDF from 0 % to 20 % of the kiln fuel input. Apparently, TDF combustion, when done in a steady-state mode, does not significantly increase CO emissions from those found during natural gas combustion.

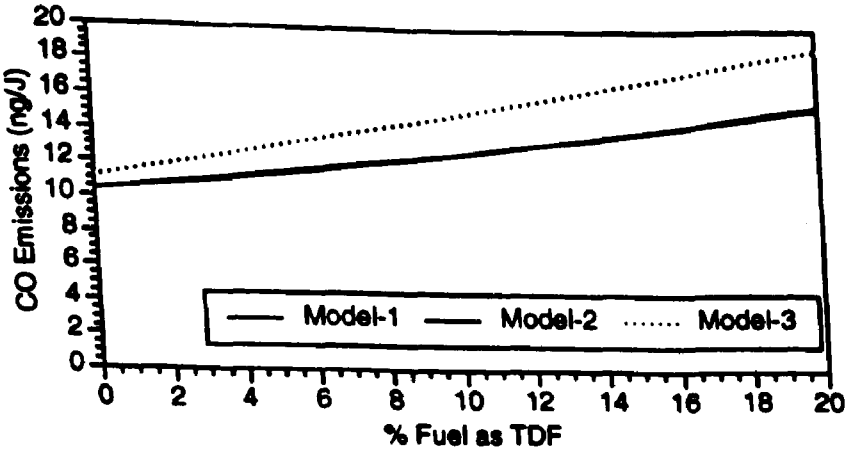

Figure 3-1. Model predictions: emissions of CO as a function of TDF feed rate; using KILNT = 1000 °C, KILNGAS=140 Nm^3/hr, KILNFUEL=9.1Nm^3/hr, and KILNO2 = 7%.

It was unusually difficult to pinpoint an optimal model for PAHEMISFAC. Of the three forms of PAH response attempted, linear, logarithmic, and reciprocal, ln(PAHEMISFAC) provided the greatest collection of acceptable alternative models. In fact, using SAS proc RSQUARE to examine all possible models, models were found containing 5, 6, 7, 8, and 9 predictors, all with $R^2 > 0.9$ and all of whose predictors were statistically significant at the 0.01 level ($p \leq 0.01$). Three predictor variables were shared in common between R^2 -optimal 5 and 9 term models, namely KILNGAS*KILNT, RKILNGAS, and FEED^2. Based on use of Mallow's C statistic, the data suggested the 9-term model to be most appropriate. Among the 5 - 9 term semi-log models, this is the preferred one, though the background "full" model used to reach this conclusion was based on only 4 error degrees of freedom, i.e., fitting a "FULL" model with 19 parameters to 23 data points. For the sake of comparison, we have included estimated coefficients and for both the R^2 -optimal 5-term (Model-1) and 9-term (Model-2) models for prediction of ln(PAHEMISFAC). The partial effect of each of the terms in the models is significant at the 0.01 level ($p \leq 0.01$).

A complete list of the residuals, i.e., [observed - fitted], for all 3 models can be found in Table F-3 in Appendix F. Of course, the residuals shown there for Models 1 and 2 are not actually the residuals of the least squares fit. The latter were the basis for the fit in the logarithmic scale; the former were obtained by exponentiating the predicted logarithms and subtracting the result from the observed. Values shown in the

following table are these differences multiplied by 10 . As is evident in Table F-3, the shrinkage in absolute values of residuals is not universal in going from the best 5-term model to the best 9-term model, e.g., TB24 and TB27. Using linear PAHEMISFAC as the response variable, one 7-predictor model, labeled as Model-3, nearly satisfied all criteria for model selection. The exception was that $p \geq 0.0180$ for the partial effect of KILNGAS*KILNO2, whereas the p-values for testing the partial effects of all other predictors were universally ≤ 0.01 . However, it appears to be an excellent model, sharing four predictors in common with Model-2, having an acceptable $R^2 \geq 0.9410$, and having smaller absolute residuals, in general, than either Model-1 or Model-2. In addition, the data seemed to "home in" on the model, whereas with ln(PAHEMISFAC) as the response, choice among 5 - 9 predictor models was not easy.

Figure 3-2 illustrates the effect of TDF feed rate on PAH emissions (as measured by the PAH analyzer), in ng/J total heat input, using nominal values of KILNT = 1000 °C, KILNGAS = 140 Nm^3/hr, and KILNO2 = 7%, for each of Models 1 through 3. Notice how Models 2 and 3 are almost indistinguishable from one another. Increasing TDF feed from 0 to 20% increases the predicted PAH emissions from those of natural gas alone by approximately a factor of 5, from a minumum of 1.9E-4 to a maximum 1.1E-3 ng/J.

PAH emissions were fairly insensitive to temperature and oxygen over the range of conditions studied, although increasing TDF feed rates tended to increase PAH emissions for all oxygen levels. A useful objective for future TDF combustion studies would be to perform some basic research on TDF pyrolysis kinetics with special attention being given the transport phenomena in the vicinity of TDF particles. Overall, supplementing the fuel with TDF tends to increase PAH emissions, but not dramatically, provided steady-state operation is maintained.

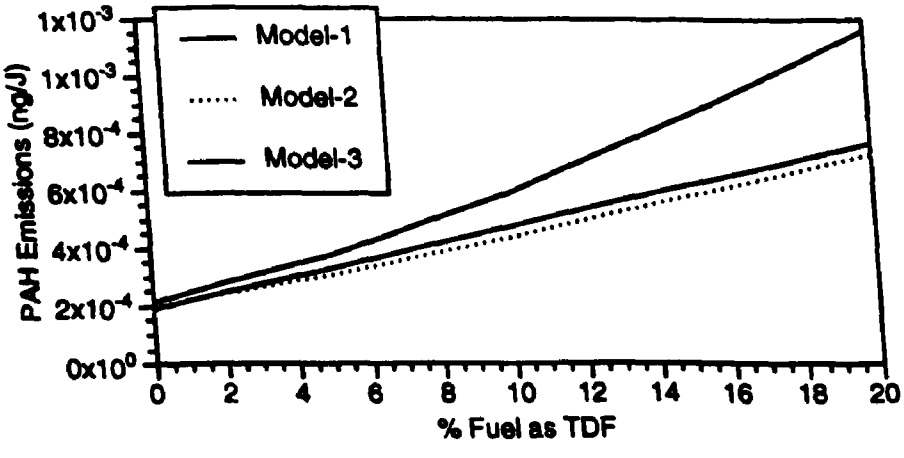

Figure 3-2. Model predictions: emissions of PAH as a function of TDF feed rate; using KILNT = 1000 °C, KILNGAS=140 Nm^3/hr, and KILNO2 = 7%.

3.2. Volatile Organic Samples

In general, the volatile organic compounds (VOCs) detected were fairly close to practical quantitation levels. A number of compounds identified in combustion samples were not present in the field blanks. However, several of the compounds found in combustion samples were also present in the field blanks at similar levels; primarily chloromethane, acetone, methylene chloride, and benzene. Benzene is a common PIC from combustion in general, and could be attributed to PICs from the natural gas flame found in the field blanks. However, benzene is also a breakdown product of Tenax, and acetone and methylene chloride are ubiquitous in laboratory environments. In addition, some samples contained trichlorofluoromethane, which is a chlorofluorocarbon commonly used in air conditioners. Appendix B contains all of the volatile organic data . Table 3-7 summarizes the results from the volatile organic samples, by averaging the emission values from all compounds that were present in concentrations greater than the quantitation level on at least one VOST tube. On compounds where one or more VOST tubes had concentrations below the quantitation level, then the quantitation level was used for averaging. The results from the trichlorofluoromethane, acetone and methylene chloride are considered suspect, and are not reported in Table 3-7. Standard deviations are reported in parenthesis.

To evaluate the differences between conditions with and without TDF, average reported concentrations from Table 3-7 were divided by the reported concentration for the 0 % TDF case (the natural gas blank), and any values that resulted in a ratio less than 2.0 for all runs were discarded. The results from this calculation are illustrated in Figure 3-3. Although emissions of most compounds during TDF combustion were not significantly different from those resulting from natural gas combustion, there were several significant differences. Emissions of chloromethane, benzene, and styrene were consistently higher while firing TDF.

Tires contain trace amounts of chlorine, which can apparently combine with other PICs present to form chloromethane. The absence of other higher molecular weight chlorinated organics suggests that the TDF chlorine was not initially associated with the organic tire matrix, but was possibly present in the inorganic parts of the tire. The TDF analysis did not attempt to determine whether the TDF chlorine was organic or inorganic, however, there may be chlorinated rubber in tires.

Benzene emissions were much higher while the RKIS was operating in a non-steady mode. This appears to indicate that TDF combustion can produce elevated levels of aromatic PICs when not combusted in a steady-state mode. Styrene emissions were approximately 3 times higher than those found during natural gas combustion, regardless of the amount of TDF being burned. Emissions of carbon disulfide and toluene

were elevated during the test when TDF was batch fed into the RKIS. These PICs are indicative of fuel-rich combustion. Xylene levels were also elevated during the batch test.

Interestingly, some PICs were reduced below levels found from natural gas combustion during unsteady TDF combustion, most notably, 2-methyl propene. Levels of 2-methyl propene increased with the addition of TDF during steady-state operation, but were reduced during transient operation. It is possible that during non-steady operation, local fuel-rich zones developed which promoted aromatic ring growth from substituted alkenes.

Table 3-7. Summary of VOC concentrations (ng/L).

compound	TB5 0 % TDF (blank)	TB1 7 % TDF (steady-state)	TB3 17 % TDF (steady-state)	TB8 19 % TDF (ramp)	TB9 15 % TDF (batch)
1,1,1, trichloroethane	0.55 (0.04)	0.88 (0.33)	1.00 (0.34)	0.52 (0.01)	0.47 (0.05)
2-methyl propene	2.36 (0.92)	5.40 (3.40)	4.38 (1.08)	1.70 (0.65)	0.50 (0.03)
2-methyl-2-propanol	0.52 (0.01)	0.51 (0.03)	4.10 (6.20)	0.52 (0.01)	0.50 (0.03)
benzene	1.65 (0.24)	2.93 (0.91)	2.83 (0.80)	17.00 (16.11)	47.31 (53.91)
bromomethane	0.49 (0.06)	0.51 (0.03)	0.58 (0.11)	2.82 (1.68)	0.83 (0.64)
carbon disulfide	0.52 (0.01)	0.81 (0.62)	0.52 (0.00)	0.52 (0.01)	2.04 (2.68)
chlorobenzene	0.52 (0.01)	0.51 (0.03)	0.52 (0.00)	0.52 (0.01)	0.48 (0.04)
chloromethane	0.59 (0.11)	1.68 (2.17)	8.81 (12.36)	55.03 (28.38)	11.17 (6.67)
ethyl benzene	0.52 (0.01)	0.51 (0.03)	0.61 (0.06)	0.52 (0.01)	1.07 (0.25)
heptane	0.52 (0.01)	0.67 (0.31)	0.56 (0.17)	0.52 (0.01)	0.50 (0.03)
hexane	0.49 (0.06)	0.58 (0.16)	0.55 (0.06)	0.52 (0.01)	0.51 (0.01)
iodomethane	0.52 (0.01)	0.51 (0.03)	0.52 (0.00)	0.54 (0.05)	0.50 (0.03)
m,p-xylene	1.52 (0.17)	0.98 (0.40)	2.40 (0.29)	0.61 (0.12)	3.85 (1.11)
nonane	0.68 (0.15)	1.72 (0.47)	0.96 (0.40)	0.52 (0.01)	0.59 (0.15)
o-xylene	0.45 (0.06)	0.51 (0.03)	0.72 (0.07)	0.52 (0.01)	1.13 (0.33)
styrene	0.65 (0.32)	1.85 (0.37)	1.62 (1.54)	1.62 (1.05)	1.69 (0.36)
toluene	0.97 (0.35)	1.18 (0.65)	1.05 (0.24)	0.80 (0.18)	2.78 (0.91)

In order to compare these quantities to other sources in the real world, it is appropriate to express the emissions of these various VOC compounds as emission factors in terms of ng/J heat input. There are two ways to perform the conversion; with or without taking into account the contribution from the natural gas. Table 3-8 lists the estimated emissions of the same compounds in terms of ng/J, by including both the natural gas and TDF contributions. Table 3-9 lists the estimated emissions with only taking into account the TDF contribution, by dividing the results from Table 3-8 by the fraction of TDF fed (i.e., the blank concentrations were not subracted out prior to dividing by the TDF fraction). It should be noted that emissions from a unit that burns 100 % TDF are not likely to be a linear extrapolation from the 10-20 % levels being co-fired here. There is very little literature on VOC emission factors from conventional combustion devices burning coal or oil, but there are data for formaldehyde emission factors in the

literature.[27] Average emission factors for formaldehyde emissions from oil-fired combustion sources average around 1.74E-1 ng/J, and for coal, 7.32E-2 ng/J, which are on the same order of magnitude, if not slightly higher, than those found during these tests. This finding suggests that VOC emissions from a properly run facility burning TDF are not significantly different from a properly operated facility burning conventional fossil fuels.

As an illustration of the differences between emissions from burning TDF in a controlled manner, as opposed to uncontrolled combustion as is found in a tire fire, using data reported from a study examining emissions from the simulated open burning of scrap tires,[9] estimated benzene emissions were approximately 280 ng/J, which is approximately 5 orders of magnitude higher than those found in this study.

Table 3-8. Estimated emissions of VOCs (ng/J), based on TDF + natural gas.

compound	TB5 0 % TDF (blank)	TB1 7 % TDF (steady-state)	TB3 17 % TDF (steady-state)	TB8 19 % TDF (ramp)	TB9 15 % TDF (batch)
1,1,1, trichloroethane	2.24E-04	3.75E-04	4.41E-04	2.24E-04	2.17E-04
2-methyl propene	9.60E-04	2.30E-03	1.94E-03	7.37E-04	2.33E-04
2-methyl-2-propanol	2.13E-04	2.15E-04	1.81E-03	2.24E-04	2.33E-04
benzene	6.71E-04	1.25E-03	1.25E-03	7.36E-03	2.19E-02
bromomethane	2.00E-04	2.15E-04	2.58E-04	1.22E-03	3.82E-04
carbon disulfide	2.13E-04	3.43E-04	2.30E-04	2.24E-04	9.43E-04
chlorobenzene	2.13E-04	2.15E-04	2.30E-04	2.24E-04	2.20E-04
chloromethane	2.40E-04	7.15E-04	3.90E-03	2.38E-02	5.16E-03
ethyl benzene	2.13E-04	2.15E-04	2.70E-04	2.24E-04	4.96E-04
heptane	2.13E-04	2.83E-04	2.48E-04	2.24E-04	2.33E-04
hexane	2.01E-04	2.45E-04	2.45E-04	2.24E-04	2.36E-04
iodomethane	2.13E-04	2.15E-04	2.30E-04	2.35E-04	2.33E-04
m,p-xylene	6.21E-04	4.17E-04	1.06E-03	2.64E-04	1.78E-03
nonane	2.77E-04	7.29E-04	4.25E-04	2.24E-04	2.71E-04
o-xylene	1.85E-04	2.15E-04	3.18E-04	2.24E-04	5.24E-04
styrene	2.63E-04	7.85E-04	7.16E-04	7.03E-04	7.80E-04
toluene	3.97E-04	5.02E-04	4.64E-04	3.48E-04	1.29E-03

Table 3-9. Estimated emissions of VOCs (ng/J), based on TDF only.

compound	TB1 7 % TDF (steady-state)	TB3 17 % TDF (steady-state)	TB8 19 % TDF (ramp)	TB9 15 % TDF (batch)
1,1,1, trichloroethane	5.36E-03	2.59E-03	1.18E-03	1.45E-03
2-methyl propene	3.28E-02	1.14E-02	3.88E-03	1.55E-03
2-methyl-2-propanol	3.07E-03	1.07E-02	1.18E-03	1.55E-03
benzene	1.78E-02	7.35E-03	3.87E-02	1.46E-01
bromomethane	3.07E-03	1.52E-03	6.42E-03	2.55E-03
carbon disulfide	4.90E-03	1.35E-03	1.18E-03	6.29E-03
chlorobenzene	3.07E-03	1.35E-03	1.18E-03	1.47E-03
chloromethane	1.02E-02	2.29E-02	1.25E-01	3.44E-02
ethyl benzene	3.07E-03	1.59E-03	1.18E-03	3.31E-03
heptane	4.04E-03	1.46E-03	1.18E-03	1.55E-03
hexane	3.51E-03	1.44E-03	1.18E-03	1.57E-03
iodomethane	3.07E-03	1.35E-03	1.24E-03	1.55E-03
m,p-xylene	5.95E-03	6.23E-03	1.39E-03	1.19E-02
nonane	1.04E-02	2.50E-03	1.18E-03	1.81E-03
o-xylene	3.07E-03	1.87E-03	1.18E-03	3.49E-03
styrene	1.12E-02	4.21E-03	3.70E-03	5.20E-03
toluene	7.17E-03	2.73E-03	1.83E-03	8.58E-03

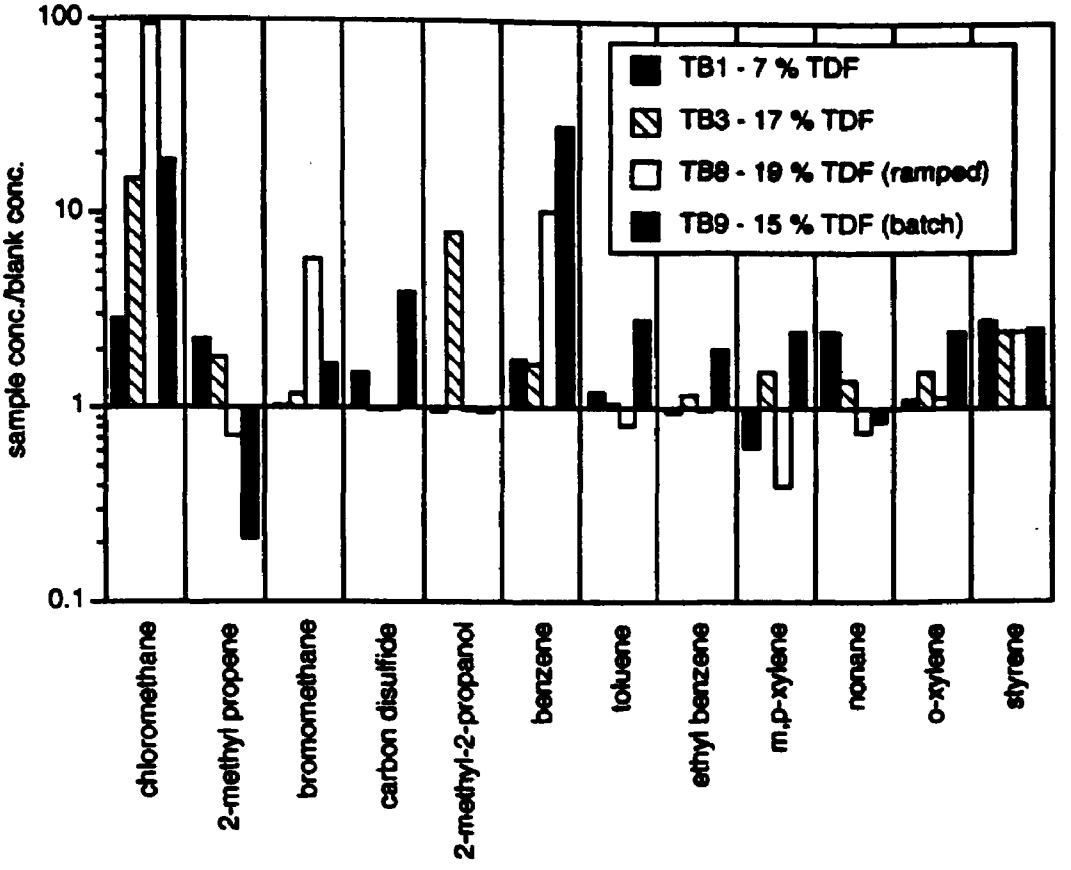

Figure 3-3. Comparison of VOC emissions between natural gas and TDF combustion.

3.3. Semi-Volatile Organic Samples

3.3.1. MM5 Sampling Trains

The complete SVOC analysis results are found in Appendix C. The results from the semi-volatile organic compound (SVOC) analyses do not seem to indicate the presence of SVOCs in detectable concentrations. Trace quantities of phenol were identified in several samples. Several phthalates were present in two samples. A wide variety of phthalates are used as plasticizers and are common laboratory contaminants. The presence of these phthalates as contaminants seems more plausible than their being PICs. However, no phthalates were found in the field blank.

As with the volatile organic analyses, surrogate standards were added to the SVOC samples to assess method performance. For several samples, achieved recovery values were less than target values, which indicates possible target loss. Recovery performance data for each sample are included in Appendix C.

For two samples (TB4 - 17 % TDF steady-state and TB9 - 15 % TDF batch), the "less than" concentrations reported are a factor of ten greater than the remaining results reported. These samples were taken to provide bioassay analyses, and as such, required TCO and GRAV analyses. These samples therefore had a larger final extract volume. It is for this reason that no surrogate recovery performance data are given as well, since the surrogate standards might have generated a false positive response on the bioassays. The bioassay results will be reported in a different document.

3.3.2. Continuous PAH Analyzer

As illustrated in Table 3-2, the PAH analyzer gave readings on all steady-state tests ranging up to 3289 ng/Nm^3, which converts into 3.3 $\mu g/Nm^3$. This concentration is below the method detection level for individual PAH compounds in the SVOC analysis. Considering that other past experiences with the PAH analyzer gave good agreement with conventional SVOC analyses,[28,29] it can be surmised that the results reported from the PAH analyzer compare favorably with the PAH concentrations that were actually present in the stack. At any rate, the PAH analyzer did not give a false positive signal, and, as shown in Figure 3-4, tracked O_2 and CO_2 quite well during the ramping test (TB8), in spite of the fact that CO emissions did not significantly change. This observation suggests that the PAH analyzer is quite sensitive to minor system disturbances, and may be useful for process control purposes.

Overall, it appears that when combusted in a well-operated facility, emissions of SVOCs from TDF combustion are not significantly different than from natural gas.

3.4. PCDD/PCDF Samples

Complete PCDD and PCDF sampling and analytical results are found in Appendix D. PCDD/PCDF samples (Method 23) were collected during only 2 test conditions: TB7 - 0 % TDF (combustion blank) and TB6 - 17 % TDF steady-state. The results of the PCDD/PCDF analyses indicate that PCDDs and PCDFs were not detected during these tests. The results from the TB6 - 17 % TDF test reveals that hexachlorodibenzofuran was present at a concentration essentially equal to the method detection limit. Similarly, the results from the combustion background test (TB7 - 0 % TDF) revealed that tetrachlorodibenzodioxin was present at a concentration also essentially equal to the method detection limit. The method blank did not detect either of these target analytes.

Since detectable quantities of chloromethane were found in several of the VOC samples, and since chlorine is present in small quantities in the TDF material, it may be possible that higher levels of PCDD and PCDF might be found from a full-scale combustion system, since it has been shown that a significant amount of formation of PCDD/PCDF occurs in the particulate control devices at temperatures around 300 °C, although moderate amounts of PCDD/PCDF formation can occur on in-flight particles.[30] In these tests, there was no particulate control device installed, so concentrations reported here only would represent those found in the transition duct between the combustor and any particulate control device. At any rate, though, it would be expected that PCDD/PCDF emissions would be low.

3.5. Metals Samples

Appendix E contains all of the metals emissions data. Metal aerosol samples (MMT) were collected during only 2 test conditions: TB7 - 0 % TDF (combustion blank) and TB6 - 17 % TDF steady-state. The intent was to analyze the front and back halves of the sampling train separately to gain insight into the distribution of metal aerosols. Unfortunately, the back half sample from the TB6 - 17 % TDF feed test was damaged during shipment and was not capable of being analyzed. The liquid from this damaged sample may have also contaminated the front half sample of the TB7 - 0 % TDF feed test (blank), since relatively high concentrations of lead and zinc were found in this fraction. The presence of these 2 metals may also be attributable to the fact that the combustion blank was collected after a number of TDF tests had been performed, and a hysteresis effect might have occurred. This possibility is supported by the presence of zinc and lead in the back half fraction of the blank sample, which would not be affected by the damaged sample. Table 3-10 lists the concentrations of metals and Table 3-11 lists the estimated emissions for the two tests where sampling occurred. If we repeat the treatment given the VOC emissions by comparing the metal emissions from these TDF combustion tests to emission factors from coal and oil in the literature, we can

examine the emissions of these metal species with a point of reference that is more well understood. Note that the linear extrapolation based on TDF feed fraction is more likely to be valid for metals than for organics.

Table 3-10. Stack concentration ($\mu g/m^3$) of metals from TDF combustion.

metal	TB7 0% TDF (blank)	TB6 17 % TDF (steady-state)
antimony	0.18	2.11
arsenic	1.12	37.16
beryllium	nd	0.05
cadmium	0.41	1.06
chromium	0.65	3.88
lead	8.05	65.96
manganese	2.82	5.79
nickel	0.71	3.51
selenium	0.83	4.50
zinc	286.94	35465

nd - none detected.

Table 3-11. Estimated metals emissions (ng/J) from TDF combustion.

	TB7 0% TDF (blank)		TB6 17 % TDF (steady-state)	
metal	TDF+natural gas	TDF only	TDF+natural gas	TDF only
antimony	7.72E-5	n/a	9.05E-4	5.32E-3
arsenic	4.80E-4	n/a	1.59E-2	9.35E-2
beryllium	nd	n/a	2.14E-5	1.26E-4
cadmium	1.76E-4	n/a	4.54E-4	2.67E-3
chromium	2.78E-4	n/a	1.66E-3	9.76E-3
lead	3.45E-3	n/a	2.83E-2	1.66E-1
manganese	1.21E-3	n/a	2.48E-3	1.46E-2
nickel	3.0E-4	n/a	1.50E-3	8.82E-3
selenium	3.56E-4	n/a	1.93E-3	1.14E-2
zinc	1.23E-1	n/a	15.21	89.47

n/a - not applicable

The literature[27] reports the values found in Table 3-12 for emission factors from coal and oil for various metals. To derive the average emission factors reported here, uncontrolled values for oil from reference 27 were averaged for both distillate and residual oil, and values for coal from uncontrolled dry bottom utility boilers burning bituminous coal. By comparing Tables 3-11 and 3-12, it is apparent that, with the exception of zinc, uncontrolled metal emissions from TDF combustion are similar in magnitude to those for coal and oil. TDF combustion gives high Zn emissions due to the fact that there are high levels of Zn in

tires, coupled with the fact that Zn is a volatile metal that tends to be emitted in the flyash as opposed to remaining in the bottom ash residue.

Table 3-12. Average emission factors for coal- and oil-fired boilers (ng/J).

metal	oil	coal
antimony	n/a	n/a
arsenic	5.00E-03	2.95E-01
beryllium	1.44E-03	3.48E-02
cadmium	5.64E-03	1.91E-02
chromium	1.49E-02	6.07E-01
lead	7.95E-03	1.36E-01
manganese	8.61E-03	1.28E+00
nickel	3.08E-01	5.00E-01
selenium	n/a	n/a
zinc	n/a	n/a

n/a - not available
Source: Reference 27

3.6 Particulate Data

Particulate matter (PM) measurements were made from the MM5 and MultiMetals trains. PM measurements are not routinely made from MM5 trains as the typical Method 5 acetone front half rinse and evaporation procedures are not compatible with the sample treatments leading to organic analyses. However, the MM5 sampling was the only particulate collection method common to all tests. The particulate data reported here are based on the total mass of particulate collected on the filter as well as the cyclone located upstream of the filter. All front half rinses were submitted for organic analysis. The complete PM data are found in Appendix F.

The MultiMetals train is suitable for determining total particulate loading as the front half acetone rinse and evaporation step is optional. Particulate values are also reported for the two tests where metals samples were collected.

Table 3-13 lists the results for the PM measurements. The PM measurements listed represent uncontrolled emissions, such as those found prior to any installed PM control device. As expected, the PM emissions during TDF combustion are higher than those from natural gas combustion. Interestingly, the PM results from run TB9 (the batch feed run) were significantly higher than for the other runs. The MM5 filter on this run was blacker than on the other runs.

3.7. XRD/XRF Results

After each run, there was a significant amount of ash residue deposited on the TDF feeding mechanism. Samples from runs TB3 and TB6 were collected and analyzed for elemental composition with X-ray fluorescence spectrometry. For this analysis, the samples were mixed with an organic binder and pressed into pellets. The samples were first scanned for qualitative characterization. For better accuracy, it is necessary to set up a quantitative scheme based on the matrix composition. Since the composition was similar to fly ash, that scheme was applied. Element concentrations determined by this method are reported here to two significant figures. Note that some elements identified from the XRF analysis (e.g., zirconium, aluminum, and silicon) may have originated in the RKIS refractory insulation, and not from the TDF. Results also confirm the high Zn emissions found in the MMT samples. The concentrations for the balance of the elements detected, in the qualitative scan, are reported to one significant figure. Table 3-14 lists the results from the XRF analysis.

Table 3-13. Particulate data.

Run	% Total Fuel as TDF	Particulate Loading (mg/Nm^3)
TB2	16.95	43.67++
TB3	17.14	137.24++
TB4	15.50	95.28++
TB5	0.00	17.37++
TB8+	19.18	132.95++
TB9+	14.97	285.46++
TB6	17.30	101.01
TB7	0.00	4.14

\+ non-continuous feed tests

++ based on filter weights from MM5 or Method 23 samples

Table 3-14. TDF fly ash composition (wt %) as determined by X-ray fluorescence.

element	TB3	TB6
aluminum	2.8	1.9
calcium	3.1	2.9
chromium	0.002	0.01
cobalt	0.005	0.01
copper	0.002	0.0001
iron	0.86	0.83
lead	0.001	0.0009
magnesium	0.86	0.95
nickel	0.007	0.003
phosphorus	0.001	0.0001
potassium	0.58	0.58
silicon	32	32
sodium	0.68	1.2
strontium	0.002	0.01
sulfur	0.0004	0.0003
titanium	0.15	0.084
zinc	2.4	5.2
zirconium	0.01	0.01

X-ray diffraction spectrometry (XRD) was also carried out on the two samples to determine the phases of the major elements. XRD is usually capable of detecting phases down to several percent. The phases identified in the two samples are listed in the following table. Because of the many factors which influence XRD reflections, it is mainly of value for qualitative rather than quantitative analysis. In certain cases, where matrices are similar and sample preparation is controlled, it may be used for quantitative analyses. For this analysis, the phases are listed in estimated order of decreasing concentration. The XRD spectra for TB3 and TB6 can be found in Appendix F. Table 3-15 lists the results from the XRD analysis.

Table 3-15. TDF fly ash composition as determined by X-ray diffraction.

name	formula	JCPDS No.	present in TB3 sample	present in TB6 sample
cristobalite	SiO_2	39-1425	X	X
quartz	SiO_2	33-1161	X	X
willemite	Zn_2SiO_4	37-1496	X	X
anhydrite	$CaSO_4$	37-1496	X	X
mullite	$Al_6Si_2O_{13}$	15-776	X	-

3.8. Effect of Transient Operation

Selected traces from the CEMs during the TB8 test, where the kiln combustion air was ramped up and down, are shown in Figures 3-4 through 3-8. Notice how the O_2 and CO_2 traces (Figures 3-4 and 3-5)

oscillate in a sinusoidal manner to mirror the changes in the combustion air. The fact that the response time (≈ 2 s) for the PAH analyzer was considerably faster than the response time for the CO analyzer (≈ 30 s), coupled with the fact that the PAH analyzer (see Figure 3-6) was considerably more sensitive to minor system disturbances during periods of "good" combustion than the CO analyzer (see Figure 3-7 and 3-8), suggests that the PAH analyzer might prove to be an effective monitor for process control purposes. These data seem to suggest that pyrolysis at the surface of the TDF particles is one of the rate controlling steps for TDF combustion. Although the TDF was not burning in suspension phase, the low feed rates that were used during these tests resulted in a fairly dispersed bed of burning TDF particles scattered around the recessed chamber of the kiln. As such, it may be a valid assumption that individual TDF particles were burning with little or no influence from nearby TDF particles. The transport of the pyrolysis products away from the TDF particles, coupled with some boundary layer resistance, appear to significantly affect the emission of PICs from TDF combustion. By ramping the combustion air up and down, it appears that the boundary layer surrounding the TDF particles is subjected to some transient disturbances, possibly de-stabilizing the flame front that is in place at the outside of the particle's boundary layer. This phenomenon might result in increased PIC emissions.

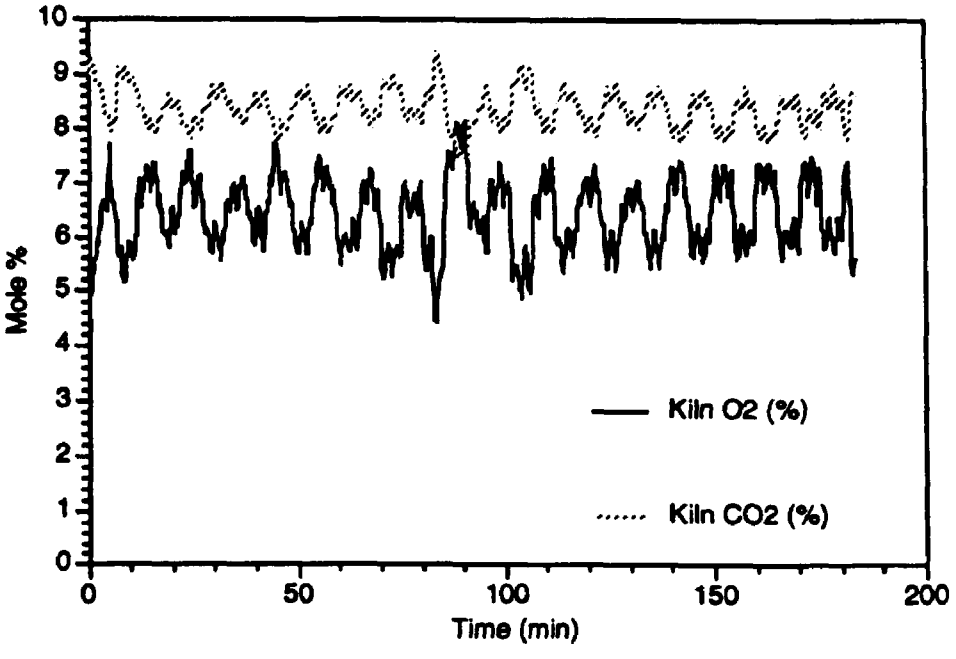

Figure 3-4. Kiln O_2 and CO_2 traces during run TB8.

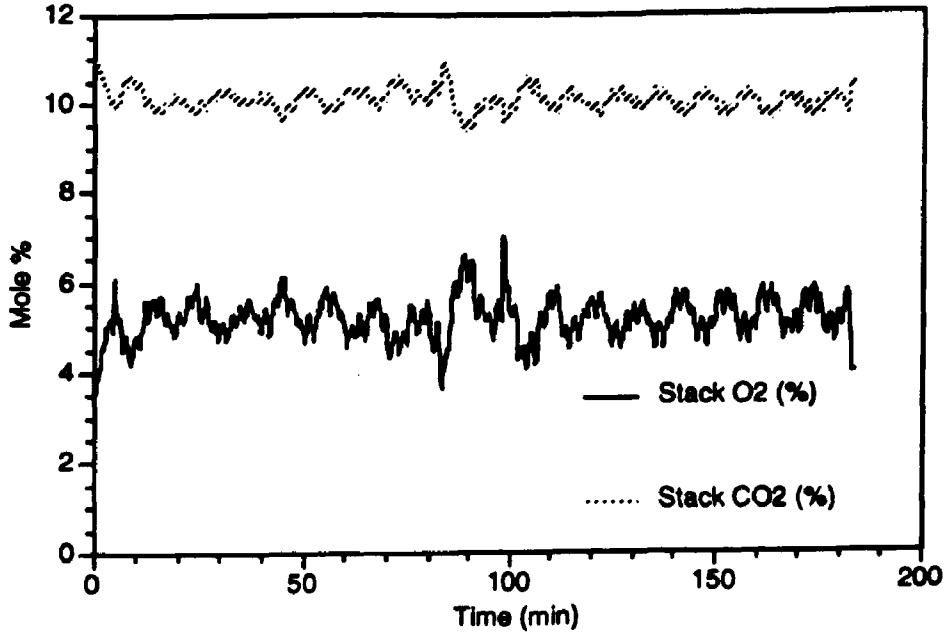

Figure 3-5. Stack O_2 and CO_2 traces during run TB8.

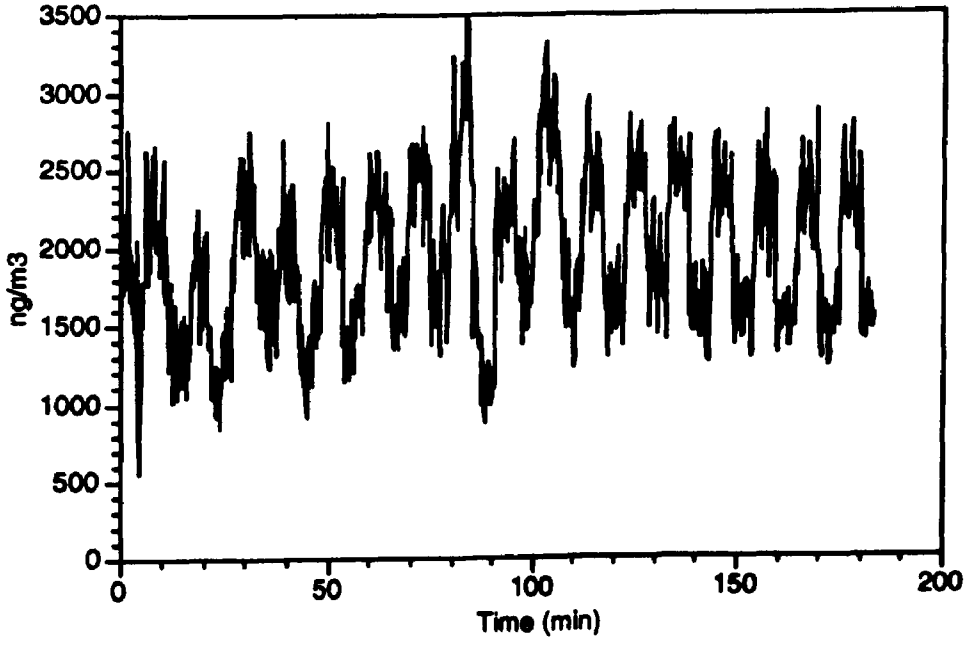

Figure 3-6. PAH analyzer trace during run TB8.

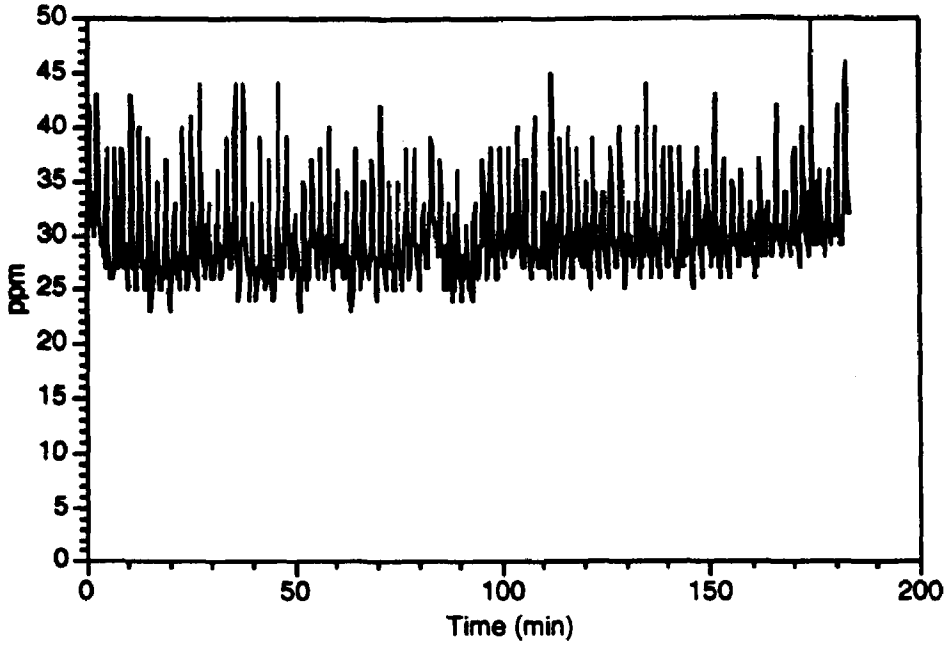

Figure 3-7. Kiln CO traces during run TB8.

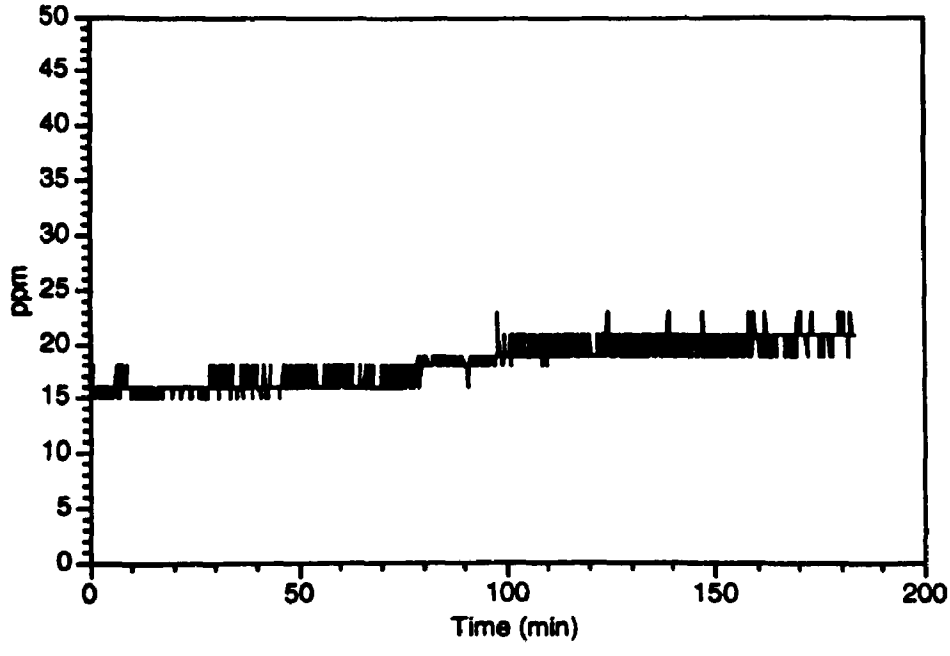

Figure 3-8. Stack CO traces during run TB8.

Selected traces from the CEMs during the TB9 test, where batches of TDF were fed at discreet intervals, are shown in Figures 3-9 through 3-13. The batch tests resulted in very high transient emissions followed by periods of essentially background emission levels. Notice how the kiln O_2 (see Figure 3-9), initially at approximately 10 %, plummets to approximately 1 % during the batch introduction of TDF. Even the post-SCC stack O_2 (see Figure 3-10) is reduced to just over 2 % during the transients. The PAH analyzer (see Figure 3-11) measured a high (214,000 ng/m^3) average concentration on the TB9 batch test, which was not found on the corresponding MM5 train samples for SVOCs. However, since the transient events resulting from batch feeding of TDF were very short relative to the total sampling time, the required isokinetic sampling protocols may have resulted in an insufficient sample being pulled into the MM5 train. These results are qualitatively similar to results seen from earlier batch feed tests on this same facility while burning polyethylene pipe,[14] where non-isokinetic sampling procedures and larger sampling volumes were required to produce detectable quantities of individual compounds. Note also how the PAH analyzer (Figure 3-11) tracks the CO traces (Figures 3-12 and 3-13) very well. As mentioned earlier, the CO analyzer is an acceptable diagnostic for "poor" combustion conditions, but cannot effectively differentiate between different levels of "good" combustion.

These data suggest that burning TDF in batches, which roughly approximates feeding of whole tires, has the potential to form significant transient emissions. This phenomena could be exacerbated in a system that exhibits significant vertical gas-phase stratification, or operates at low excess air levels, such as cement kilns. The size of the facility, however, will certainly impact the intensity of transient emissions resulting from batch charging of tires or TDF, since for an extremely large facility, a constant stream of whole tires may roughly approximate steady-state operation. Even so, the potential for generation of large transients should not be ignored.

These two transient experiments highlight the limitations of using CO as a surrogate indicator of combustor performance. While CO is high during periods of "poor" combustion, as is evidenced during the batch feed tests, CO does not give a good indication of de-tuned combustor performance during periods of relatively "good" combustion. In other words, the CO analyzer is effective as a diagnostic of "poor" combustion, but cannot differentiate between "good" and "great" combustion.

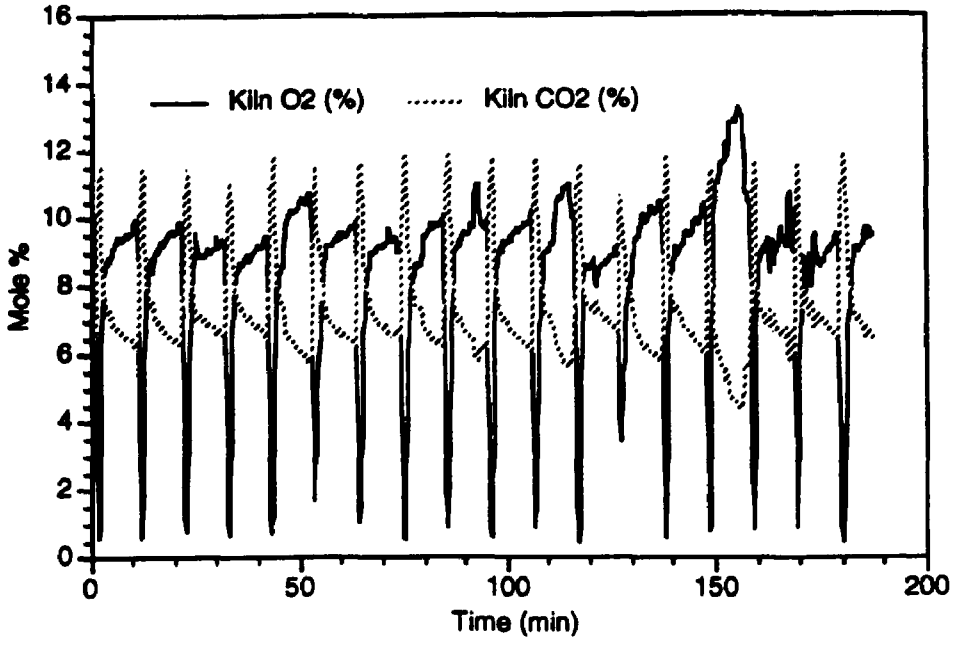

Figure 3-9. Kiln O_2 and CO_2 traces during run TB9.

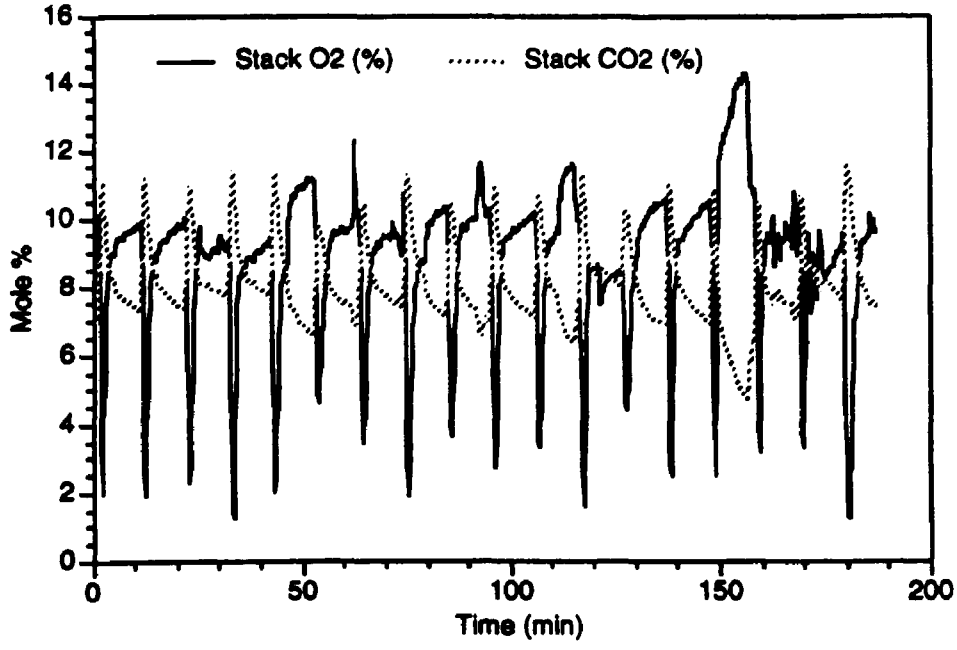

Figure 3-10. Stack O_2 and CO_2 traces during run TB9.

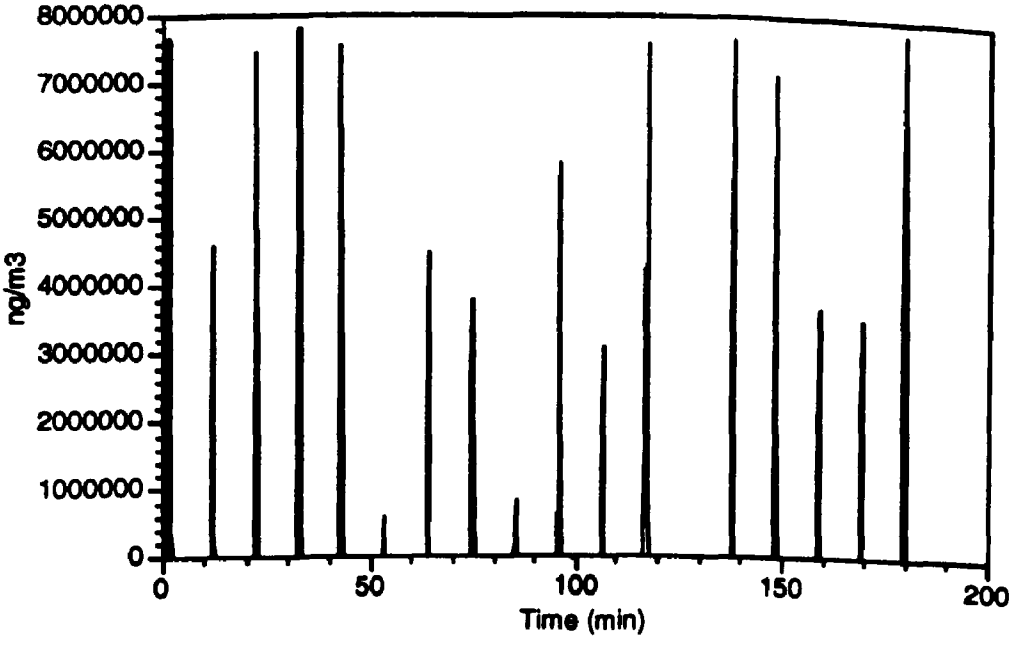

Figure 3-11. PAH analyzer trace during run TB9.

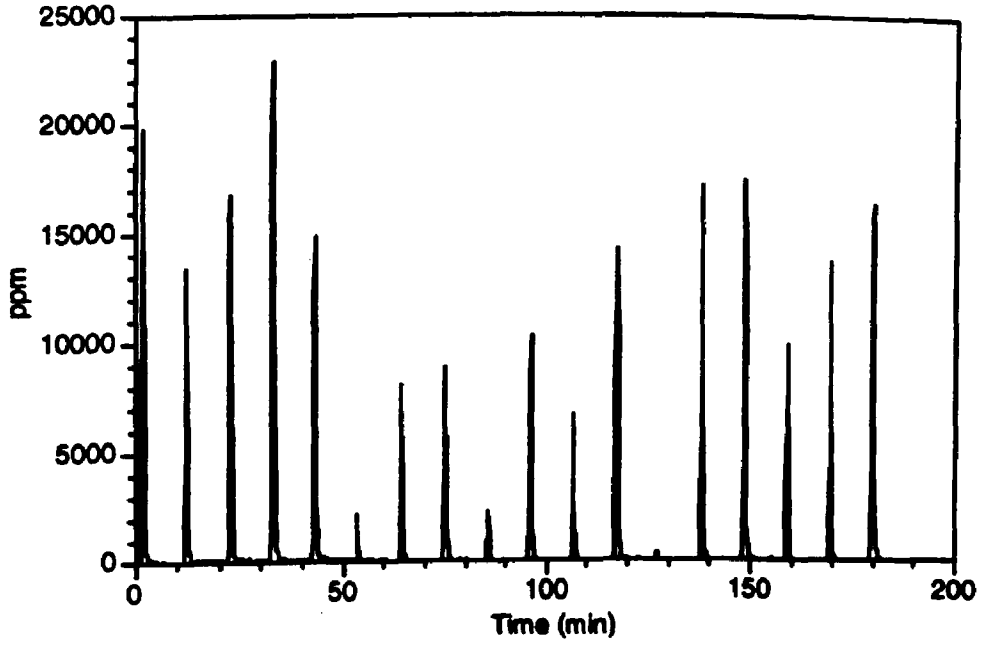

Figure 3-12. Kiln CO traces during run TB9.

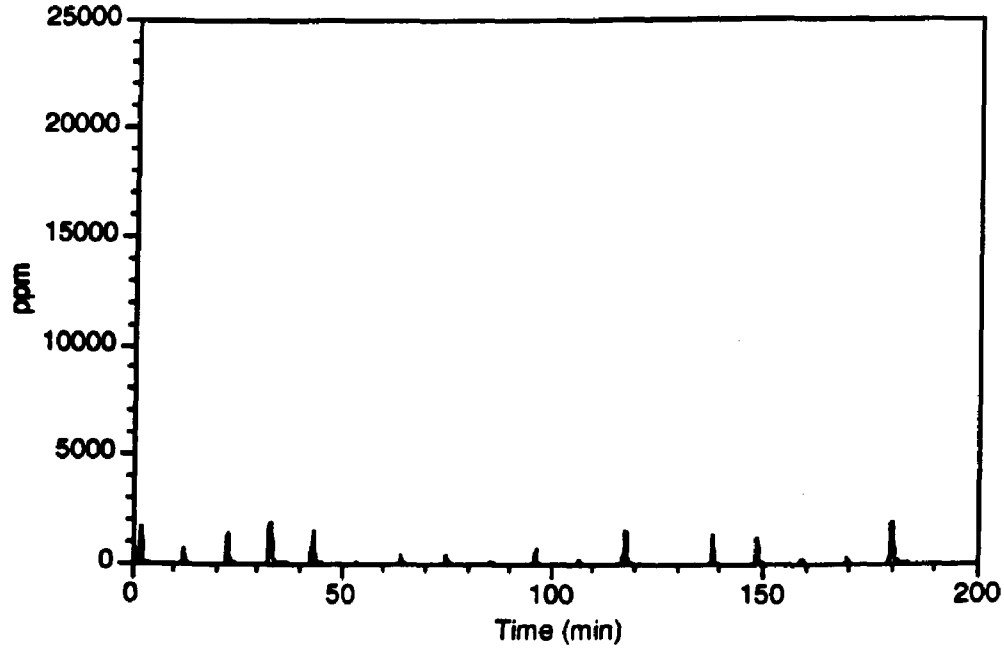

Figure 3-13. Stack CO traces during run TB9.

4. CONCLUSIONS

A series of experiments were performed on a bench-scale rotary kiln incinerator simulator (RKIS) facility to examine HAPs from combustion of TDF. Both steady-state and transient testing was performed so that an evaluation of continuous vs. incremental TDF feeding could be achieved. Samples were analyzed continuously by CEM for O_2, CO, CO_2, NO, THCs, SO_2, and PAHs. VOST, MM5, Method 23, and MMT samples were collected to analyze for VOCs, SVOCs, PCDD/PCDF, and metal aerosols, respectively. X-ray diffraction and X-ray fluorescence techniques were used to identify species in the fly ash. A regression analysis was completed on the CEM data to examine pollutant emission trends.

Several VOCs were identified, particularly chloromethane, benzene, and styrene. The concentrations of those VOCs was affected by the amount and mode of TDF feeding. Emissions of benzene, in particular, are particularly sensitive to transient upsets of the combustion process. Comparison of calculated emission factors to those found in the literature for conventional fossil fuel combustion indicate that VOC emissions from TDF combustion are comparable to those from coal and oil combustion.

No significant amounts of SVOCs were identified. The PAH analyzer indicated PAH concentrations on the same order as the detection level of the SVOC analytical methods, with the exception of the test where TDF was batch fed to the RKIS facility. The PAH analyzer indicated considerably higher transient concentrations of PAHs during batch feeding, however, these elevated PAH levels were not detected with the MM5 samples. It is possible that the short duration of the transients, coupled with the mandatory isokinetic sampling protocols, prevented sufficient amounts of pollutants from being sampled.

Emission levels of PCDD and PCDF were found to be similar in magnitude to the combustion blank which consisted of a natural gas flame. Those congeners of PCDD and PCDF identified in all samples were on the same order of magnitude as the method detection level.

Elevated levels of arsenic, lead, and zinc were found in the stack gas. Zinc was present in significant concentrations. Analysis of the fly ash residue indicate that the majority of the particulate matter was SiO_2, $Al_6Si_2O_{13}$, and Zn_2SiO_4. Comparison of calculated emission factors from TDF combustion to those found in the literature for conventional fossil fuel combustion suggests that, with the exception of zinc, the magnitudes of metal emissions are similar to coal and oil, although the distributions are significantly different, especially with respect to emissions of mercury and selenium, which are significantly higher from coal combustion.

The PAH analyzer tracked transient kiln operation during periods of "good" combustion more effectively than the CO analyzer, and with a faster response. It may be significantly more effective than CO for process control applications due to its sensitivity. Regression analysis of PAH analyzer measurements indicated that an approximately five-fold increase (over natural gas emissions) in PAH emissions occurs while increasing the TDF fuel input fraction from 0 to 20%.

Regression analysis of CO emissions from the steady-state tests did not find a significant correlation with kiln operating conditions. A slight increase in CO emissions with increasing TDF feed rate was found.

The results suggest that burning TDF in batches, such as during the feeding of whole tires, has the potential to form significant transient emissions. This phenomenon could be exacerbated in a system that exhibits significant vertical gas-phase stratification, or operates at low excess air levels, such as cement kilns. The size of the facility, however, will certainly impact the intensity of transient emissions resulting from batch charging of tires or TDF, since for an extremely large facility, a constant stream of whole tires may roughly approximate steady-state operation. Even so, the potential for generation of large transients should not be ignored, especially in smaller facilities.

Data gaps still exist, since this limited study was performed on a small combustor, under controlled conditions. The following issues might be addressed in future research.

- The effect of TDF particle size and feeding mode on HAP emissions should be investigated more fully. This study was done using a single TDF particle size, and included only limited testing on different feeding modes.

- Emissions of HAPs from combustion of wire-in TDF should be investigated. It would be logical to assume that emissions of metals from combustion of wire-in TDF may be significantly different than from TDF that has had the wire removed. Combustion temperature would likely affect metals emissions significantly, since the partitioning of metals between the bottom ash residue and the fly ash would change.

- Characteristics of other TDF-generated residues, such as bottom ash, should be investigated, especially in regards to leachability of metals, and slag composition and quality.

- Emissions of HAPs from co-firing of TDF with other solid fuels, such as coal, biomass-derived fuels, municipal solid waste, or refuse-derived fuel should be investigated.

- The characteristics of TDF-generated flyash should be investigated more fully, including the particle size distributions and speciation of the metals, especially as a function of halogens or sulfur which might be present due to co-firing of other fuels.

- Some basic research, on a very small scale, should be performed, to examine the chemistry of TDF pyrolysis and combustion.

- Tests on other types of facilities (such as a vertically-fired unit) should be performed. Studies examining TDF combustion in suspension vs. bed-burning phases should be performed.

Overall, it appears that, with the exception of zinc, potential emissions from TDF combustion are not significantly different from emissions from combustion of conventional fossil fuels, when burned in a well-designed and well-operated combustion device. If unacceptable particulate loading occurs due to zinc emissions, then the emissions would have to be controlled by an appropriate particulate control device.

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APPENDIX A. QA/QC EVALUATION REPORT

This project was performed under the Level III Quality Assurance Project Plan entitled "Combustion of Scrap Tires in a Rotary Kiln", and assigned QTRAK #86016/III. All critical measurements met the data quality objectives satisfactorily. Certain non-critical measurements, such as NO and SO_2 did not meet data quality objectives. However, the QA goals of the project were met.

A.1. Volatile Organic Samples

In general, the volatile organic compounds detected were fairly close to practical quantitation levels. A number of the compounds identified in combustion samples were not present in the field blanks. However, several of the compounds found in combustion samples were also present in the field blanks at similar levels; primarily chloromethane, acetone, and methylene chloride. Acetone and methylene chloride are ubiquitous in laboratory environments. Each VOST tube was individually QC checked so as to ensure that species measured would indeed originate in the stack. No tube contained more than 10 ng of any compound. The VOST tube QC checks did not indicate inherent contamination at these levels. Therefore, the results from these compounds should be considered somewhat suspect. All analytical method performance criteria were met during analysis of these samples. Appendix B contains all of the VOC data, including surrogate compound recovery.

A.2. Semi-Volatile Organic Samples

The results from the semi-volatile organic compound (SVOC) analyses do not seem to indicate the presence of SVOCs in significant concentrations. Trace quantities of phenol were identified in several samples. Several phthalates were present in two samples. A wide variety of phthalates are used as plasticizers and are common laboratory contaminants. The presence of these phthalates as contaminants seems more plausible than their being PICs. However, no phthalates were found in the field blank.

As with the volatile organic analyses, surrogate standards were added to the SVOC samples to assess method performance. For several samples, achieved recovery values were less than target

values. It is possible that targes were lost on these samples. Recovery performance data for each sample, as well as isokinetic sampling information, are included in Appendix C.

For two samples (20% TDF steady-state and 20% TDF batch), the "less than" concentrations reported are a factor of ten greater than the remaining results reported. These samples were taken to provide bioassay analyses, and as such, required TCO and GRAV analyses. These samples therefore had a larger final extract volume. It is for this reason that no surrogate recovery performance data are given as well, since the surrogate standards might have generated a false positive response on the bioassays.

A.3. PCDD/PCDF Samples

PCDD/PCDF samples (Method 23) were collected during only 2 test conditions: 0 % TDF (combustion blank) and 20% TDF steady-state. The results of the PCDD/PCDF analyses indicate that PCDDs and PCDFs were not detected during these tests. The results from the 20% TDF test reveals that hexachlorodibenzofuran was present at a concentration essentially equal to the method detection limit. Similarly, the results from the combustion background test (no TDF) revealed that tetrachlorodibenzodioxin was present at a concentration also essentially equal to the method detection limit. The method blank did not detect either of these target analytes. Appendix D contains all of the data regarding the PCDD/PCDF analyses, including isokinetic sampling information and surrogate standard recovery information.

A.4. Metals Samples

Metals samples (Method 29) were also only collected during only 2 test conditions: 0 % TDF (combustion blank) and 20% TDF steady-state. The intent was to analyze the front and back halves of the sampling train separately to gain insight into the distribution of metal aerosols. Unfortunately, the back half sample from the 20% TDF feed test was damaged during shipment and was not capable of being analyzed. The liquid from this damaged sample may have also contaminated the front half sample of the 0% TDF feed test (blank), since relatively high concentrations of lead and zinc were found in this fraction. The presence of these 2 metals may also be attributable to the fact that the combustion blank was collected after a number of TDF tests had been performed, and a hysteresis effect might have occurred. This possibility is supported by the presence of zinc and lead in the back half fraction of the blank sample, which was not affected by the

damaged sample. Appendix E contains all of the data regarding the metals analyses, including surrogate compound recovery and isokinetic sampling information.

A.5. QCER for CEM Data

A 3-point calibration was performed on each CEM daily. The data collected for each test were validated by post-test zero and span checks. The results of post-test CEM zero and span checks are presented in Table A-1. The overall accuracy, precision, and completeness data quality indicator (DQI) levels achieved along with respective DQI goals for each CEM measurement are presented in Table A-2. As Tables A-1 and A-2 indicate, difficulties were encountered with the NO and SO_2 measurements. Excessive drift was encountered during many of the tests performed. Fortunately, these were not critical measurements, and the lack of data for these measurements does not compromise the quality of this study.

A.6. General QA Information

Appendix F contains other analytical data, including a summary of all extractive sampling, dates of individual runs, and the XRD spectra. Isokinetic variation is based on a single point location sampling relative to the highest velocity traverse point established during the pre-test velocity traverse. The highest velocity location was selected to maximize collected sample volumes. With the exception of the test performed on 5/11/93, all test samples were collected within acceptance of method isokinetic variation limits. The pretest velocity traverses, along with determined moisture levels, were also used to derive volumetric stack flows.

Table A-1. Rotary Kiln Tire Burn CEM Operation Summary

		FS (%)	25	Span	14.7	FS (%)	20	Span	15	FS ppm	2000	Span	713
		O2 Zero		O2 Span		CO2 Zero		CO2 Span		CO Zero		CO Span	
Date		Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias
5/13/93	Kiln	0.0	0.0	15.0	1.2	0.0	0.0	15.2	1.0	-2	-0.1	717	0.2
	Stack	0.0	0.0	14.3	-1.6	0.0	0.0	15.2	1.0	1	0.1	714	0.1
5/17/93	Kiln	0.0	0.0	15.0	1.2	0.0	0.0	15.1	0.5	5	0.3	712	-0.1
	Stack	0.0	0.0	14.8	0.4	0.0	0.0	14.9	-0.5	5	0.3	714	0.1
5/18/93	Kiln	0.0	0.0	14.7	0.0	0.0	0.0	15.0	0.0	22	1.1	740	1.4
	Stack	0.0	0.0	14.7	0.0	0.1	0.4	15.3	1.5	-5	-0.3	719	0.3
5/19/93	Kiln	0.4	1.4	15.1	1.6	0.1	0.3	15.2	1.0	6	0.3	718	0.3
	Stack	0.0	0.2	14.9	0.8	0.1	0.6	15.2	1.0	6	0.3	723	0.5
5/20/93	Kiln	0.0	0.1	14.7	0.0	0.0	0.0	15.1	0.5	9	0.5	721	0.4
	Stack	0.0	0.2	14.7	0.0	0.0	-0.2	15.2	1.0	2	0.1	720	0.4
5/21/93	Kiln	0.0	0.0	14.8	0.4	0.0	0.0	15.1	0.5	5	0.3	721	0.4
	Stack	0.1	0.2	14.7	0.0	0.0	0.1	15.1	0.5	3	0.2	722	0.5
5/25/93	Kiln	0.1	0.6	14.8	0.4	0.0	-0.2	15.4	2.0	26	1.3	745	1.6
	Stack	0.1	0.5	14.3	-1.6	0.1	0.3	15.2	1.0	2	0.1	720	0.4
5/26/93	Kiln	0.1	0.2	14.9	0.8	0.0	0.2	15.2	1.0	11	0.6	728	0.8
	Stack	0.0	0.2	14.7	0.0	0.0	0.2	15.1	0.5	0	0.0	718	0.3
5/27/93	Kiln	0.1	0.6	14.8	0.4	0.0	0.1	15.2	1.0	16	0.8	729	0.8
	Stack	0.1	0.3	14.8	0.4	0.0	0.0	15.2	1.0	5	0.3	715	0.1
	Averages	0.1	0.2	14.8	0.5	0.0	0.1	15.2	0.8	6.5	0.4	722.0	0.4
	Std Dev	0.1		0.2		0.0		0.1		7.7		8.5	

	O2	CO2	CO	NO	THC	SO2
Average Bias (%)	0.4	0.5	0.4	5.2	0.4	3.4
Precision (%RSD)	1.4	0.7	1.2	8.5	5.1	17.7

N/A = Not Applicable
N/P = Not Performed
N/U = Not Used

(Continued)

Table A-1. Rotary Kiln Tire Burn CEM Operation Summary (continued)

		FS ppm 250 NO Zero		Span 253 NO Span		FS ppm 500 THC Zero		Span 109 THC Span		FS ppm 1000 SO2 Zero		Span 184 SO2 Span	
Date		Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias	Meas.	%Bias
5/13/93	Kiln	8	3.2	265	4.8	N/U	N/A	N/U	N/A				
	Stack	-1	-0.4	250	-1.2	-3	-0.6	115	1.2	60	6.0	215	3.1
5/17/93	Kiln	4	1.6	286	13.2	N/U	N/A	N/U	N/A				
	Stack	15	6.0	272	7.6	N/U	N/A	N/U	N/A	22	2.2	214	3.0
5/18/93	Kiln	25	10.0	260	2.8	-2	-0.4	104	-1.0				
	Stack	-2	-0.8	276	9.2	1	0.2	110	0.2	-14	-1.4	158	-2.6
5/19/93	Kiln	4	1.6	220	-13.2	N/U	N/A	N/U	N/A				
	Stack	15	6.0	302	19.6	N/U	N/A	N/U	N/A	-32	-3.2	130	-5.4
5/20/93	Kiln	3	1.2	257	1.6	0	0.0	99	-2.0				
	Stack	6	2.4	294	16.4	0	0.0	96	-2.6	25	2.5	207	2.3
5/21/93	Kiln	0	0.0	265	4.8	2	0.4	105	-0.8				
	Stack	0	0.0	240	-5.2	0	0.0	108	0.2	32	3.2	222	3.8
5/25/93	Kiln	6	2.4	234	-7.6	2	0.4	109	0.0				
	Stack	8	3.2	281	11.2	0	0.0	106	-0.6	40	4.0	N/P	N/A
5/26/93	Kiln	9	3.6	250	-1.2	N/U	N/A	N/U	N/A				
	Stack	3	1.2	280	10.8	N/U	N/A	N/U	N/A	70	7.0	N/P	N/A
5/27/93	Kiln	13	5.2	238	-6.0	N/U	N/A	N/U	N/A				
	Stack	-2	-0.8	234	-7.6	N/U	N/A	N/U	N/A	-15	-1.5	165	-1.9
	Averages	6.3	2.6	261.3	7.7	-0.4	0.1	105.8	0.7	20.9	3.4	187.3	3.4
	Std Dev	6.9		22.2		1.5		5.4		32.9		33.2	

Table A-2. Data quality indicator results for CEM measurements.

	Accuracy *		Precision @		Completeness	
Meas.	Goal	Achiev. #	Goal	Achiev.	Goal	Achiev.
O_2	< 3	0.4	< 10	1.4	> 90	100
CO_2	< 3	0.5	< 10	0.7	> 90	100
CO	< 3	0.4	< 10	1.2	> 90	100
NO	< 3	5.2	< 10	8.5	> 90	11
THC	< 3	0.3	< 10	5.1	> 90	100
SO_2	< 3	3.2	< 10	17.7	> 90	44

* Accuracy expressed as percent bias from full scale of measurement range.
# Based on overall absolute value average of zero and span checks.
@ Expressed as percent relative standard deviation

APPENDIX B. VOLATILE ORGANIC SAMPLING DATA

VOLATILE ORGANIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln   Test Date: 4-29-93

Test Number	VOST-1	Sampling Run No.	TB1-VOST
Condition	10 % Tires	Operator	RT
Location	Exhaust Duct	Exhaust Duct Flow	Unknown DSCFM

Sample ID	50/CC58	AP15/759	100/CC57	99/89
Volume Collected (Liters)	19.192	21.586	19.345	19.285
Detectible Compounds	11	8	11	12

	ng/L	ng/L	ng/L	ng/L
dichlorodifluoromethane	< 0.52	< 0.46	< 0.52	< 0.52
chloromethane	0.54	< 0.46	4.93	0.80
2-Methylpropene	9.27	2.82	2.28	7.24
vinyl chloride	< 0.52	< 0.46	< 0.52	< 0.52
bromomethane	< 0.52	< 0.46	< 0.52	< 0.52
chloroethane	< 0.52	< 0.46	< 0.52	< 0.52
trichlorofluoromethane	< 0.52	< 0.46	< 0.52	< 0.52
1,1-dichloroethene	< 0.52	< 0.46	< 0.52	< 0.52
Carbon Disulfide	< 0.52	< 0.46	1.73	< 0.52
iodomethane	< 0.52	< 0.46	< 0.52	< 0.52
Acetone	1.40	1.86	1.27	1.06
Vinyl Acetate	< 0.52	< 0.46	< 0.52	< 0.52
methylene chloride	15.45	25.38	29.85	31.96
trans-1,2-dichloroethene	< 0.52	< 0.46	< 0.52	< 0.52
2-Methyl-2-Propanol	< 0.52	< 0.46	< 0.52	< 0.52
Hexane	0.52	< 0.46	< 0.52	0.81
1,1-dichloroethane	< 0.52	< 0.46	< 0.52	0.52
2-Butanone	0.52	< 0.46	0.52	0.52
chloroform	0.52	< 0.46	0.52	0.52
1,1,1-trichloroethane	0.52	< 0.46	0.87	1.2[illegible]
carbon tetrachloride	< 0.52	< 0.46	< 0.52	0.52
benzene	2.71	2.35	2.20	4.2[illegible]
1,2-dichloroethane	0.52	< 0.46	0.52	0.52
Fluorobenzene	0.52	< 0.46	0.52	0.52
2,5-Dimethyl-3-Hexene	0.52	< 0.46	< 0.52	0.52
2-Chloro-2-Methylpropane	0.52	< 0.46	0.52	0.52
Heptane	0.55	< 0.46	0.52	[illegible]
trichloroethene	0.52	< 0.46	0.52	0.52
1,2-dichloropropane	0.52	< 0.46	0.52	0.52
dibromomethane	0.52	< 0.46	< 0.52	[illegible]
1,4-Dioxane	0.52	< 0.46	< 0.52	0.52
bromodichloromethane	0.52	0.46	0.52	[illegible]
cis-1,3-dichloropropene	0.52	0.46	0.52	[illegible]
4-Methyl-2-Pentanone	[illegible]	0.46	0.52	[illegible]
toluene	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.46	[illegible]	[illegible]

	ng/L	ng/L	ng/L	ng/L
1,1,2-trichloroethane	< 0.52	< 0.46	< 0.52	< 0.52
Bromoacetone	< 0.52	< 0.46	< 0.52	< 0.52
tetrachloroethene	< 0.52	< 0.46	< 0.52	< 0.52
2-Hexanone	< 0.52	< 0.46	< 0.52	< 0.52
dibromochloromethane	< 0.52	< 0.46	< 0.52	< 0.52
1,2-dibromoethane	< 0.52	< 0.46	< 0.52	< 0.52
chlorobenzene	< 0.52	< 0.46	< 0.52	< 0.52
1,1,1,2-Tetrachloroethane	< 0.52	< 0.46	< 0.52	< 0.52
ethyl benzene	< 0.52	< 0.46	< 0.52	< 0.52
m,p-xylene	0.94	0.69	0.73	1.56
Nonane	1.94	1.16	1.53	2.23
o-xylene	< 0.52	< 0.46	< 0.52	< 0.52
Styrene	2.01	2.25	1.74	1.39
bromoform	< 0.52	< 0.46	< 0.52	< 0.52
Cumene	< 0.52	< 0.46	< 0.52	< 0.52
1,2,3-Trichloropropane	< 0.52	< 0.46	< 0.52	< 0.52
1,1,2,2-tetrachloroethane	< 0.52	< 0.46	< 0.52	< 0.52
1,4-Dichloro-2-butene	< 0.52	< 0.46	< 0.52	< 0.52
Pentachloroethane	< 0.52	< 0.46	< 0.52	< 0.52
1,3-Dichlorobenzene	< 0.52	< 0.46	< 0.52	< 0.52
1,4-Dichlorobenzene	< 0.52	< 0.46	< 0.52	< 0.52
1,2-Dichlorobenzene	< 0.52	< 0.46	< 0.52	< 0.52
1,2-Dibromo-3-chloropropane	< 0.52	< 0.46	< 0.52	< 0.52
Master Index	2046	2047	2048	2049
Surrogate Compounds Recovery	%	%	%	%
d6-Benzene	110	100	104	98
d4-1,2-dichloroethane	109	105	108	105
d8-toluene	96	106	97	102
4-bromofluorobenzene	101	101	104	110

VOLATILE ORGANIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-13-93

Test Number	VOST-2	Sampling Run No.	TB2-VOST
Condition	20 % Tires	Operator	RT
Location	Exhaust Duct	Exhaust Duct Flow	121.6 DSCFM

Sample ID	512/570	CC86/56	380/108
Volume Collected (Liters)	19.16	19.172	19.359
Detectible Compounds	13	14	17

	ng/L	ng/L	ng/L
dichlorodifluoromethane	< 0.52	< 0.52	0.82
chloromethane	2.56	0.83	23.05
2-Methylpropene	5.61	3.61	3.91
vinyl chloride	< 0.52	< 0.52	< 0.52
bromomethane	< 0.52	< 0.52	0.71
chloroethane	< 0.52	< 0.52	< 0.52
trichlorofluoromethane	< 0.52	< 0.52	< 0.52
1,1-dichloroethene	< 0.52	< 0.52	< 0.52
Carbon Disulfide	< 0.52	< 0.52	< 0.52
iodomethane	< 0.52	< 0.52	< 0.52
Acetone	1.60	1.60	10.23
Vinyl Acetate	< 0.52	< 0.52	< 0.52
methylene chloride	11.92	81.06	57.78
trans-1,2-dichloroethene	< 0.52	< 0.52	< 0.52
2-Methyl-2-Propanol	< 0.52	< 0.52	11.26
Hexane	< 0.52	0.62	< 0.52
1,1-dichloroethane	< 0.52	< 0.52	< 0.52
2-Butanone	< 0.52	< 0.52	< 0.52
chloroform	< 0.52	< 0.52	< 0.52
1,1,1-trichloroethane	0.91	0.71	1.37
carbon tetrachloride	< 0.52	< 0.52	< 0.52
benzene	1.95	3.53	3.00
1,2-dichloroethane	< 0.52	< 0.52	< 0.52
Fluorobenzene	< 0.52	< 0.52	< 0.52
2,5-Dimethyl-3-Hexene	< 0.52	< 0.52	< 0.52
2-Chloro-2-Methylpropane	< 0.52	< 0.52	< 0.52
Heptane	0.45	0.76	0.46
trichloroethene	< 0.52	< 0.52	< 0.52
1,2-dichloropropane	< 0.52	< 0.52	< 0.52
dibromomethane	< 0.52	< 0.52	< 0.52
1,4-Dioxane	< 0.52	< 0.52	< 0.52
bromodichloromethane	< 0.52	< 0.52	< 0.52
cis-1,3-dichloropropene	< 0.52	< 0.52	< 0.52
4-Methyl-2-Pentanone	< 0.52	0.52	< 0.52
toluene	2.53	1.29	1.04
trans-1,3-dichloropropene	< 0.52	0.52	< 0.52

	ng/L	ng/L	ng/L
1,1,2-trichloroethane	< 0.52	< 0.52	< 0.52
Bromoacetone	< 0.52	< 0.52	< 0.52
tetrachloroethene	< 0.52	< 0.52	< 0.52
2-Hexanone	< 0.52	< 0.52	< 0.52
dibromochloromethane	< 0.52	< 0.52	< 0.52
1,2-dibromoethane	< 0.52	< 0.52	< 0.52
chlorobenzene	< 0.52	< 0.52	< 0.52
1,1,1,2-Tetrachloroethane	< 0.52	< 0.52	< 0.52
ethyl benzene	0.58	0.68	0.57
m,p-xylene	2.58	2.55	2.06
Nonane	0.79	1.42	0.67
o-xylene	0.71	0.79	0.66
Styrene	0.97	3.38	0.51
bromoform	< 0.52	< 0.52	< 0.52
Cumene	< 0.52	< 0.52	< 0.52
1,2,3-Trichloropropane	< 0.52	< 0.52	< 0.52
1,1,2,2-tetrachloroethane	< 0.52	< 0.52	< 0.52
1,4-Dichloro-2-butene	< 0.52	< 0.52	< 0.52
Pentachloroethane	< 0.52	< 0.52	< 0.52
1,3-Dichlorobenzene	< 0.52	< 0.52	< 0.52
1,4-Dichlorobenzene	< 0.52	< 0.52	< 0.52
1,2-Dichlorobenzene	< 0.52	< 0.52	< 0.52
1,2-Dibromo-3-chloropropane	< 0.52	< 0.52	< 0.52
Master Index	2054	2055	2056
Surrogate Compounds Recovery	%	%	%
d6-Benzene	108	104	107
d4-1,2-dichloroethane	107	97	103
d8-toluene	92	94	96
4-bromofluorobenzene	107	98	96

VOLATILE ORGANIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-18-93

Test Number	VOST-3	Sampling Run No.	TB3-VOST
Condition	No Tires	Operator	RT, JEB
Location	Exhaust Duct	Exhaust Duct Flow	173.6 DSCFM

Sample ID	700/10	165/02	531/108
Volume Collected (Liters)	19.229	19.145	19.037
Detectible Compounds	11	12	9

	ng/L	ng/L	ng/L
dichlorodifluoromethane	< 0.52	< 0.52	< 0.53
chloromethane	< 0.52	0.72	< 0.53
2-Methylpropene	2.48	3.21	1.38
vinyl chloride	< 0.52	< 0.52	< 0.53
bromomethane	< 0.52	0.42	< 0.53
chloroethane	< 0.52	< 0.52	< 0.53
trichlorofluoromethane	0.44	< 0.52	< 0.53
1,1-dichloroethene	< 0.52	< 0.52	< 0.53
Carbon Disulfide	< 0.52	< 0.52	< 0.53
iodomethane	< 0.52	< 0.52	< 0.53
Acetone	2.61	3.12	2.59
Vinyl Acetate	< 0.52	< 0.52	< 0.53
methylene chloride	184.05	43.49	20.76
trans-1,2-dichloroethene	< 0.52	< 0.52	< 0.53
2-Methyl-2-Propanol	< 0.52	< 0.52	< 0.53
Hexane	< 0.52	0.43	< 0.53
1,1-dichloroethane	< 0.52	< 0.52	< 0.53
2-Butanone	< 0.52	< 0.52	< 0.53
chloroform	< 0.52	< 0.52	< 0.53
1,1,1-trichloroethane	0.60	< 0.52	< 0.53
carbon tetrachloride	< 0.52	< 0.52	< 0.53
benzene	1.86	1.38	1.70
1,2-dichloroethane	< 0.52	< 0.52	< 0.53
Fluorobenzene	< 0.52	< 0.52	< 0.53
2,5-Dimethyl-3-Hexene	< 0.52	< 0.52	< 0.53
2-Chloro-2-Methylpropane	< 0.52	< 0.52	< 0.53
Heptane	< 0.52	< 0.52	< 0.53
trichloroethene	< 0.52	< 0.52	< 0.53
1,2-dichloropropane	< 0.52	< 0.52	< 0.53
dibromomethane	< 0.52	< 0.52	< 0.53
1,4-Dioxane	< 0.52	< 0.52	< 0.53
bromodichloromethane	< 0.52	< 0.52	< 0.53
cis-1,3-dichloropropene	< 0.52	< 0.52	< 0.53
4-Methyl-2-Pentanone	< 0.52	< 0.52	< 0.53
toluene	1.11	1.35	0.79
trans-1,3-dichloropropene	< 0.52	< 0.52	< 0.53

	ng/L	ng/L	ng/L
1,1,2-trichloroethane	< 0.52	< 0.52	< 0.53
Bromoacetone	< 0.52	< 0.52	< 0.53
tetrachloroethene	< 0.52	< 0.52	< 0.53
2-Hexanone	< 0.52	< 0.52	< 0.53
dibromochloromethane	< 0.52	< 0.52	< 0.53
1,2-dibromoethane	< 0.52	< 0.52	< 0.53
chlorobenzene	< 0.52	< 0.52	< 0.53
1,1,1,2-Tetrachloroethane	< 0.52	< 0.52	< 0.53
ethyl benzene	< 0.52	< 0.52	< 0.53
m,p-xylene	1.61	1.63	1.33
Nonane	0.83	0.54	0.67
o-xylene	0.42	0.52	0.42
Styrene	0.49	0.44	1.01
bromoform	< 0.52	< 0.52	< 0.53
Cumene	< 0.52	< 0.52	< 0.53
1,2,3-Trichloropropane	< 0.52	< 0.52	< 0.53
1,1,2,2-tetrachloroethane	< 0.52	< 0.52	< 0.53
1,4-Dichloro-2-butene	< 0.52	< 0.52	< 0.53
Pentachloroethane	< 0.52	< 0.52	< 0.53
1,3-Dichlorobenzene	< 0.52	< 0.52	< 0.53
1,4-Dichlorobenzene	< 0.52	< 0.52	< 0.53
1,2-Dichlorobenzene	< 0.52	< 0.52	< 0.53
1,2-Dibromo-3-chloropropane	< 0.52	< 0.52	< 0.53
Master Index	2057	2058	2062
Surrogate Compounds Recovery	%	%	%
d6-Benzene	105	104	96
d4-1,2-dichloroethane	88	99	98
d8-toluene	88	96	95
4-bromofluorobenzene	106	100	102

VOLATILE ORGANIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-21-93

Test Number	VOST-4	Sampling Run No.	TB4-VOST
Condition	Ramping (20 % Tires)	Operator	JEB
Location	Exhaust Duct	Exhaust Duct Flow	141.5 DSCFM

Sample ID	535/757	101/186	13/26
Volume Collected (Liters)	19.47	19.271	19.202
Detectible Compounds	9	11	9

	ng/L	ng/L	ng/L
dichlorodifluoromethane	< 0.51	< 0.52	< 0.52
chloromethane	22.30	72.78	70.02
2-Methylpropene	0.96	2.02	2.13
vinyl chloride	< 0.51	< 0.52	< 0.52
bromomethane	1.00	4.31	3.14
chloroethane	< 0.51	< 0.52	< 0.52
trichlorofluoromethane	< 0.51	0.41	< 0.52
1,1-dichloroethene	< 0.51	< 0.52	< 0.52
Carbon Disulfide	< 0.51	< 0.52	< 0.52
iodomethane	< 0.51	0.52	0.60
Acetone	4.45	5.76	5.16
Vinyl Acetate	< 0.51	< 0.52	< 0.52
methylene chloride	14.20	26.05	11.75
trans-1,2-dichloroethene	< 0.51	< 0.52	< 0.52
2-Methyl-2-Propanol	< 0.51	< 0.52	< 0.52
Hexane	< 0.51	< 0.52	< 0.52
1,1-dichloroethane	< 0.51	< 0.52	< 0.52
2-Butanone	< 0.51	< 0.52	< 0.52
chloroform	< 0.51	< 0.52	< 0.52
1,1,1-trichloroethane	< 0.51	< 0.52	< 0.52
carbon tetrachloride	< 0.51	< 0.52	< 0.52
benzene	35.16	11.42	4.42
1,2-dichloroethane	< 0.51	< 0.52	< 0.52
Fluorobenzene	< 0.51	< 0.52	< 0.52
2,5-Dimethyl-3-Hexene	< 0.51	< 0.52	< 0.52
2-Chloro-2-Methylpropane	< 0.51	< 0.52	< 0.52
Heptane	< 0.51	< 0.52	< 0.52
trichloroethene	< 0.51	< 0.52	< 0.52
1,2-dichloropropane	< 0.51	< 0.52	< 0.52
dibromomethane	< 0.51	< 0.52	< 0.52
1,4-Dioxane	< 0.51	< 0.52	< 0.52
bromodichloromethane	< 0.51	< 0.52	< 0.52
cis-1,3-dichloropropene	< 0.51	< 0.52	< 0.52
4-Methyl-2-Pentanone	< 0.51	< 0.52	< 0.52
toluene	1.81	1.41	< 0.52
trans-1,3-dichloropropene	< 0.51	< 0.52	< 0.52

	ng/L	ng/L	ng/L
1,1,2-trichloroethane	< 0.51	< 0.52	< 0.52
Bromoacetone	< 0.51	< 0.52	< 0.52
tetrachloroethene	< 0.51	< 0.52	< 0.52
2-Hexanone	< 0.51	< 0.52	< 0.52
dibromochloromethane	< 0.51	< 0.52	< 0.52
1,2-dibromoethane	< 0.51	< 0.52	< 0.52
chlorobenzene	< 0.51	< 0.52	< 0.52
1,1,1,2-Tetrachloroethane	< 0.51	< 0.52	< 0.52
ethyl benzene	< 0.51	< 0.52	< 0.52
m,p-xylene	0.50	0.74	0.59
Nonane	< 0.51	< 0.52	< 0.52
o-xylene	< 0.51	< 0.52	< 0.52
Styrene	2.61	1.74	< 0.52
bromoform	< 0.51	< 0.52	< 0.52
Cumene	< 0.51	< 0.52	< 0.52
1,2,3-Trichloropropane	< 0.51	< 0.52	< 0.52
1,1,2,2-tetrachloroethane	< 0.51	< 0.52	< 0.52
1,4-Dichloro-2-butene	< 0.51	< 0.52	< 0.52
Pentachloroethane	< 0.51	< 0.52	< 0.52
1,3-Dichlorobenzene	< 0.51	< 0.52	< 0.52
1,4-Dichlorobenzene	< 0.51	< 0.52	< 0.52
1,2-Dichlorobenzene	< 0.51	< 0.52	< 0.52
1,2-Dibromo-3-chloropropane	< 0.51	< 0.52	< 0.52
Master Index	2064	2065	2066
Surrogate Compounds Recovery	%	%	%
d6-Benzene	89	59	93
d4-1,2-dichloroethane	107	100	109
d8-toluene	89	85	87
4-bromofluorobenzene	101	106	102

VOLATILE ORGANIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln　　　　Test Date: 5-25-93

Test Number	VOST-5	Sampling Run No.	TB5-VOST
Condition	Batch (20 % Tires)	Operator	JEB
Location	Exhaust Duct	Exhaust Duct Flow	174.2 DSCFM

Sample ID	463/142	A100/36	522/340
Volume Collected (Liters)	19.188	21.153	19.062
Detectible Compounds	13	11	13
	ng/L	ng/L	ng/L
dichlorodifluoromethane	< 0.52	< 0.47	< 0.52
chloromethane	18.81	6.49	8.20
2-Methylpropene	< 0.52	< 0.47	< 0.52
vinyl chloride	< 0.52	< 0.47	< 0.52
bromomethane	1.57	< 0.47	0.44
chloroethane	< 0.52	< 0.47	< 0.52
trichlorofluoromethane	< 0.52	< 0.47	0.73
1,1-dichloroethene	< 0.52	< 0.47	< 0.52
Carbon Disulfide	5.13	< 0.47	< 0.52
iodomethane	< 0.52	< 0.47	< 0.52
Acetone	7.74	7.48	9.88
Vinyl Acetate	< 0.52	< 0.47	< 0.52
methylene chloride	20.39	[illegible]	18.87
trans-1,2-dichloroethene	0.52	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.52
[illegible]	[illegible]	6.55	26.94
[illegible]	0.52	0.47	< 0.52
[illegible]	< 0.52	0.47	*< 0.52
2,3-Dimethyl-3-Hexene	< 0.52	0.47	< 0.52
2-Chloro-2-Methylpropane	0.52	0.47	< 0.52
Heptane	0.52	< 0.47	< 0.52
trichloroethane	< 0.52	< 0.47	< 0.52
1,2-dichloropropane	< 0.52	< 0.47	< 0.52
dibromomethane	0.52	0.47	< 0.52
1,4-Dioxane	0.52	0.47	0.52
bromodichloromethane	0.52	0.47	0.52
[illegible]	[illegible]	0.47	0.52
[illegible]	[illegible]	0.47	0.52
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.52

	ng/L	ng/L	ng/L
1,1,2-trichloroethane	< 0.52	< 0.47	< 0.52
Bromoacetone	< 0.52	< 0.47	< 0.52
tetrachloroethene	< 0.52	< 0.47	< 0.52
2-Hexanone	< 0.52	< 0.47	< 0.52
dibromochloromethane	< 0.52	< 0.47	< 0.52
1,2-dibromoethane	< 0.52	< 0.47	< 0.52
chlorobenzene	0.44	< 0.47	< 0.52
1,1,1,2-Tetrachloroethane	< 0.52	< 0.47	< 0.52
ethyl benzene	1.06	0.83	1.33
m,p-xylene	3.65	2.86	5.05
Nonane	< 0.52	0.48	0.76
o-xylene	1.08	0.83	1.49
Styrene	1.91	1.27	1.88
bromoform	< 0.52	< 0.47	< 0.52
Cumene	< 0.52	< 0.47	< 0.52
1,2,3-Trichloropropane	< 0.52	< 0.47	< 0.52
1,1,2,2-tetrachloroethane	< 0.52	< 0.47	< 0.52
1,4-Dichloro-2-butene	< 0.52	< 0.47	< 0.52
Pentachloroethane	< 0.52	< 0.47	< 0.52
1,3-Dichlorobenzene	< 0.52	< 0.47	< 0.52
1,4-Dichlorobenzene	< 0.52	< 0.47	< 0.52
1,2-Dichlorobenzene	< 0.52	< 0.47	< 0.52
1,2-Dibromo-3-chloropropane	< 0.52	< 0.47	< 0.52
Master Index	**2067**	**2068**	**2069**
Surrogate Compounds Recovery	**%**	**%**	**%**
d6-Benzene	84	63	82
d4-1,2-dichloroethane	99	114	106
d8-toluene	86	84	86
4-bromofluorobenzene	107	108	112

TIRE BURN
Acurex-RTP Laboratory Results
EPA Method 8240 / VOST Matrix
Hewlett Packard 5890 GC / 5971 MSD; 30m x 0.53u DB-624 fused silica capillary
Tekmar LSC-2000 w/Carbotrap/Carbosieve SIII.
PQL = Practical Quantitation Limit
N/D = Not Detected
J = Detected @< PQL
N/A = Not Applicable

Sample Type	VOST	VOST	VOST	VOST	
Master Index	2053	2054	2055	2056	
Sample ID	701/335	512/570	CC86/56	380/108	
Sample Collected (Liters)	---	19.16	19.172	19.359	
Collection Date	---	05/13/93	05/13/93	05/13/93	
Analysis Date	06/08/93	06/08/93	06/08/93	06/08/93	PQL
	ng	ng/L	ng/L	ng/L	ng/(x)L
dichlorodifluoromethane	ND	ND	ND	0.82	10
chloromethane	56.5	2.6	0.8	23.05	10
2-Methylpropene	ND	5.6	3.6	3.91	10
vinyl chloride	ND	ND	ND	ND	10
bromomethane	ND	ND	ND	0.71	10
chloroethane	ND	ND	ND	ND	10
trichlorofluoromethane	ND	ND	ND	ND	10
1,1-dichloroethene	ND	ND	ND	ND	10
Carbon Disulfide	ND	ND	ND	ND	10
iodomethane	ND	ND	ND	ND	10
Acetone	21.3	1.6	1.6	10.23	10
Vinyl Acetate	ND	ND	ND	ND	10
methylene chloride	143.0	11.9	81.1	57.78	10
trans-1,2-dichloroethene	ND	ND	ND	ND	10
2-Methyl-2-Propanol	ND	ND	ND	11.26	10
Hexane	ND	ND	0.6	ND	10
1,1-dichloroethane	ND	ND	ND	ND	10
2-Butanone	ND	ND	ND	ND	10
chloroform	ND	ND	ND	ND	10
1,1,1-trichloroethane	ND	0.9	0.7	1.37	10
carbon tetrachloride	ND	ND	ND	ND	10
benzene	23.3	2.0	3.5	3	10
1,2-dichloroethane	ND	ND	ND	ND	10
Fluorobenzene	ND	ND	ND	ND	10
2,5-Dimethyl-3-Hexene	ND	ND	ND	ND	10
2-Chloro-2-Methylpropane	ND	ND	ND	ND	10
Heptane	ND	0.5	0.8	0.46	10
trichloroethene	ND	ND	ND	ND	10
1,2-dichloropropane	ND	ND	ND	ND	10
dibromomethane	ND	ND	ND	ND	10
1,4-Dioxane	ND	ND	ND	ND	10
bromodichloromethane	ND	ND	ND	ND	10
cis-1,3-dichloropropene	ND	ND	ND	ND	10
4-Methyl-2-Pentanone	ND	ND	ND	0.62	10
toluene	ND	0.82	1.29	1.04	10
trans-1,3-dichloropropene	ND	ND	ND	ND	10
1,1,2-trichloroethane	ND	ND	ND	ND	10
Bromoacetone	ND	ND	ND	ND	10

tetrachloroethene	ND	ND	ND	ND	10
2-Hexanone	ND	ND	ND	ND	10
dibromochloromethane	ND	ND	ND	ND	10
1,2-dibromoethane	ND	ND	ND	ND	10
chlorobenzene	ND	ND	ND	ND	10
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	10
ethyl benzene	ND	0.58	0.68	0.57	10
m,p-xylene	ND	2.58	2.55	2.06	10
Nonane	ND	0.79	1.42	0.67	10
o-xylene	ND	0.71	0.79	0.66	10
Styrene	ND	0.97	3.38	0.51	10
bromoform	ND	ND	ND	ND	10
Cumene	ND	ND	ND	ND	10
1,2,3-Trichloropropane	ND	ND	ND	ND	10
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	10
1,4-Dichloro-2-butene	ND	ND	ND	ND	10
Pentachloroethane	ND	ND	ND	ND	10
1,3-Dichlorobenzene	ND	ND	ND	ND	10
1,4-Dichlorobenzene	ND	ND	ND	ND	10
1,2-Dichlorobenzene	ND	ND	ND	ND	10
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	10
Master Index	2053	2054	2055	2056	
Surrogate Compounds Recovery	%	%	%	%	
d6-Benzene	91	108	104	107	
d4-1,2-dichloroethane	153	107	97	103	
d8-toluene	100	92	94	96	
4-bromofluorobenzene	94	107	98	96	

Analyst _____ Laboratory Manager _____ Date 8/2/93

Lotus 1-2-3 File Name: C:\EXCEL\RPT\TBSH2.XLS

TIRE BURN
Acurex-RTP Laboratory Results
EPA Method 8240 / VOST Matrix
Hewlett Packard 5890 GC / 5971 MSD; 30m x 0.53u DB-624 fused silica capillary
Tekmar LSC-2000 w/Carbotrap/Carbosieve SIII.
PQL = Practical Quantitation Limit
N/D = Not Detected
J = Detected @< PQL
N/A = Not Applicable

Sample Type	VOST	VOST	VOST	VOST	
Master Index	2057	2058	2062	2063	
Sample ID	700/10	165/102	531/108	365/76	
Sample Collected (Liters)	19.229	19.145	19.037	---	
Collection Date	05/18/93	05/18/93	05/18/93	---	
Analysis Date	06/08/93	06/08/93	06/09/93	06/09/93	PQL
	ng/L	ng/L	ng/L	ng	ng/(x)L
dichlorodifluoromethane	ND	ND	ND	ND	10
chloromethane	ND	0.7	ND	26.85	10
2-Methylpropene	2.5	3.2	1.4	ND	10
vinyl chloride	ND	ND	ND	ND	10
bromomethane	ND	0.4	ND	ND	10
chloroethane	ND	ND	ND	ND	10
trichlorofluoromethane	0.4	ND	ND	ND	10
1,1-dichloroethene	ND	ND	ND	ND	10
Carbon Disulfide	ND	ND	ND	ND	10
iodomethane	ND	ND	ND	ND	10
Acetone	2.6	3.1	2.6	73.49	10
Vinyl Acetate	ND	ND	ND	ND	10
methylene chloride	184.1	43.5	20.8	1119.42	10
trans-1,2-dichloroethene	ND	ND	ND	ND	10
2-Methyl-2-Propanol	ND	ND	ND	ND	10
Hexane	ND	0.4	ND	ND	10
1,1-dichloroethane	ND	ND	ND	ND	10
2-Butanone	ND	ND	ND	ND	10
chloroform	ND	ND	ND	ND	10
1,1,1-trichloroethane	0.6	ND	ND	ND	10
carbon tetrachloride	ND	ND	ND	ND	10
benzene	1.9	1.4	1.7	23.64	10
1,2-dichloroethane	ND	ND	ND	ND	10
Fluorobenzene	ND	ND	ND	ND	10
2,5-Dimethyl-3-Hexene	ND	ND	ND	ND	10
2-Chloro-2-Methylpropane	ND	ND	ND	ND	10
Heptane	ND	ND	ND	ND	10
trichloroethene	ND	ND	ND	ND	10
1,2-dichloropropane	ND	ND	ND	ND	10
dibromomethane	ND	ND	ND	ND	10
1,4-Dioxane	ND	ND	ND	ND	10
bromodichloromethane	ND	ND	ND	ND	10
cis-1,3-dichloropropene	ND	ND	ND	ND	10
4-Methyl-2-Pentanone	ND	ND	ND	ND	10
toluene	1.37	0.85	0.7	ND	10
trans-1,3-dichloropropene	ND	ND	ND	ND	10
1,1,2-trichloroethane	ND	ND	ND	ND	10
Bromoacetone	ND	ND	ND	ND	10

tetrachloroethene	ND	ND	ND	ND	10
2-Hexanone	ND	ND	ND	ND	10
dibromochloromethane	ND	ND	ND	ND	10
1,2-dibromoethane	ND	ND	ND	ND	10
chlorobenzene	ND	ND	ND	ND	10
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	10
ethyl benzene	ND	ND	ND	ND	10
m,p-xylene	1.61	1.63	1.33	ND	10
Nonane	0.83	0.54	0.67	ND	10
o-xylene	0.42	0.52	0.42	ND	10
Styrene	0.49	0.44	1.01	ND	10
bromoform	ND	ND	ND	ND	10
Cumene	ND	ND	ND	ND	10
1,2,3-Trichloropropane	ND	ND	ND	ND	10
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	10
1,4-Dichloro-2-butene	ND	ND	ND	ND	10
Pentachloroethane	ND	ND	ND	ND	10
1,3-Dichlorobenzene	ND	ND	ND	ND	10
1,4-Dichlorobenzene	ND	ND	ND	ND	10
1,2-Dichlorobenzene	ND	ND	ND	ND	10
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	10
Master Index	2057	2058	2062	2063	
Surrogate Compounds Recovery	%	%	%	%	
d6-Benzene	105	104	96	96	
d4-1,2-dichloroethane	88	99	98	124	
d8-toluene	88	96	95	92	
4-bromofluorobenzene	106	100	102	101	

Analyst _____ Laboratory Manager_____ Date_____

Lotus 1-2-3 File Name: C:\EXCEL\RPT\TBSH3.XLS

APPENDIX C. SEMI-VOLATILE ORGANIC SAMPLING DATA

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-11-93

Test Number	MM5-1	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	20 % Tires	Pitot Cp	0.84	Barom. Press.	29.81 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.3 "H2O
Operator	RT	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB1-MM5	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1434	Stop Time	1704	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1434		1.80	711.582	595	220	68	104	96	9.0
1	1457		1.60	729.000	597	220	94	124	102	9.0
2	1520		1.70	746.000	599	220	80	128	112	9.0
3	1540		1.70	761.000	587	220	76	126	106	9.0
4	1606		1.70	781.000	594	220	76	122	100	9.0
5	1631		1.70	800.000	595	220	84	122	104	9.6
6	1704		1.60	824.217	590	220	80	126	106	10.0
Average			1.69		594	220	80	122	104	

Total Volume Metered, Vm	112.635	Cubic Ft.	Measured O2	7.20
Total Sampling Time, ø	150	minutes	Measured CO2	7.40
Moisture Collected	NA	grams	Measured H2O	12.0
Average Stack Gas Velocity, v	13.5	ft/sec.	Molecular Wt	28.1

Exhaust Duct Flow	149.0	SCFM	131.1	DSCFM
Gas Volume Collected:	105.302	DSCF	2.9818	DSCM
Average Sampling Rate	0.702	DSCFM,	1.612	ACFM ======> 66.9 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-11-93

Test Number	MM5-1	Sampling Run No.	TB1-MM5
Condition	20 % Tires	Operator	RT
Location	Exhaust Duct	Exhaust Duct Flow	131.1 DSCFM
Start Time	1434	Volume Collected	2.9818 DSCM
Stop Time	1704	Isokinetic	66.9 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	5.7	< 1.91
4	PHENOL	108-95-2	*	ND	3.0	< 1.01
6	ANILINE	62-53-3	*	ND	2.5	< 0.84
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	3.6	< 1.21
8	2-CHLOROPHENOL	95-57-8	*	ND	6.1	< 2.05
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	1.7	< 0.57
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	1.9	< 0.64
12	BENZYL ALCOHOL	100-51-6	*	ND	1.8	< 0.60
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	3.4	< 1.14
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	3.9	< 1.31
16	2-METHYLPHENOL	95-48-7	*	ND	4.7	< 1.58
17	4-METHYLPHENOL	106-44-5	*	ND	0.1	< 0.03
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	3.0	< 1.01
19	4-NITROSO-MORPHOLINE	59-89-2		ND	4.6	< 1.54
20	2-METHYL-BENZENAMINE	98-84-0		ND	3.0	< 1.01
22	HEXACHLOROETHANE	67-72-1	*	ND	8.5	< 2.85
23	NITROBENZENE	98-95-3	*	ND	3.0	< 1.01
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	4.4	< 1.48
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	2.6	< 0.87
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	2.1	< 0.70
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	2.2	< 0.74
30	NAPHTHALENE	91-20-3	*	ND	1.3	< 0.44
31	4-CHLOROANILINE	106-47-8	*	ND	1.9	< 0.64
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	2.8	< 0.94
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	5.4	< 1.81
36	METHOXYMETHYLBENZEAMINE	5961-59-1		ND	2.4	< 0.80
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	.77	< 0.26
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	2.7	< 0.91
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	1.0	< 0.34
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	3.1	< 1.04
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	5.5	< 1.84

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	.97	< 0.33
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	1.1	< 0.37
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	1.6	< 0.54
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PHATHALATE	131-11-3	*	ND	1.2	< 0.40
50	2,6-DINITROTOLUENE	606-20-2	*	ND	3.6	< 1.21
51	ACENAPHTHYLENE	208-96-8	*	ND	.30	< 0.10
52	3-NITROANILINE	99-09-2	*	ND	.79	< 0.26
54	ACENAPHTHENE	83-32-9	*	ND	.98	< 0.33
55	2,4-DINITROTOLUENE	121-14-2	*	ND	2.9	< 0.97
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	.84	< 0.28
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	2.7	< 0.91
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	1.1	< 0.37
62	DIETHYL PHATHALATE	84-66-2	*	ND	1.5	< 0.50
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	.82	< 0.27
65	FLUORENE	86-73-7	*	ND	1.3	< 0.44
66	DIPHENYLAMINE	122-39-4		ND	1.6	< 0.54
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	1.4	< 0.47
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	.26	< 0.09
70	HEXACHLOROBENZENE	118-74-1	*	ND	1.4	< 0.47
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	3.5	< 1.17
73	PENTACHLOROPHENOL	87-86-5	*	ND	8.5	< 2.85
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	.29	< 0.10
77	PHENANTHRENE	85-01-8	*	ND	.55	< 0.18
78	ANTHRACENE	120-12-7	*	ND	.90	< 0.30
79	DI-N-BUTYLPHATHALATE	84-74-2	*	ND	5.9	< 1.98
80	METHAPYRILENE	91-80-5		ND	1.1	< 0.37
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	0.9	< 0.30
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	2.5	< 0.84
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	2.0	< 0.67
87	BUTYL BENZYL PHATHALATE	85-68-7	*	ND	4.8	< 1.61
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	.98	< 0.33
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	.39	< 0.13
90	BIS(2-ETHYLHEXYL)PHATHALATE	117-81-7	*	ND	2.9	< 0.97
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	.61	< 0.20
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	2.7	< 0.91
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	.59	< 0.20
94	CHRYSENE	218-01-9	*	ND	1.6	< 0.54
96	DI-N-OCTYLPHATHALATE	117-84-0	*	ND	3.5	< 1.17
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	5.9	< 1.98
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	9.3	< 3.12
101	BENZO(A)PYRENE	50-32-8	*	ND	6.8	< 2.28
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	11	< 3.69
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	8.4	< 2.82
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	16	< 5.37

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)	F	30	15
5	D5-PHENOL(ACID SUR)	(10-94)	P	24.58	12.29
21	D5-NITROBENZENE(B/N SUR)	(35-114)	F	8.88	8.88
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)	F	8.05	8.05
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)	F	4.89	2.445
86	D14-TERPHENYL(B/N SUR)	(33-141)	F	7.48	7.48

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 200UG/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-13-93

Test Number	MM5-2	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	20 % Tires	Pitot Cp	0.84	Barom. Press.	29.92 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.5 "H2O
Operator	RT	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB2-MM5	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1221	Stop Time	1532	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1221		2.80	824.517	606	220				11.0
1	1229		2.80	832.000	614	220	98	120	100	13.0
2	1255		2.80	857.000	620	220	87	140	112	13.0
3	1314		2.80	875.000	589	220	76	144	120	15.0
4	1331		2.80	892.000	593	220	70	150	122	15.0
5	1350		2.80	910.000	603	220	66	150	124	15.0
6	1410		2.80	930.000	620	220	65	150	124	16.0
7	1439		2.80	959.000	610	220	66	148	123	16.0
8	1505		2.80	983.000	592	220	58	146	122	16.0
9	1532		2.80	1010.081	621	220	60	146	122	16.0
Average			3.11		607	220	72	144	119	

Total Volume Metered, Vm	185.564 Cubic Ft.	Measured O2	7.30
Total Sampling Time, ø	191 minutes	Measured CO2	7.70
Moisture Collected	608.9 grams	Measured H2O	13.4
Average Stack Gas Velocity, v	12.9 ft/sec.	Molecular Wt	28.0

Exhaust Duct Flow	140.4 SCFM	121.6 DSCFM	
Gas Volume Collected:	169.242 DSCF	4.7924 DSCM	
Average Sampling Rate	0.886 DSCFM,	2.086 ACFM	======> 100.9 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln

Test Date: 5-13-93

Test Number	MM5-2	Sampling Run No.	TB2-MM5
Condition	20 % Tires	Operator	RT
Location	Exhaust Duct	Exhaust Duct Flow	121.6 DSCFM
Start Time	1221	Volume Collected	4.7924 DSCM
Stop Time	1532	Isokinetic	100.9 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	5.7	< 1.19
4	PHENOL	108-95-2	*	1.0 J	3.0	0.21
6	ANILINE	62-53-3	*	ND	2.5	< 0.52
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	3.6	< 0.75
8	2-CHLOROPHENOL	95-57-8	*	ND	6.1	< 1.27
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	1.7	< 0.35
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	1.9	< 0.40
12	BENZYL ALCOHOL	100-51-6	*	ND	1.8	< 0.38
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	3.4	< 0.71
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	3.9	< 0.81
16	2-METHYLPHENOL	95-48-7	*	ND	4.7	< 0.98
17	4-METHYLPHENOL	106-44-5	*	ND	0.1	< 0.02
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	3.0	< 0.63
19	4-NITROSO-MORPHOLINE	59-89-2		ND	4.6	< 0.96
20	2-METHYL-BENZENAMINE	98-84-0		ND	3.0	< 0.63
22	HEXACHLOROETHANE	67-72-1	*	ND	8.5	< 1.77
23	NITROBENZENE	98-95-3	*	ND	3.0	< 0.63
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	4.4	< 0.92
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	2.6	< 0.54
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	2.1	< 0.44
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	2.2	< 0.46
30	NAPHTHALENE	91-20-3	*	ND	1.3	< 0.27
31	4-CHLOROANILINE	106-47-8	*	ND	1.9	< 0.40
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	2.8	< 0.58
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	5.4	< 1.13
36	METHOXYMETHYLBENZRAMINE	5961-59-1		ND	2.4	< 0.50
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	.77	< 0.16
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	2.7	< 0.56
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	1.0	< 0.21
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	3.1	< 0.65
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	5.5	< 1.15

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	.97	< 0.20
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	1.1	< 0.23
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	1.6	< 0.33
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PHATHALATE	131-11-3	*	ND	1.2	< 0.25
50	2,6-DINITROTOLUENE	606-20-2	*	ND	3.6	< 0.75
51	ACENAPHTHYLENE	208-96-8	*	ND	.30	< 0.06
52	3-NITROANILINE	99-09-2	*	ND	.79	< 0.16
54	ACENAPHTHENE	83-32-9	*	ND	.98	< 0.20
55	2,4-DINITROTOLUENE	121-14-2	*	ND	2.9	< 0.61
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	.84	< 0.18
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	2.7	< 0.56
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	1.1	< 0.23
62	DIETHYL PHATHALATE	84-66-2	*	ND	1.5	< 0.31
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	.82	< 0.17
65	FLUORENE	86-73-7	*	ND	1.3	< 0.27
66	DIPHENYLAMINE	122-39-4		ND	1.6	< 0.33
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	1.4	< 0.29
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	.26	< 0.05
70	HEXACHLOROBENZENE	118-74-1	*	ND	1.4	< 0.29
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	3.5	< 0.73
73	PENTACHLOROPHENOL	87-86-5	*	ND	8.5	< 1.77
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	.29	< 0.06
77	PHENANTHRENE	85-01-8	*	ND	.55	< 0.11
78	ANTHRACENE	120-12-7	*	ND	.90	< 0.19
79	DI-N-BUTYLPHATHALATE	84-74-2	*	ND	5.9	< 1.23
80	METHAPYRILENE	91-80-5		ND	1.1	< 0.23
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	0.9	< 0.19
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	2.5	< 0.52
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	2.0	< 0.42
87	BUTYL BENZYL PHATHALATE	85-68-7	*	ND	4.8	< 1.00
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	.98	< 0.20
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	.39	< 0.08
90	BIS(2-ETHYLHEXYL)PHATHALATE	117-81-7	*	ND	2.9	< 0.61
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	.61	< 0.13
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	2.7	< 0.56
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	.59	< 0.12
94	CHRYSENE	218-01-9	*	ND	1.6	< 0.33
96	DI-N-OCTYLPHATHALATE	117-84-0	*	ND	3.5	< 0.73
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	5.9	< 1.23
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	9.3	< 1.94
101	BENZO(A)PYRENE	50-32-8	*	ND	6.8	< 1.42
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	11	< 2.30
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	8.4	< 1.75
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	16	< 3.34

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)	F	28.59	14.30
5	D5-PHENOL(ACID SUR)	(10-94)	P	28.70	14.35
21	D5-NITROBENZENE(B/N SUR)	(35-114)	F	15.05	15.05
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)	F	13.13	13.13
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)	F	15.40	7.70
86	D14-TERPHENYL(B/N SUR)	(33-141)	F	13.18	13.18

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICIENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 200UG/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-17-93

Test Number	MM5-3	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	20 % Tires	Pitot Cp	0.84	Barom. Press.	29.76 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.7 "H2O
Operator	RT	Meter Y	0.974	Est. Moisture	12.0 %
Run No.	TB3-MM5	Meter dH@	2.00	Est. Oxygen	7.5 %
Start Time	1118	Stop Time	1547	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1118		3.50	529.041	675	220	70	92	92	10.0
1	1140		3.50	550.000	676	220	70	119	101	10.0
2	1212		3.50	584.000	676	220	76	128	114	11.0
3	1308		3.50	641.000	673	220	72	130	120	11.0
4	1349		3.50	685.000	678	220	73	130	120	13.0
5	1438		3.50	736.000	665	220	66	131	120	14.0
6	1512		3.50	770.000	664	220	69	131	120	14.0
7	1547		3.50	805.843	662	220	60	131	120	15.0
Average			3.50		671	220	70	124	113	

Total Volume Metered, Vm	276.802 Cubic Ft.	Measured O2	8.50
Total Sampling Time, ø	269 minutes	Measured CO2	7.10
Moisture Collected	754.8 grams	Measured H2O	11.4
Average Stack Gas Velocity, v	14.5 ft/sec.	Molecular Wt	28.2

Exhaust Duct Flow.	148.4 SCFM	131.5 DSCFM	
Gas Volume Collected:	246.692 DSCF	6.9856 DSCM	
Average Sampling Rate	0.917 DSCFM,	2.251 ACFM	======> 100.0 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Deecription: Rotary Kiln Test Date: 5-17-93

Test Number	MM5-3	Sampling Run No.	TB3-MM5
Condition	20 % Tires	Operator	RT
Location	Exhaust Duct	Exhaust Duct Flow	131.5 DSCFM
Start Time	1118	Volume Collected	6.9856 DSCM
Stop Time	1547	Isokinetic	100.0 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	57	< 8.2
4	PHENOL	108-95-2	*	ND	30	< 4.3
6	ANILINE	62-53-3	*	ND	25	< 3.6
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	36	< 5.2
8	2-CHLOROPHENOL	95-57-8	*	ND	61	< 8.7
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	17	< 2.4
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	19	< 2.7
12	BENZYL ALCOHOL	100-51-6	*	ND	18	< 2.6
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	34	< 4.9
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	39	< 5.6
16	2-METHYLPHENOL	95-48-7	*	ND	47	< 6.7
17	4-METHYLPHENOL	106-44-5	*	ND	1	< 0.1
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	30	< 4.3
19	4-NITROSO-MORPHOLINE	59-89-2		ND	46	< 6.6
20	2-METHYL-BENZENAMINE	98-84-0		ND	30	< 4.3
22	HEXACHLOROETHANE	67-72-1	*	ND	85	< 12.2
23	NITROBENZENE	98-95-3	*	ND	30	< 4.3
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	44	< 6.3
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	26	< 3.7
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	21	< 3.0
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	22	< 3.1
30	NAPHTHALENE	91-20-3	*	ND	13	< 1.9
31	4-CHLOROANILINE	106-47-8	*	ND	19	< 2.7
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	28	< 4.0
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	54	< 7.7
36	METHOXYMETHYLBENZEAMINE	5961-59-1		ND	24	< 3.4
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	8	< 1.1
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	27	< 3.9
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	10	< 1.4
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	31	< 4.4
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	55	< 7.9

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	10	< 1.4
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	11	< 1.6
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	16	< 2.3
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PHATHALATE	131-11-3	*	ND	12	< 1.7
50	2,6-DINITROTOLUENE	606-20-2	*	ND	36	< 5.2
51	ACENAPHTHYLENE	208-96-8	*	ND	3	< 0.4
52	3-NITROANILINE	99-09-2	*	ND	8	< 1.1
54	ACENAPHTHENE	83-32-9	*	ND	10	< 1.4
55	2,4-DINITROTOLUENE	121-14-2	*	ND	29	< 4.2
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	8	< 1.1
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	27	< 3.9
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	11	< 1.6
62	DIETHYL PHATHALATE	84-66-2	*	ND	15	< 2.1
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	8	< 1.1
65	FLUORENE	86-73-7	*	ND	13	< 1.9
66	DIPHENYLAMINE	122-39-4		ND	16	< 2.3
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	14	< 2.0
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	3	< 0.4
70	HEXACHLOROBENZENE	118-74-1	*	ND	14	< 2.0
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	35	< 5.0
73	PENTACHLOROPHENOL	87-86-5	*	ND	85	< 12.2
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	3	< 0.4
77	PHENANTHRENE	85-01-8	*	ND	6	< 0.9
78	ANTHRACENE	120-12-7	*	ND	9	< 1.3
79	DI-N-BUTYLPHATHALATE	84-74-2	*	ND	59	< 8.4
80	METHAPYRILENE	91-80-5		ND	11	< 1.6
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	9	< 1.3
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	25	< 3.6
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	20	< 2.9
87	BUTYL BENZYL PHATHALATE	85-68-7	*	ND	48	< 6.9
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	10	< 1.4
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	4	< 0.6
90	BIS(2-ETHYLHEXYL)PHATHALATE	117-81-7	*	ND	29	< 4.2
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	6	< 0.9
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	27	< 3.9
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	6	< 0.9
94	CHRYSENE	218-01-9	*	ND	16	< 2.3
96	DI-N-OCTYLPHATHALATE	117-84-0	*	ND	35	< 5.0
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	59	< 8.4
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	93	< 13.3
101	BENZO(A)PYRENE	50-32-8	*	ND	68	< 9.7
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	110	< 15.7
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	84	< 12.0
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	160	< 22.9

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)			NA
5	D5-PHENOL(ACID SUR)	(10-94)			NA
21	D5-NITROBENZENE(B/N SUR)	(35-114)			NA
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)			NA
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)			NA
86	D14-TERPHENYL(B/N SUR)	(33-141)			NA

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 200UG/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

NA = NOT APPLICABLE; SURROGATES NOT ADDED TO SAMPLE

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-18-93

Test Number	M5-4	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	No Tires	Pitot Cp	0.84	Barom. Press.	29.66 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.5 "H2O
Operator	RT, JEB	Meter Y	0.974	Est. Moisture	12.0 %
Run No.	TB4-M5	Meter dH@	2.00	Est. Oxygen	7.5 %
Start Time	1130	Stop Time	1431	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1130		3.50	806.138	596	220	56	91	91	14.0
1	1159		3.80	836.000	595	220	68	120	102	14.0
2	1218		3.80	857.000	596	220	70	127	110	14.0
3	1241		3.80	885.000	598	220	60	131	115	14.0
4	1256		3.80	898.000	597	220	60	130	116	13.0
5	1318		3.80	922.000	595	220	60	130	117	13.0
6	1338		3.80	944.000	590	220	56	130	117	13.0
7	1358		3.80	965.000	591	220	59	131	118	13.0
8	1415		3.80	984.000	604	220	60	131	118	13.0
9	1431			1001.188						
Average			3.77		596	220	61	125	112	

Total Volume Metered, Vm	195.050 Cubic Ft.	Measured O2	9.30
Total Sampling Time, ø	181 minutes	Measured CO2	6.30
Moisture Collected	617.3 grams	Measured H2O	13.0
Average Stack Gas Velocity, v	18.2 ft/sec.	Molecular Wt	27.9

Exhaust Duct Flow	199.5 SCFM	173.6 DSCFM		
Gas Volume Collected:	173.557 DSCF	4.9146 DSCM		
Average Sampling Rate	0.959 DSCFM,	2.243 ACFM	======>	89.7 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln

Test Date: 5-18-93

Test Number	MM5-4	Sampling Run No.	TB4-MM5
Condition	No Tires	Operator	RT, JEB
Location	Exhaust Duct	Exhaust Duct Flow	173.6 DSCFM
Start Time	1130	Volume Collected	4.9146 DSCM
Stop Time	1431	Isokinetic	89.7 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	5.7	< 1.16
4	PHENOL	108-95-2	*	ND	3.0	< 0.61
6	ANILINE	62-53-3	*	ND	2.5	< 0.51
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	3.6	< 0.73
8	2-CHLOROPHENOL	95-57-8	*	ND	6.1	< 1.24
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	1.7	< 0.35
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	1.9	< 0.39
12	BENZYL ALCOHOL	100-51-6	*	ND	1.8	< 0.37
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	3.4	< 0.69
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	3.9	< 0.79
16	2-METHYLPHENOL	95-48-7	*	ND	4.7	< 0.96
17	4-METHYLPHENOL	106-44-5	*	ND	0.1	< 0.02
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	3.0	< 0.61
19	4-NITROSO-MORPHOLINE	59-89-2		ND	4.6	< 0.94
20	2-METHYL-BENZENAMINE	98-84-0		ND	3.0	< 0.61
22	HEXACHLOROETHANE	67-72-1	*	ND	8.5	< 1.73
23	NITROBENZENE	98-95-3	*	ND	3.0	< 0.61
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	4.4	< 0.90
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	2.6	< 0.53
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	2.1	< 0.43
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	2.2	< 0.45
30	NAPHTHALENE	91-20-3	*	ND	1.3	< 0.26
31	4-CHLOROANILINE	106-47-8	*	ND	1.9	< 0.39
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	2.8	< 0.57
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	5.4	< 1.10
36	METHOXYMETHYLBENZEAMINE	5961-59-1		ND	2.4	< 0.49
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	.77	< 0.16
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	2.7	< 0.55
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	1.0	< 0.20
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	3.1	< 0.63
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	5.5	< 1.12

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	.97	< 0.20
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	1.1	< 0.22
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	1.6	< 0.33
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PHATHALATE	131-11-3	*	ND	1.2	< 0.24
50	2,6-DINITROTOLUENE	606-20-2	*	ND	3.6	< 0.73
51	ACENAPHTHYLENE	208-96-8	*	ND	.30	< 0.06
52	3-NITROANILINE	99-09-2	*	ND	.79	< 0.16
54	ACENAPHTHENE	83-32-9	*	ND	.98	< 0.20
55	2,4-DINITROTOLUENE	121-14-2	*	ND	2.9	< 0.59
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	.84	< 0.17
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	2.7	< 0.55
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	1.1	< 0.22
62	DIETHYL PHATHALATE	84-66-2	*	ND	1.5	< 0.31
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	.82	< 0.17
65	FLUORENE	86-73-7	*	ND	1.3	< 0.26
66	DIPHENYLAMINE	122-39-4		ND	1.6	< 0.33
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	1.4	< 0.28
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	.26	< 0.05
70	HEXACHLOROBENZENE	118-74-1	*	ND	1.4	< 0.28
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	3.5	< 0.71
73	PENTACHLOROPHENOL	87-86-5	*	ND	8.5	< 1.73
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	.29	< 0.06
77	PHENANTHRENE	85-01-8	*	ND	.55	< 0.11
78	ANTHRACENE	120-12-7	*	ND	.90	< 0.18
79	DI-N-BUTYLPHATHALATE	84-74-2	*	ND	5.9	< 1.20
80	METHAPYRILENE	91-80-5		ND	1.1	< 0.22
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	0.9	< 0.18
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	2.5	< 0.51
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	2.0	< 0.41
87	BUTYL BENZYL PHATHALATE	85-68-7	*	ND	4.8	< 0.98
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	.98	< 0.20
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	.39	< 0.08
90	BIS(2-ETHYLHEXYL)PHATHALATE	117-81-7	*	ND	2.9	< 0.59
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	.61	< 0.12
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	2.7	< 0.55
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	.59	< 0.12
94	CHRYSENE	218-01-9	*	ND	1.6	< 0.33
96	DI-N-OCTYLPHATHALATE	117-84-0	*	3.36 J	3.5	0.68
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	5.9	< 1.20
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	9.3	< 1.89
101	BENZO(A)PYRENE	50-32-8	*	ND	6.8	< 1.38
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	11	< 2.24
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	8.4	< 1.71
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	16	< 3.26

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)	P	134.91	67.46
5	D5-PHENOL(ACID SUR)	(10-94)	P	134.75	67.38
21	D5-NITROBENZENE(B/N SUR)	(35-114)	P	58.82	58.82
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)	P	51.27	51.27
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)	P	67.28	33.64
86	D14-TERPHENYL(B/N SUR)	(33-141)	P	56.79	56.79

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICIENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 200UG/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-21-93

Test Number	MM5-5	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	Ramping (20%)	Pitot Cp	0.84	Barom. Press.	29.70 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.1 "H2O
Operator	JKB	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB5-MM5	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1140	Stop Time	1440	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1140		3.50	423.179	629	220	59	98	79	12.4
1	1200		3.50	437.600	630	220	60	108	82	12.8
2	1215		3.50	453.200	636	220	62	124	92	12.6
3	1230		3.50	468.600	634	220	68	131	100	13.5
4	1245		3.50	484.700	637	220	65	134	104	12.8
5	1300		3.50	500.500	640	220	64	135	106	13.0
6	1315		3.50	516.200	641	220	63	135	108	13.3
7	1330		3.50	532.000	643	220	58	137	109	13.5
8	1345		3.50	547.700	641	220	58	138	110	14.3
9	1400		3.50	564.100	642	220	64	139	110	14.4
10	1420		3.50	584.700	643	220	58	139	111	14.7
11	1440			605.643						
Average			3.50		638	220	62	129	101	

Total Volume Metered, Vm	182.464 Cubic Ft.	Measured O2	6.40
Total Sampling Time, ø	180 minutes	Measured CO2	8.40
Moisture Collected	585.9 grams	Measured H2O	13.1
Average Stack Gas Velocity, v	15.4 ft/sec.	Molecular Wt	28.1

Exhaust Duct Flow	162.9 SCFM	141.5 DSCFM		
Gas Volume Collected:	170.053 DSCF	4.8154 DSCM		
Average Sampling Rate	0.945 DSCFM,	2.297 ACFM	======>	96.6 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-21-93

Test Number	M5-5	Sampling Run No.	TBS-M5
Condition	Ramping (20 % Tires)	Operator	JEB
Location	Exhaust Duct	Exhaust Duct Flow	141.5 DSCFM
Start Time	1140	Volume Collected	4.8154 DSCM
Stop Time	1440	Isokinetic	96.6 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	5.7	< 1.03
4	PHENOL	108-95-2	*	1.69 J	3.0	0.30
6	ANILINE	62-53-3	*	ND	2.5	< 0.45
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	3.6	< 0.65
8	2-CHLOROPHENOL	95-57-8	*	ND	6.1	< 1.10
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	1.7	< 0.31
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	1.9	< 0.34
12	BENZYL ALCOHOL	100-51-6	*	ND	1.8	< 0.32
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	3.4	< 0.61
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	3.9	< 0.70
16	2-METHYLPHENOL	95-48-7	*	ND	4.7	< 0.85
17	4-METHYLPHENOL	106-44-5	*	ND	0.1	< 0.02
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	3.0	< 0.54
19	4-NITROSO-MORPHOLINE	59-89-2		ND	4.6	< 0.83
20	2-METHYL-BENZENAMINE	98-84-0		ND	3.0	< 0.54
22	HEXACHLOROETHANE	67-72-1	*	ND	8.5	< 1.53
23	NITROBENZENE	98-95-3	*	ND	3.0	< 0.54
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	4.4	< 0.79
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	2.6	< 0.47
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	2.1	< 0.38
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	2.2	< 0.40
30	NAPHTHALENE	91-20-3	*	ND	1.3	< 0.23
31	4-CHLOROANILINE	106-47-8	*	ND	1.9	< 0.34
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	2.8	< 0.51
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	5.4	< 0.97
36	METHOXYMETHYLBENZEAMINE	5961-59-1		ND	2.4	< 0.43
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	.77	< 0.14
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	2.7	< 0.49
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	1.0	< 0.18
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	3.1	< 0.56
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	5.5	< 0.99

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	.97	< 0.17
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	1.1	< 0.20
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	1.6	< 0.29
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PHATHALATE	131-11-3	*	ND	1.2	< 0.22
50	2,6-DINITROTOLUENE	606-20-2	*	ND	3.6	< 0.65
51	ACENAPHTHYLENE	208-96-8	*	ND	.30	< 0.05
52	3-NITROANILINE	99-09-2	*	ND	.79	< 0.14
54	ACENAPHTHENE	83-32-9	*	ND	.98	< 0.18
55	2,4-DINITROTOLUENE	121-14-2	*	ND	2.9	< 0.52
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	.84	< 0.15
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	2.7	< 0.49
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	1.1	< 0.20
62	DIETHYL PHATHALATE	84-66-2	*	ND	1.5	< 0.27
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	.82	< 0.15
65	FLUORENE	86-73-7	*	ND	1.3	< 0.23
66	DIPHENYLAMINE	122-39-4		ND	1.6	< 0.29
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	1.4	< 0.25
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	.26	< 0.05
70	HEXACHLOROBENZENE	118-74-1	*	ND	1.4	< 0.25
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	3.5	< 0.63
73	PENTACHLOROPHENOL	87-86-5	*	ND	8.5	< 1.53
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	.29	< 0.05
77	PHENANTHRENE	85-01-8	*	ND	.55	< 0.10
78	ANTHRACENE	120-12-7	*	ND	.90	< 0.16
79	DI-N-BUTYLPHATHALATE	84-74-2	*	1.38 J	5.9	0.25
80	METHAPYRILENE	91-80-5		ND	1.1	< 0.20
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	0.9	< 0.16
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	2.5	< 0.45
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	2.0	< 0.36
87	BUTYL BENZYL PHATHALATE	85-68-7	*	ND	4.8	< 0.87
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	.98	< 0.18
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	.39	< 0.07
90	BIS(2-ETHYLHEXYL)PHATHALATE	117-81-7	*	5.48	2.9	< 0.52
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	.61	< 0.11
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	2.7	< 0.49
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	.59	< 0.11
94	CHRYSENE	218-01-9	*	ND	1.6	< 0.29
96	DI-N-OCTYLPHATHALATE	117-84-0	*	ND	3.5	< 0.63
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	5.9	< 1.06
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	9.3	< 1.68
101	BENZO(A)PYRENE	50-32-8	*	ND	6.8	< 1.23
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	11	< 1.98
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	8.4	< 1.52
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	16	< 2.89

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)	P	102.8	51.40
5	D5-PHENOL(ACID SUR)	(10-94)	P	100.7	50.35
21	D5-NITROBENZENE(B/N SUR)	(35-114)	P	76.85	76.85
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)	P	45.73	45.73
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)	P	55.33	27.67
86	D14-TERPHENYL(B/N SUR)	(33-141)	P	51.7	51.70

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICIENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 2000G/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-25-93

Test Number	MM5-6	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	Batch (20%)	Pitot Cp	0.84	Barom. Press.	29.95 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-4.1 "H2O
Operator	JEB	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB6-MM5	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1253	Stop Time	1600	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1253		4.20	607.046	677	220	57	91	88	12.1
1	1313		4.20	628.900	676	220	65	130	98	13.2
2	1328		4.20	645.900	651	220	68	141	107	17.8
3	1343		4.20	663.200	693	220	65	148	114	19.0
4	1358			680.454						
5	1413		4.20	681.191	684	220	61	122	114	11.6
6	1428		4.20	698.600	634	220	65	147	116	12.0
7	1443		4.20	715.700	627	220	68	148	119	12.7
8	1500		4.20	735.200	619	220	65	151	121	14.4
9	1515		4.20	752.400	669	220	62	152	122	15.5
10	1530		4.20	769.500	720	220	65	154	124	17.0
11	1545		4.20	786.900	672	220	63	155	124	18.0
12	1600			803.996						
Average			4.20		666	220	64	140	113	

Total Volume Metered, Vm	196.213 Cubic Ft.	Measured O2	8.40
Total Sampling Time, ø	172 minutes	Measured CO2	7.30
Moisture Collected	518.1 grams	Measured H2O	11.1
Average Stack Gas Velocity, v	18.9 ft/sec.	Molecular Wt	28.2

Exhaust Duct Flow	195.9 SCFM	174.2 DSCFM	
Gas Volume Collected:	181.029 DSCF	5.1262 DSCM	
Average Sampling Rate	1.052 DSCFM,	2.547 ACFM	======> 90.7 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln

Test Date: 5-25-93

Test Number	MM5-6	Sampling Run No.	TB6-MM5
Condition	Batch	Operator	JEB
Location	Exhaust Duct	Exhaust Duct Flow	174.2 DSCFM
Start Time	1253	Volume Collected	5.1262 DSCM
Stop Time	1600	Isokinetic	90.7 %

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
1	N-NITROSODIMETHYLAMINE	62-75-9	*	ND		----
3	N-NITROSODIETHYLAMINE	55-18-5		ND	57	< 7.2
4	PHENOL	108-95-2	*	ND	30	< 3.8
6	ANILINE	62-53-3	*	ND	25	< 3.2
7	BIS(2-CHLOROETHYL)ETHER	111-44-4	*	ND	36	< 4.6
8	2-CHLOROPHENOL	95-57-8	*	ND	61	< 7.7
9	1,3-DICHLOROBENZENE	541-73-1	*	ND	17	< 2.2
11	1,4-DICHLOROBENZENE	106-46-7	*	ND	19	< 2.4
12	BENZYL ALCOHOL	100-51-6	*	ND	18	< 2.3
13	1,2-DICHLOROBENZENE	95-50-1	*	ND	34	< 4.3
14	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1		ND		----
15	1-PHENYLETHANONE	98-86-2		ND	39	< 4.9
16	2-METHYLPHENOL	95-48-7	*	ND	47	< 6.0
17	4-METHYLPHENOL	106-44-5	*	ND	1	< 0.1
18	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	*	ND	30	< 3.8
19	4-NITROSO-MORPHOLINE	59-89-2		ND	46	< 5.8
20	2-METHYL-BENZENAMINE	98-84-0		ND	30	< 3.8
22	HEXACHLOROETHANE	67-72-1	*	ND	85	< 10.8
23	NITROBENZENE	98-95-3	*	ND	30	< 3.8
24	1-NITROSO-PIPERDINE	100-75-4		ND		----
25	ISOPHORONE	78-59-1	*	ND	44	< 5.6
26	2,4-DIMETHYLPHENOL	105-67-9	*	ND	26	< 3.3
27	BIS(2-CHLOROETHOXY)METHANE	111-91-1	*	ND	21	< 2.7
28	1,2,4-TRICHLOROBENZENE	120-82-1	*	ND	22	< 2.8
30	NAPHTHALENE	91-20-3	*	ND	13	< 1.6
31	4-CHLOROANILINE	106-47-8	*	ND	19	< 2.4
32	2,6-DICHLOROPHENOL	87-65-0	*	ND	28	< 3.6
33	HEXACHLOROBUTADIENE	87-68-3	*	ND		----
34	HEXACHLOROPROPENE	70-30-4		ND		----
35	N-NITROSO-DI-N-BUTYLAMINE	924-16-3		ND	54	< 6.8
36	METHOXYMETHYLBENZEAMINE	5961-59-1		ND	24	< 3.0
37	4-CHLORO-3-METHYLPHENOL	59-50-7	*	ND	8	< 1.0
38	5-CHLORO-2-METHYLANILINE	95-79-4		ND	27	< 3.4
39	2-METHYLNAPHTHALENE	91-57-6	*	ND	10	< 1.3
40	HEXACHLOROCYCLOPENTADIENE	77-47-4	*	ND		----
41	1,2,4,5-TETRACHLOROBENZENE	95-94-3		ND	31	< 3.9
42	2,4,6-TRICHLOROPHENOL	88-06-2	*	ND		----
43	2,4,5-TRICHLOROPHENOL	95-95-4	*	ND	55	< 7.0

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
44	2,3,4-TRICHLOROPHENOL	15950-66-0	*	ND	10	< 1.3
45	2-CHLORONAPHTHALENE	91-58-7	*	ND	11	< 1.4
46	1-CHLORONAPHTHALENE	90-13-1	*	ND	16	< 2.0
47	2-NITROANILINE	88-74-4	*	ND		----
49	DIMETHYL PH THALATE	131-11-3	*	ND	12	< 1.5
50	2,6-DINITROTOLUENE	606-20-2	*	ND	36	< 4.6
51	ACENAPHTHYLENE	208-96-8	*	ND	3	< 0.4
52	3-NITROANILINE	99-09-2	*	ND	8	< 1.0
54	ACENAPHTHENE	83-32-9	*	ND	10	< 1.3
55	2,4-DINITROTOLUENE	121-14-2	*	ND	29	< 3.7
56	PENTACHLOROBENZENE	608-93-5		ND		----
57	DIBENZOFURAN	132-64-9	*	ND	8	< 1.0
58	2,3,5,6-TETRACHLOROPHENOL	935-95-5		ND		----
59	4-NITROPHENOL	100-02-7	*	ND	27	< 3.4
60	2,3,4,6-TETRACHLOROPHENOL	58-90-2		ND		----
61	2-NAPHTHALENAMINE	91-59-8		ND	11	< 1.4
62	DIETHYL PH THALATE	84-66-2	*	ND	15	< 1.9
63	4-CHLOROPHENYLPHENYL ETHER	7005-72-3		ND		----
64	4-NITROANILINE	100-01-6		ND	8	< 1.0
65	FLUORENE	86-73-7	*	ND	13	< 1.6
66	DIPHENYLAMINE	122-39-4		ND	16	< 2.0
67	4,6-DINITRO-2-METHYLPHENOL	534-52-1	*	ND		----
68	AZOBENZENE	103-33-3		ND	14	< 1.8
69	N-(4-ETHOXYPHENYL)-ACETAMINE	62-44-2		ND	3	< 0.4
70	HEXACHLOROBENZENE	118-74-1	*	ND	14	< 1.8
71	4-BROMOPHENYL-PHENYLETHER	101-55-3		ND	35	< 4.4
73	PENTACHLOROPHENOL	87-86-5	*	ND	85	< 10.8
74	PENTACHLORONITROBENZENE	82-68-8		ND		----
75	N-NITROSODIPHENYLAMINE	86-30-6		ND	3	< 0.4
77	PHENANTHRENE	85-01-8	*	ND	6	< 0.8
78	ANTHRACENE	120-12-7	*	ND	9	< 1.1
79	DI-N-BUTYLPH THALATE	84-74-2	*	ND	59	< 7.5
80	METHAPYRILENE	91-80-5		ND	11	< 1.4
81	DIPHENYLTRIAZENE	136-35-6		ND		----
82	FLUORANTHENE	206-44-0	*	ND	9	< 1.1
83	BENZIDINE	92-87-5	*	ND		----
84	PYRENE	129-00-0	*	ND	25	< 3.2
85	N,N-DIMETHYL-AMINOAZOBENZENE	60-11-7		ND	20	< 2.5
87	BUTYL BENZYL PH THALATE	85-68-7	*	ND	48	< 6.1
88	3,3'-DIMETHYLBENZIDINE	119-93-7		ND	10	< 1.3
89	2-ACETYLAMINOFLUORENE	640-19-7		ND	4	< 0.5
90	BIS(2-ETHYLHEXYL)PH THALATE	117-81-7	*	ND	29	< 3.7
91	3,3'-DIMETHOXYBENZIDINE	119-90-4		ND	6	< 0.8
92	3,3'-DICHLOROBENZIDINE	91-94-1	*	ND	27	< 3.4
93	BENZO(A)ANTHRACENE	56-55-3	*	ND	6	< 0.8
94	CHRYSENE	218-01-9	*	ND	16	< 2.0
96	DI-N-OCTYLPH THALATE	117-84-0	*	ND	35	< 4.4
97	7,12-DIMETHYLBENZ(A)ANTHRACEN	57-97-6		ND		----
98	BENZO(B)FLUORANTHENE	205-99-2	*	ND	59	< 7.5
99	BENZO(K)FLUORANTHENE	207-08-9	*	ND	93	< 11.8
101	BENZO(A)PYRENE	50-32-8	*	ND	68	< 8.6
102	3-METHYLCHOLANTHRENE	56-49-5		ND		----

#	TARGET ANALYTE	CAS#	ATC	SAMPLE MASS (ug)	IDL (ug)	Loading (ug/M^3)
103	INDENO[1,2,3-cd]PYRENE	193-39-5	*	ND	110	< 14.0
104	DIBENZ[a,h]ANTHRACENE	53-70-3	*	ND	84	< 10.7
105	BENZO[ghi]PERYLENE	191-24-2	*	ND	160	< 20.3

#	SURROGATE STANDARDS	REQUIRED VALUES	P/F	TOTAL MASS(ug)	RECOVERY %
2	2-FLUOROPHENOL(ACID SUR)	(21-100)			NA
5	D5-PHENOL(ACID SUR)	(10-94)			NA
21	D5-NITROBENZENE(B/N SUR)	(35-114)			NA
48	2-FLUOROBIPHENYL(B/N SUR)	(43-116)			NA
72	2,4,6-TRIBROMOPHENOL(ACIDSUR)	(10-123)			NA
86	D14-TERPHENYL(B/N SUR)	(33-141)			NA

CAS# = CHEM ABSTRACT NUMBER.

ATC = AIR TOXIC COMPOUND.

IDL = INSTRUMENT DETECTION LEVEL.

ND = NOT DETECTED.

J = DETECTED AT LESS THAN THE INSTRUMENT DETECTION LEVEL.

SURROGATE STANDARDS = COMPOUNDS SPIKED INTO THE SAMPLE PRIOR TO EXTRACTION IN ORDER TO DETERMINE EXTRACTION EFFICENCY.

ACID SUR = ACID SURROGATE COMPOUND,SPIKED IN AT 200UG/ML.

B/N SUR = BASE/NEUTRAL SURROGATE COMPOUND,SPIKED IN AT 100UG/ML.

P/F = PASS OR FAIL.

NA = NOT APPLICABLE; SURROGATES NOT ADDED TO SAMPLE

APPENDIX D. PCDD/PCDF DATA

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-19-93

Test Number	M23-1	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	20 % Tires	Pitot Cp	0.84	Barom. Press.	29.52 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.6 "H2O
Operator	RT, JEB	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB1-M23	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1150	Stop Time	1520	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1150		2.80	26.185	626	220	63	98	88	7.0
1	1208		2.70	36.000				101	91	8.0
2	1215		3.00					101	91	10.0
3	1230		3.00	56.000	628	220	63	130	102	10.5
4	1250		3.00	74.000	627	220	63	136	110	10.5
5	1305		3.00	90.000	628	220	67	138	112	10.5
6	1320		3.00	105.000	629	220	70	140	114	11.0
7	1340		3.00	125.000	628	220	62	140	115	11.0
8	1400		3.00	145.000	627	220	65	140	116	11.0
9	1420		3.00	165.000	626	220	68	141	116	11.0
10	1435		3.00	180.000	627	220	58	142	116	11.5
11	1454		3.00	198.000	626	220	58	142	117	11.0
12	1520			227.663	627	220	92	142	117	11.0
Average			2.96		627	220	66	130	108	

Total Volume Metered, Vm	201.478 Cubic Ft.	Measured O2	7.80
Total Sampling Time, ø	210 minutes	Measured CO2	7.70
Moisture Collected	653.1 grams	Measured H2O	13.3
Average Stack Gas Velocity, v	14.8 ft/sec.	Molecular Wt	28.0

Exhaust Duct Flow	156.8 SCFM	136.0 DSCFM		
Gas Volume Collected:	185.069 DSCF	5.2406 DSCM		
Average Sampling Rate	0.881 DSCFM,	2.140 ACFM	=======>	94.4 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

SAMPLE: TB-D10X-1 CALIBRATION DATE: 06-17-93

	File Name	Total Sample Volume (microliters)	Volume Injected (microliters)	Volume Sampled (M^3)
Run	TBD10X01	100	2	5.241

	RRF Labeled Internal/ Labeled Recovery	RRF Unlabeled Native/ Labeled Internal
TCDD	0.954	0.932
TCDF	1.411	0.846
PeCDD	0.711	1.123
PeCDF	1.100	0.796
HexCDD	0.626	0.995
HexCDF	1.047	1.005
HepCDD	0.595	0.954
HepCDF	0.961	0.916
OCDD	0.436	1.137
OCDF	0.436	1.428

SAMPLE DESCRIPTION: MZ3-1 20% Tires

DATE REPORTED: 08-06-93

DATE INJECTED: 07-30-93

PROJECT: Tire Combustion

Theoretical Concentration of Labeled Internal Standards in Sample

	picagrams/ microliter	Total Amt Injected (pg/injection)
TCDD	250	500
TCDF	250	500
PeCDD	500	1000
PeCDF	500	1000
HexCDD	500	1000
HexCDF	500	1000
HepCDD	500	1000
HepCDF	500	1000
OCDD	1000	2000
OCDF	1000	2000

Theoretical Concentration of Labeled Recovery Standard in Sample

	(picagrams/ microliter)	Total Amt Injected (pg/injection)
TCDD	250	500

Quantitation of Labeled Recovery Standard

	Retention Time	Area Count
Run	22.907	2036557

TOTAL TCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	22.905	1436124	369.6	73.9

Unlabeled TCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
					0.000
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL TCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	21.931	2200035	302.8	76.6

Unlabeled TCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (pg/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL PeCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	26.774	2293794	792.1	79.2

Unlabeled PeCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL PeCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	25.738	3482466	777.3	77.7

Unlabeled PeCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HexCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	29.932	1722368	675.5	67.5

Unlabeled HexCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HexCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	29.152	2876248	674.5	67.4

Unlabeled HexCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
1	30.304	65401	22.6	1.1	0.216
1 Isomer(s)		TOTALS:	22.6	1.1	0.216

TOTAL HepCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	32.920	1322960	545.9	54.6

Unlabeled HepCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HepCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	31.935	2209758	564.5	56.5

Unlabeled HepCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL OCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	35.616	1888743	1063.6	53.2

Unlabeled OCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL OCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	35.616	1888743	1063.6	53.2

Unlabeled OCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-20-93

Test Number	M23-2	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	No Tires	Pitot Cp	0.84	Barom. Press.	29.55 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.1 "H2O
Operator	RT, JEB	Meter Y	1.014	Est. Moisture	12.0 %
Run No.	TB2-M23	Meter dH@	1.91	Est. Oxygen	7.5 %
Start Time	1038	Stop Time	1348	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1038		3.20	229.436	580	220	48	90	92	7.8
1	1053		3.20	243.900	582	220	58	116	89	8.6
2	1108		3.20	258.900	584	220	59	125	97	8.4
3	1123		3.20	274.100	584	220	61	129	104	8.4
4	1138		3.20	289.400	586	220	64	132	108	8.4
5	1153		3.20	304.900	596	220	58	134	110	8.5
6	1216		3.20	329.000	602	220	57	134	112	8.5
7	1234		3.20	347.000	600	220	60	135	113	8.7
8	1254		3.20	368.000	604	220	65	135	113	8.8
9	1313		3.20	387.000	600	220	60	134	113	8.8
10	1330		3.20	404.400	599	220	50	136	114	8.8
11	1348			422.860						
Average			3.20		592	220	58	127	106	

Total Volume Metered, Vm	193.424 Cubic Ft.	Measured O2	9.80
Total Sampling Time, ø	190 minutes	Measured CO2	5.90
Moisture Collected	539.5 grams	Measured H2O	11.6
Average Stack Gas Velocity, v	16.3 ft/sec.	Molecular Wt	28.0

Exhaust Duct Flow	178.2 SCFM	157.5 DSCFM		
Gas Volume Collected:	178.723 DSCF	5.0609 DSCM		
Average Sampling Rate	0.941 DSCFM,	2.166 ACFM	======>	96.1 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

SAMPLE: TB-DIOX-2 CALIBRATION DATE: 04-17-93

	File Name	Total Sample Volume (microliters)	Volume Injected (microliters)	Volume Sampled (M^3)
Run	TBDIOX02	100	2	5.061

	RRF Labeled Internal/ Labeled Recovery	RRF Unlabeled Native/ Labeled Internal
TCDD	0.954	0.932
TCDF	1.411	0.846
PeCDD	0.711	1.123
PeCDF	1.100	0.796
HexCDD	0.626	0.995
HexCDF	1.047	1.005
HepCDD	0.595	0.954
HepCDF	0.961	0.916
OCDD	0.436	1.137
OCDF	0.436	1.428

SAMPLE DESCRIPTION: N23-2 0% Tires.

DATE REPORTED: 08-09-93

DATE INJECTED: 07-30-93

PROJECT: Tire Combustion

Theoretical Concentration of Labeled Internal Standards in Sample

	picagrams/ microliter	Total Amt Injected (pg/injection)
TCDD	250	500
TCDF	250	500
PeCDD	500	1000
PeCDF	500	1000
HexCDD	500	1000
HexCDF	500	1000
HepCDD	500	1000
HepCDF	500	1000
OCDD	1000	2000
OCDF	1000	2000

Theoretical Concentration of Labeled Recovery Standard in Sample

	(picagrams/ microliter)	Total Amt Injected (pg/injection)
TCDD	250	500

Quantitation of Labeled Recovery Standard

	Retention Time	Area Count
Run	22.949	1960202

TOTAL TCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	22.943	2077458	585.3	117.1

Unlabeled TCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
2	22.957	92060	23.8	1.2	0.235
1 Isomer(s)		TOTALS:	23.8	1.2	0.235

TOTAL TCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	21.947	2738037	521.6	104.3

Unlabeled TCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/N^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL PeCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	26.816	2975238	1124.8	112.5

Unlabeled PeCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL PeCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	25.787	4449984	1087.4	108.7

Unlabeled PeCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HexCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	29.993	2002250	859.7	86.0

Unlabeled HexCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HexCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	29.204	3321770	852.8	85.3

Unlabeled HexCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picograms)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HepCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	32.981	1269394	573.4	57.3

Unlabeled HepCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL HepCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery
Run	32.012	2130218	595.8	59.6

Unlabeled HepCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL OCDDs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery	
Run	35.658	1264358	779.5	39.0	q-below qc-criteria

Unlabeled OCDD Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

TOTAL OCDFs

Labeled Internal Standard Quantitation

	Retention Time	Area Count	Concentration	% Recovery	
Run	35.658	1264358	779.5	39.0	q-below qc-criteria

Unlabeled OCDF Quantitation

Peak #	Retention Time	Area Count	Mass (picagrams)	Total Sample Mass (nanograms)	Total Sample Concentration (ng/M^3)
0 Isomer(s)		TOTALS:	0.0	0.0	0.000

APPENDIX E. METALS DATA

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln

Date: 5-19-93

Test Number	M5MM-1	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	20 % Tires	Pitot Cp	0.84	Barom. Press.	29.52 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.6 "H2O
Operator	JEB, RT	Meter Y	0.974	Est. Moisture	12.0 %
Run No.	TB1-M5MM	Meter dH@	2.00	Est. Oxygen	7.5 %
Start Time	1121	Stop Time	1451	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1121		2.80	1.466	630	220	56	88	86	5.8
1	1136		2.80	15.000	631	220	62	100	89	5.0
2	1151		2.80	28.000	634	220	61	107	95	5.2
3	1206		2.80	42.000	626	220	65	112	100	5.2
4	1221		2.80	56.000	627	220	63	114	104	5.3
5	1238		2.80	72.000	628	220	60	114	105	5.3
6	1303		2.80	95.000	628	220	61	116	108	5.5
7	1320		2.80	110.000	629	220	63	116	108	6.0
8	1340		2.80	129.000	628	220	68	116	108	6.8
9	1355		2.80	144.000	628	220	60	116	108	6.8
10	1410		2.80	157.000	625	220	62	116	108	7.0
11	1425		2.80	171.000	628	220	65	117	108	7.4
12	1440		2.80	186.000	627	220	57	118	108	7.5
13	1451		2.80	195.812						
Average			2.80		628	220	62	112	103	

Total Volume Metered, Vm	194.346 Cubic Ft.	Measured O2	7.80
Total Sampling Time, ø	210 minutes	Measured CO2	7.70
Moisture Collected	577.6 grams	Measured H2O	12.3
Average Stack Gas Velocity, v	14.8 ft/sec.	Molecular Wt	28.1

Exhaust Duct Flow	156.4 SCFM	137.1 DSCFM		
Gas Volume Collected:	175.024 DSCF	4.9561 DSCM		
Average Sampling Rate	0.833 DSCFM,	2.004 ACFM	======>	88.5 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln Test Date: 5-19-93

Test Number	M5MM-1	Sampling Run No.	TB1-M5MM
Condition	20 % Tires	Operator	JEB, RT
Location	Exhaust Duct	Exhaust Duct Flow	137.1 DSCFM
Start Time	1121	Volume Collected	175.024 DSCF
Stop Time	1451	Isokinetic	88.5 %

	--- Front Half ---		--- Back Half ---		---- Total ----	
	ug	ug/m^3	ug	ug/m^3	ug	ug/m^3
Arsenic	210.00	37.16	NA	NA	NA	NA
Beryllium	0.30	0.05	NA	NA	NA	NA
Cadmium	6.00	1.06	NA	NA	NA	NA
Chromium	21.90	3.88	NA	NA	NA	NA
Nickel	19.85	3.51	NA	NA	NA	NA
Manganese	32.70	5.79	NA	NA	NA	NA
Selenium	25.40	4.50	NA	NA	NA	NA
Antimony	11.90	2.11	NA	NA	NA	NA
Lead	372.7	65.96	NA	NA	NA	NA
Zinc	200400	35465	NA	NA	NA	NA

NOTE: Back Half sample lost to shipping damage.

ISOKINETIC SAMPLING FIELD DATA

Source Description: Rotary Kiln Date: 5-20-93

Test Number	M5MM-2	Stack Diam.	8.25 "	Ambient Temp.	80 °F
Condition	No Tires	Pitot Cp	0.84	Barom. Press.	29.55 "Hg
Location	Exhaust Duct	Nozzle Diam.	0.623 "	Static Press.	-3.1 "H2O
Operator	RT, JEB	Meter Y	0.974	Est. Moisture	12.0 %
Run No.	TB2-M5MM	Meter dH@	2.00	Est. Oxygen	7.5 %
Start Time	1038	Stop Time	1348	Est. CO2	7.5 %

Pnt. #	Clock Time	dP "H2O	dH "H2O	Gas Meter Cubic Ft.	Temperatures, °F Stack	Oven	Imp.	Meter T, °F In	Out	Vac. "Hg
0	1038		3.10	198.579	580	220	52	90	84	9.2
1	1058		3.10	217.600	584	220	60	105	90	9.4
2	1113		3.10	232.400	585	220	55	111	97	9.4
3	1128		3.10	247.000	586	220	54	114	101	9.4
4	1143		3.10	261.900	587	220	52	115	104	9.3
5	1200		3.10	278.600	598	220	55	115	105	9.2
6	1218		3.10	296.000	602	220	61	116	106	9.2
7	1236		3.10	313.000	600	220	64	117	106	9.6
8	1255		3.10	333.000	604	220	76	117	107	11.0
9	1313		3.10	351.000	600	220	68	118	107	11.0
10	1333		3.10	369.800	600	220	58	118	107	10.8
11	1348			384.593						
Average			3.10		593	220	60	112	101	

Total Volume Metered, Vm	186.014 Cubic Ft.	Measured O2	9.80
Total Sampling Time, ø	190 minutes	Measured CO2	5.90
Moisture Collected	498.1 grams	Measured H2O	11.2
Average Stack Gas Velocity, v	16.3 ft/sec.	Molecular Wt	28.1

Exhaust Duct Flow	177.9 SCFM	158.0 DSCFM		
Gas Volume Collected:	167.901 DSCF	4.7545 DSCM		
Average Sampling Rate	0.884 DSCFM,	2.027 ACFM	======>	90.0 % Isokinetic

Note: Average velocity based on preliminary traverse. Single point isokinetic sampling was conducted at highest-velocity traverse point.

ISOKINETIC SAMPLING RESULTS SUMMARY

Source Description: Rotary Kiln

Test Date: 5-20-93

Test Number	M5MM-2	Sampling Run No.	TB2-M5MM
Condition	No Tires	Operator	JEB, RT
Location	Exhaust Duct	Exhaust Duct Flow	158.0 DSCFM
Start Time	1038	Volume Collected	167.9 DSCF
Stop Time	1348	Isokinetic	90.0 %

	--- Front Half ---		--- Back Half ---		---- Total ----	
	ug	ug/m^3	ug	ug/m^3	ug	ug/m^3
Arsenic	6.05	1.12	<1.00	----	----	----
Beryllium	<0.25	----	<0.25	----	----	----
Cadmium	0.70	0.13	1.50	0.28	2.20	0.41
Chromium	3.55	0.65	<1.00	----	3.55	0.65
Nickel	2.20	0.41	1.66	0.31	3.86	0.71
Manganese	6.00	1.11	9.30	1.72	15.3	2.82
Selenium	<1.00	----	4.50	0.83	4.50	0.83
Antimony	1.00	0.18	<1.00	----	1.00	0.18
Lead	42.0	7.75	1.65	0.30	43.7	8.05
Zinc	1500	276.72	55.4	10.22	1555	286.94

NOTE: Front Half sample may exhibit some cross-contamination from TB1 back half.

APPENDIX F. OTHER DATA

Table F-1. Kiln tire burn runs.

Date	Run
4/29/93	TB1
5/11/93	TB2
5/13/93	TB3
5/17/93	TB4
5/18/93	TB5
5/19/93	TB6
5/20/93	TB7
5/21/93	TB8
5/25/93	TB9
5/26/93	TB10
5/26/93	TB11
5/26/93	TB12
5/26/93	TB13
5/26/93	TB14
5/26/93	TB15
5/26/93	TB16
5/26/93	TB17
5/26/93	TB18
5/26/93	TB19
5/26/93	TB20
5/26/93	TB21
5/26/93	TB22
5/27/93	TB23
5/27/93	TB24
5/27/93	TB25
5/27/93	TB26
5/27/93	TB27
5/27/93	TB28
5/27/93	TB29
5/27/93	TB30

Table F-2. Kiln Tire Burns Sampling Summary.

Tire BTU % of Load	Other Condition	Test Date	Run No.	Exhaust DSCFM	Sampling Notes
0	Steady	5-18	VOST-3	173.607	
		5-18	MM5-4	173.607	
		5-20	M23-2	157.511	
		5-20	MSMM-2	157.991	
10	Steady	4-29	VOST-1	Unknown	
20	Steady	5-11	MM5-1	131.088	
		5-13	VOST-2	121.592	
		5-13	MM5-2	121.592	
		5-17	MM5-3	131.520	TCO/GRAV Analysis
		5-19	M23-1	136.050	
		5-19	MSMM-1	137.141	
20	Ramping	5-21	VOST-4	141.482	
		5-21	MM5-5	141.482	
20	Batch	5-25	VOST-5	174.184	
		5-25	MM5-6	174.184	TCO/GRAV Analysis

Table F-3. Kiln Tire Burn Particulate Summary

Test Run	Date	Particulate Coll. (g)	Volume Samp. (m^3)	Part. Load. (mg/m^3)
MM5-1 (TB2)	5/11/93	0.13023	2.982	43.67
MM5-2 (TB3)	5/13/93	0.65767	4.792	137.24
MM5-3 (TB4)	5/17/93	0.66563	6.986	95.28
MM5-4 (TB5)	5/18/93	0.08536	4.915	17.37
MM5-5 (TB8)	5/21/93	0.64017	4.815	132.95
MM5-6 (TB9)	5/25/93	1.46328	5.126	285.46
MMT-1 (TB6)	5/19/93	0.5007	4.957	101.01
MMT-2 (TB7)	5/20/93	0.0197	4.755	4.14

Table F-4. Residuals from COEMISFAC regression models.

Run	Model-1	Model-2	Model-3
TB6	-0.207	-0.196	-0.343
TB7	0.163	0.156	-1.714
TB10	-0.070	-0.068	0.622
TB11	0.479	0.480	0.735
TB12	0.854	0.856	0.717
TB13	1.921	1.923	2.723
TB14	-0.870	-0.868	-1.210
TB15	-1.099	-1.099	-0.697
TB16	-0.493	-0.493	-0.933
TB17	-0.897	-0.897	-1.018
TB18	-0.581	-0.583	-0.828
TB19	0.198	0.196	-0.007
TB20	-0.004	-0.006	1.663
TB21	0.688	0.686	0.721
TB22	-0.639	-0.641	-0.610
TB23	-1.698	-1.694	-1.746
TB24	1.381	1.382	1.007
TB25	-0.813	-0.811	-1.279
TB26	1.381	1.382	2.582
TB27	-2.007	-2.010	0.330
TB28	-0.037	-0.040	-1.155
TB29	4.036	4.033	1.734
TB30	-0.485	-0.488	-1.295

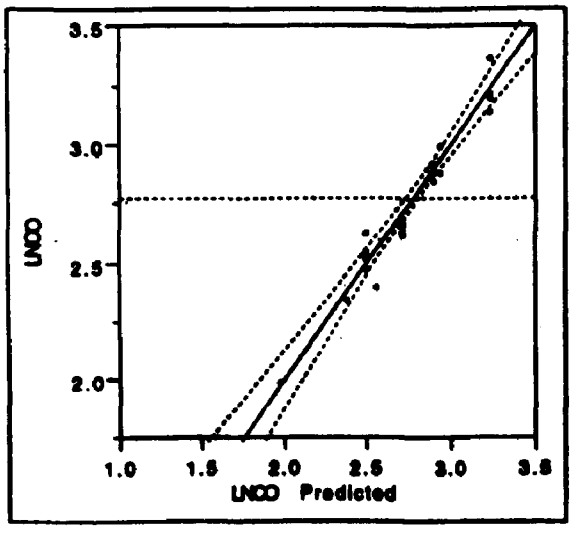

Figure F-1. CO Model 1; Predicted ln(COEMISFAC) vs. measured ln(COEMISFAC).

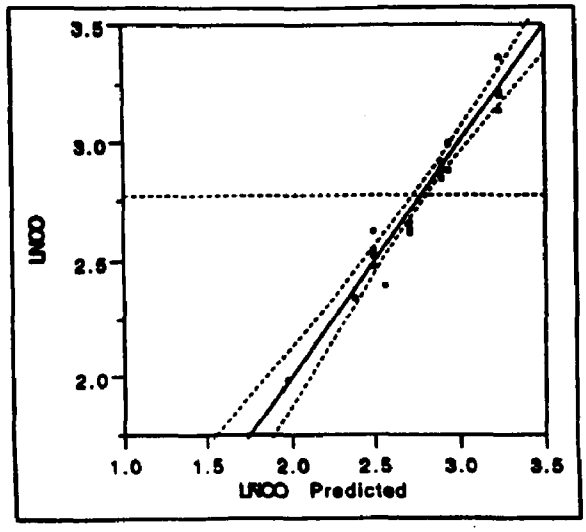

Figure F-2. CO Model 2; Predicted ln(COEMISFAC) vs. measured ln(COEMISFAC).

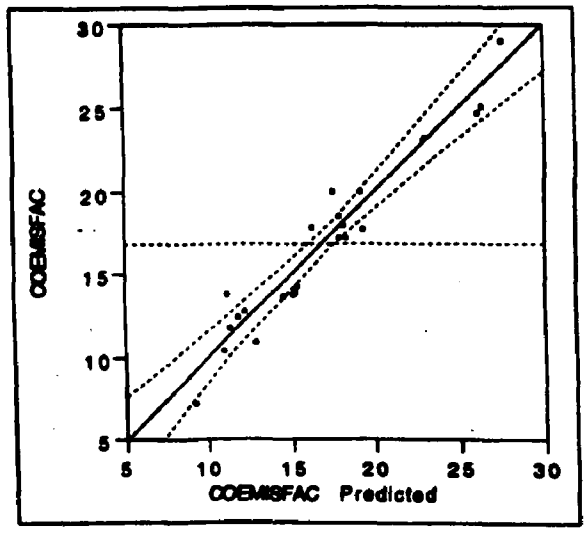

Figure F-3. CO Model 3; Predicted COEMISFAC vs. measured COEMISFAC.

Table F-5. Residuals (x 1000) from PAHEMISFAC regression models.

Run	Model-1	Model-2	Model-3
TB6	-1.802	-0.436	-0.367
TB7	0.169	0.138	0.512
TB10	-0.340	-0.360	-0.181
TB11	0.218	-0.044	-0.279
TB12	-0.360	-0.612	-0.271
TB13	0.139	-0.090	0.497
TB14	-0.923	0.133	-0.632
TB15	0.588	1.040	0.107
TB16	1.049	1.137	0.243
TB17	-0.525	-0.318	-1.145
TB18	0.415	0.857	0.810
TB19	-0.766	-0.444	0.659
TB20	3.105	2.088	1.023
TB21	-1.220	-0.546	-0.252
TB22	1.934	-1.106	-0.645
TB23	0.457	0.317	-0.945
TB24	0.776	3.357	2.065
TB25	-1.010	-1.937	-0.284
TB26	-0.670	1.501	0.708
TB27	-0.358	-3.030	-1.412
TB28	2.676	-0.054	1.046
TB29	-1.076	1.492	-0.414
TB30	-1.023	-2.285	-0.844

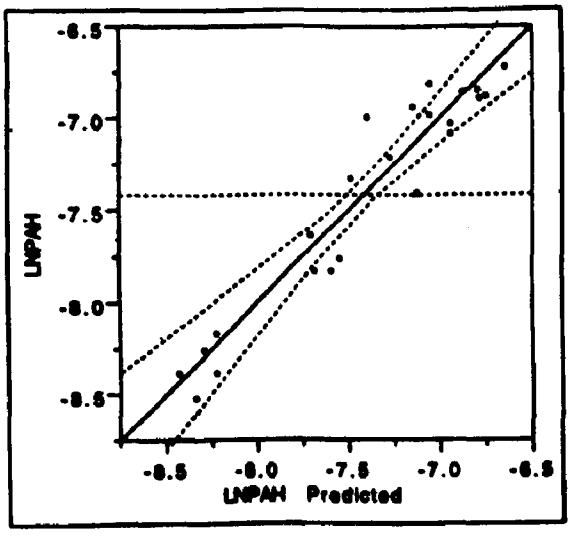

Figure F-4. PAH Model 1; Predicted ln(PAHEMISFAC) vs. measured ln(PAHEMISFAC).

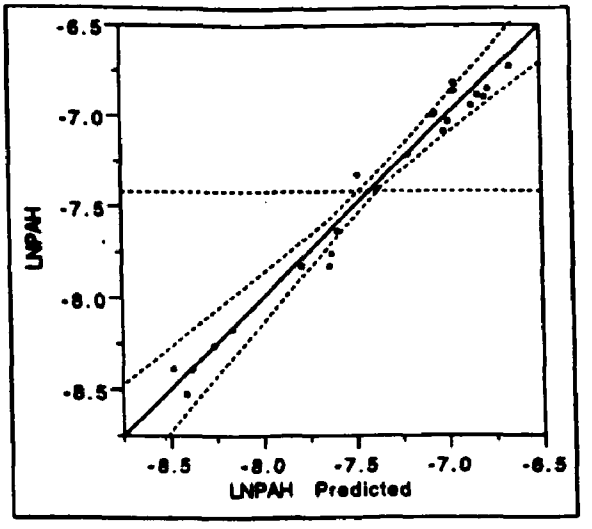

Figure F-5. PAH Model 2; Predicted ln(PAHEMISFAC) vs. measured ln(PAHEMISFAC).

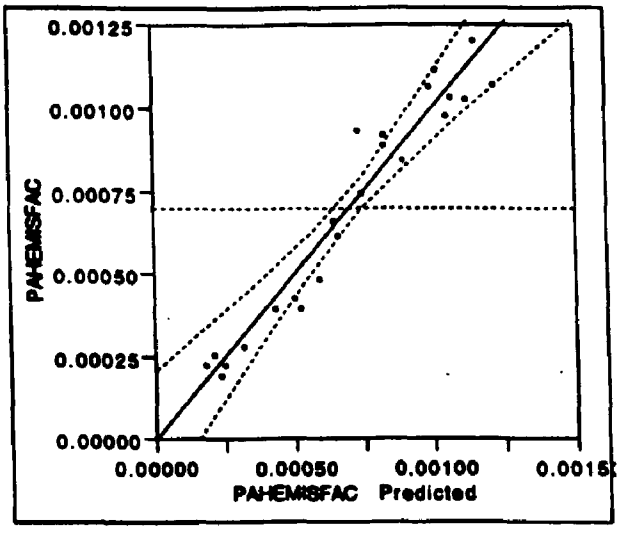

Figure F-6. PAH Model 3; Predicted PAHEMISFAC vs. measured PAHEMISFAC.