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EMISSIONS FROM STREET VENDOR COOKING DEVICES (CHARCOAL GRILLING)

Prepared for:

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Centro de Información Sobre Contaminación de Aire

C I C A

FINAL REPORT

EMISSIONS FROM STREET VENDOR COOKING DEVICES (CHARCOAL GRILLING)

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PREFACE

The U.S.-Mexico Border Information Center on Air Pollution *(Centro de Información sobre Contaminación de Aire Para la Frontera entre EE.UU.-México*, or CICA) was established by the U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS) to provide technical support and assistance in evaluating air pollution problems along the U.S.-Mexico Border. These services and products are available at no cost to Federal, State and Local Agencies and universities in Mexico. Others can use these services depending on available resources. CICA provides ready access to EPA information and expertise. It draws on professional staff from the EPA's OAQPS and Office of Research and Development (ORD). Private contractors are also available when appropriate.

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Establishing a reliable emissions inventory for all significant sources of air pollutants in the Mexicali, Baja California, Mexico - Imperial Valley, California, U.S.A. area is part of a comprehensive effort to identify air pollution problems and implement measures to improve ambient air quality along the U.S.-Mexico border. The purpose of this project was to determine potential emissions from street vendor cooking devices in Mexicali, Mexico. These devices often line the streets of Mexicali, especially the downtown area, and generate a considerable amount of visible emissions. To accomplish this task, CICA requested EPA's Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, ORD, to conduct a laboratory simulation. CICA also provided funding for this work. This report is the result of that effort.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The U.S. EPA, working through the Clean Air Technology Center (CATC) and U.S.-Mexico Border Information Center on Air Pollution (Centro de Informacion Sobre Contaminacion de Aire Para la Frontera entre EE.-UU. y Mexico, or CICA), along with the Mexican Instituto National de Ecoligfa (INE), has jointly initiated a program to establish a reliable emissions inventory for a significant source of air pollutants in the Mexicali-Imperial Valley area, i.e. street vendor cooking devices.

Emissions from street vendor cooking devices, prevalent in the streets of Mexicali, Mexico, were investigated experimentally by measuring levels of particulate matter (PM), particle size distributions (PM_{10} and $PM_{2.5}$), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), aldehydes and oxides of nitrogen and sulfur, emitted when meats were cooked over a charcoal fire on a grill. The test grill was carefully chosen to simulate the street vendor cooking devices in Mexicali. A total of nine test runs were planned for the program. In order to investigate the emission rate, both beef and chicken meat were tested. Furthermore, both kinds of meat were marinated with a mixture, similar to that used by the street vendors. Initially, it was planned to use only charcoal from Mexicali; however, difficulties in obtaining sufficient quantities necessitated using locally obtained charcoal for some of the tests. Both types of charcoal were compared to ensure similar physical and chemical properties. Some of the tests conducted were with non-marinated beef for comparison. Two blank runs were performed sampling charcoal fires without meat. Finally, a simple control device, normally used in an exhaust fan to trap grease over a kitchen stove, was evaluated for its effectiveness in reducing emissions. A summary of the test condition is shown in Table E-1.

Each test run averaged approximately three hours of charcoal burning, of which the meat-cooking period lasted one to two hours. For each test run, approximately 5-6 kg of meat was cooked, and an average of 6 kg of charcoal was burned. Total PM and SVOCs were sampled by using the EPA MM5G Method. PM with aerodynamic diameters equal to and below 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$) were evaluated using an Andersen Mark III inertial cascade impactor. VOC were sampled using SUMMA canisters. VOC and SVOC samples were analyzed by a GC-Mass spectrometer. Aldehydes were sampled using SNPH-Cartridges and analyzed by High Performance Liquid Chromograph (HPLC) as described in the EPA Method 1P-6A. Carbon monoxide (CO), oxygen (O_2), carbon dioxide (CO_2), nitric oxide (NO), total hydrocarbon (THC) and sulfur dioxide (SO_2) were measured with continuous emission monitors (CEM).

All of the emission parameters measured during the test runs appeared to be reasonable with an exception of the sulfur dioxide measurements. Wide fluctuations of the SO_2 CEM readings for all the test runs suggested a malfunction of the SO_2 instrument or the measuring range of the instrument was too high

for the low level of SO_2 present. Emission results of the test runs are summarized in Table E-2. The results are tabulated as emissions based on total cooking time, emissions per unit weight of meat and charcoal used and emissions per unit weight of meat cooked.

Based on the analysis of the test results, the following conclusions were made on emissions from the street vendor cooking devices:

- Emissions of total PM, total VOCs and total SVOCs from the street vendor cooking is basically the result of cooking meat; i.e., charcoal does not contribute to these emissions.
- Marinated meat yielded an increased total VOC and total PM emissions compared to non-marinated meat.
- There were no significant differences in emission rates between chicken and beef.
- Emissions of CO and NO derive from charcoal fire rather than the cooking of meat.
- Emission of THC is almost entirely due to the initial burning of hydrocarbon present in the charcoal. THC emission was only confined during the first half-an-hour of charcoal light off.
- Based on very limited observations, the simple screen placed in the stack (emission control device) appeared to be very effective in reducing emissions of PM, VOCs, SVOCs and THC from the street vendor cooking devices, but only one test was performed to evaluate this device; therefore, no conclusive results were obtained.
- Particle size distribution of all the test runs was very similar. The majority of the particles had an aerodynamic diameter less than 2.5 μm ($PM_{2.5}$). Only 20-wt.% of the particles had an aerodynamic diameter between 10 μm and 2.5 μm.

Table E-1. Summary of Test Condition

Test Number	Type of Meat	Marinade	Charcoal	Emission Control
MC1	Beef	Yes	Mexican	No
MC2	Chicken	Yes	Mexican	No
MC3	Beef	No	Mexican	No
MC4	None		Local	No
MC5	None		Mexican	No
MC6	Beef	Yes	Local	No
MC7	Chicken	Yes	Local	No
MC8	Beef	No	Local	No
MC9	Beef	No	Local	Yes

Table E-2. Emission Data Summary

Total Emission Rates, g/hr

	Test Condition	NO	THC	PM	CO	Aldehydes	VOC	SVOCs
MC1	Beef-Marinade	5.21	20.38	18.06	385.6	2.579	2.334	0.0056
MC2	Chicken-Marinade	16.46	20.17	22.65	376.3	2.160	2.383	0.0259
MC3	Beef-No Marinade	8.46	13.20	19.53	462.9	1.976	2.169	0.0152
MC4	Charcoal Only	13.15	1.43	1.27	435.7	0.360	0.253	ND*
MC5	Charcoal Only	16.34	4.53	2.81	494.3	0.346	0.485	ND
MC6	Beef-Marinade	14.16	6.89	32.49	484.3	3.177	2.941	0.006
MC7	Chicken-Marinade	6.62	3.53	34.94	556.7	3.281	3.607	0.0087
MC8	Beef-No Marinade	5.17	14.47	30.41	518.1	2.819	2.598	0.003
MC9	Beef-No Marinade Control Screen	6.26	1.19	23.70	574.5	1.776	1.157	ND

*ND - none detected

Total Emission per Unit Weight of Meat Plus Charcoal, g/kg of meat + charcoal

	Test Condition	NO	THC	PM	CO	Aldehydes	VOC	SVOCs
MC1	Beef-Marinade	2.55	9.98	8.85	188.9	1.263	1.105	0.002
MC2	Chicken-Marinade	7.85	9.62	10.80	179.4	1.030	1.089	0.0116
MC3	Beef-No Marinade	3.33	5.19	7.68	182.1	0.777	0.826	0.0053
MC4	Charcoal Only	5.98	0.65	0.58	198.1	0.163	0.115	ND*
MC5	Charcoal Only	10.30	2.85	1.77	311.5	0.218	0.300	ND
MC6	Beef-Marinade	4.35	2.11	9.97	148.7	0.975	0.866	0.0018
MC7	Chicken-Marinade	1.90	1.02	10.05	160.2	0.944	0.998	0.0022
MC8	Beef-No Marinade	1.35	3.77	7.91	134.8	0.734	0.653	0.0008
MC9	Beef-No Marinade Control Screen	1.51	0.29	5.71	138.5	0.428	0.268	ND

*ND - none detected

Total Emission per Unit of Meat Cooked, g/kg of meat cooked

	Test Condition	NO	THC	PM	CO	Aldehydes	VOC	SVOCs
MC1	Beef-Marinade	2.36	9.21	8.16	174.3	1.165	1.055	0.0025
MC2	Chicken-Marinade	6.37	7.80	8.76	145.5	0.835	0.921	0.0100
MC3	Beef-No Marinade	3.32	5.19	7.67	181.8	0.776	0.852	0.0060
MC4	Charcoal Only	NA**	NA	NA	NA	NA	NA	NA
MC5	Charcoal Only	NA	NA	NA	NA	NA	NA	NA
MC6	Beef-Marinade	4.70	2.29	10.79	160.8	1.055	0.977	0.0020
MC7	Chicken-Marinade	2.02	1.08	10.68	170.2	1.003	1.102	0.0027
MC8	Beef-No Marinade	1.45	4.06	8.52	145.2	0.790	0.728	0.0008
MC9	Beef-No Marinade Control Screen	1.76	0.33	6.64	161.1	0.498	0.325	0

**NA - not applicable

ACKNOWLEDGMENTS

Mark Fuentes of CARB, San Diego and Gasper Torres and Robert Fisher of Imperial Valley Air Pollution Control District contributed significantly to the project by providing a tour to the city of Mexicali and obtaining a supply of charcoal from Mexico for the testing. Peter Kariher and Russell Logan of ARCADIS Geraghty & Miller performed testing and sampling. Also, Dennis Tabor and William Preston of ARCADIS Geraghty & Miller carried out organic analyses.

1.0 INTRODUCTION

Establishing a reliable emissions inventory for significant sources of air pollutants in the Mexicali-Imperial Valley area is part of a comprehensive effort to identify air pollution problems and implement measures to improve ambient air quality along the U.S. and Mexico border. The U.S. EPA, working through the Clean Air Technology Center (CATC) and U.S.-Mexico Border Information Center on Air Pollution (Centro de Informacion Sobre Contaminacion de Aire Para la Frontera entre EE.-UU. y Mexico, or CICA) along with the Mexican Instituto National de Ecoligfa (INE), have jointly initiated a program to achieve this goal.

A preliminary background study and an initial assessment of air emissions source categories in Mexicali, Mexico had previously been made[1]. The source categories were identified to be street vendor cooking devices, open sewage impoundment, canals and conveyance systems. Recently, Desert Research Institute investigated emissions from charbroiling by conducting on-site measurements from taco stands and restaurants with open-air charcoal stoves in Mexicali as a part of their Imperial Valley/Mexicali cross border PM_{10} study[2].

The objective of this project was to investigate one of the unique source categories in Mexicali, Mexico—street vendor cooking devices. Various emissions from street vendor cooking devices are characterized, and if possible, low-cost control technologies that reduce emissions are evaluated. Emissions of concern from the street vendor cooking devices are particulate matter (PM_{10} and $PM_{2.5}$), semivolatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), aldehydes, nitrogen oxides (NO_x) and sulfur oxides (SO_x).

To achieve these objectives, ARCADIS Geraghty & Miller under EPA Contract No. 68-D4-0005 conducted laboratory studies to obtain the required emissions data by using a cooking device similar to those used in Mexicali, Mexico. A low-cost control technology that might be suitable to use in Mexicali, Mexico was also evaluated in a single test. The technical approach to the project was developed based on observations made during site-visits to Mexicali, Mexico. In general, street vendor cooking includes a variety of activities in which food is prepared in either portable or fixed structures. The food items prepared in these units include grilled meats for use in tacos, burritos and other typical northern Mexican cuisine. The cooking devices use either charcoal or propane or other common compressed gas for their heat source. The meat is cooked exclusively over the charcoal fire to enhance its flavor. Burners using compressed gas are used mainly for heating hot plates that keep the already cooked food warm and toast tortillas. Therefore, it is believed that the only significant emissions from the street vendor cooking devices are from those using charcoal and not from the compressed gas-fired burners.

It was observed during the site-visit that the most visible emissions (smoke) occurred at the time the meat was being cooked—when fat from the meat dripped onto the hot coals. There are two types of charcoal being used for most the cooking devices: standard barbecue briquettes, very similar to the ones commercially available in the U.S., and natural wood charcoal, known as Mesquite charcoal. Although no systematic surveys were made, it appears that the natural wood charcoal is most frequently used for most of the cooking devices.

It was also observed during the site-visit that the meat most often used for cooking is beef of approximately one (1) cm thick with 10 x 15 cm sides. The cut of beef most frequently used is sirloin or flank steak. Another type of meat used by the street vendors is a chicken thigh. A marinade was used to marinate both beef and chicken for a few hours before cooking. In order to simulate the Mexican street vendor cooking as closely as possible, it was decided to test both the beef and the chicken with and without marinade for the laboratory program.

Initially, efforts were made to obtain an actual cooking device used in Mexico. However, it was found to be impractical due to the short period of time available for testing. Instead, a charcoal grill very similar to the Mexican version was obtained locally and used for the entire series of testing. Natural wood charcoal was used for testing.

The emissions from meat cooking probably depend strongly on the cooking method used, the fat content of the meat and the type of meat used. There are several possible ways to quantify the mass emission rates from the cooking devices. Quantities of fuel consumed, meat products grilled, square meters of grill area covered by the cooking meat and type of meat grilled may be used to calculate an emissions factor, or series of emissions factors, that could be used to describe the average rate of mass emissions from the cooking devices. The testing parameters measured during each meat cooking test run were:

- Ambient Pressure (Atm)
- Ambient Temperature or Room Temperature (°C)
- Sample Time (min)
- Continuous Mass Measurement of Fuel, meat and grill (kg)
- Burn Rate (kg/hr)
- Stack Temperature (°C)
- Initial Fuel Weight (kg)
- Final Fuel Weight (kg)
- Initial Weight of Meat (kg)
- Final Weight of Meat (kg)
- Fat Content of Meat (%)

- Weight of Residue Scraped from the Cooking Grill (kg)
- Dilution Rate
- Carbon Monoxide (CO)
- Total PM
- PM_{10} and $PM_{2.5}$
- Aldehydes
- Volatile Organic Compounds (VOCs)
- Semi Volatile Organic Compounds (SVOCs)
- Nitric Oxide (NO)
- Sulfur Dioxide (SO_2)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)

Total PM and SVOC samples were collected using MM5G[3] sampling procedure, while PM_{10} and $PM_{2.5}$ were measured using an Andersen Mark III inertial cascade impactor[4]. VOC samples were collected in SUMMA canisters[5], and aldehyde samples were obtained using DNPH (Dinitro phenyl hydrazine)-cartridges according to Modified Method IP-6A[6]. NO_x and SO_X, along with the other standard compounds measured with CEM systems, such as CO, CO_2 and O_2, were measured during the study. (The sampling and analytical methods used are detailed in Section 2.0.)

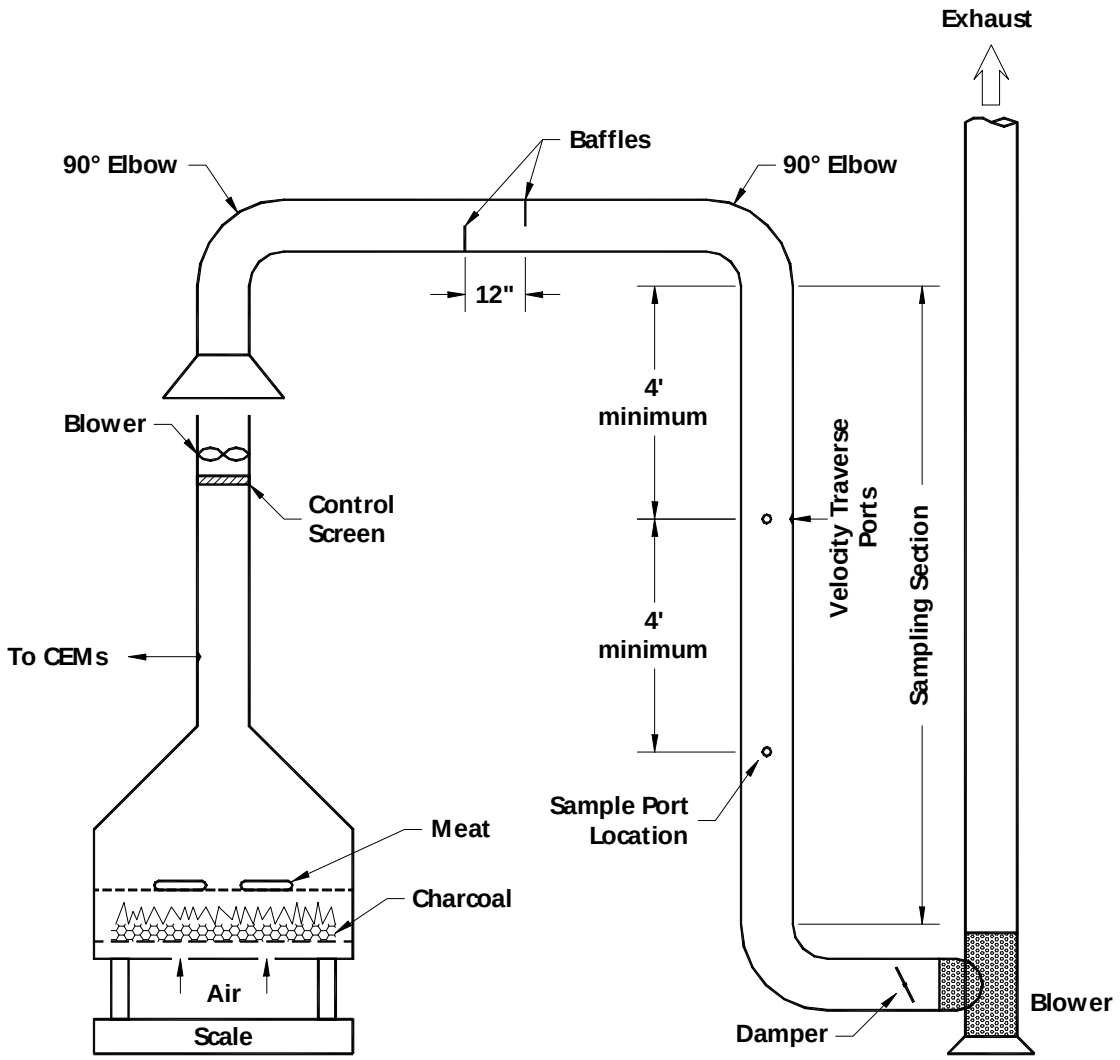
An aluminum mesh screen similar to the filter screen used for kitchen hood filters was evaluated as a candidate low-cost controls technology for grills with a hood or stack. Since most Mexican street vending is a low budget operation, the control device must be inexpensive. In addition, the street vendors will likely have no access to an electric outlet. Thus, a proposed control device must be able to operate without an external energy source, or perhaps it could be powered by solar energy. A type of grease trap installed in the exhaust flue with a solar powered fan may be appropriate. Because of time and funding limitations, only one test was made to evaluate effectiveness of the filter screen. Further testing will be necessary to arrive at any meaningful conclusion on the effectiveness of this device.

2.0 EXPERIMENTAL PROCEDURE

2.1 Test Facility

The test was conducted at EPA's Woodstove Test Facility located at the ARCADIS Geraghty & Miller site in Research Triangle Park, North Carolina. The Woodstove Test Facility is equipped with a dilution tunnel (Figure 2-1) for sampling prior to exhausting the flue gas to outside. The dilution tunnel consists of a 6-inch duct with sampling ports connected to a blower which leads to an exhaust duct on the outside of the building. Prior to cooking tests, the dilution tunnel stack up to the blower was replaced with a new stack. The laboratory is equipped with gas sampling systems and CEMs for CO, CO_2, O_2, NO, SO_2 and THC.

Figure 2-1. Mexican Street Vendor Cooking Devices Test Facility



The heart of the test facility is the cooking grill that closely duplicates the Mexican street vendor cooking devices. Based on the site-visit, it was concluded that the source of most emissions from either street vendors or the stationary permanent eateries is the smoke and other pollutants emitted from the charcoal-fired grill cooking of either chicken of beef. All charcoal-fired grills inspected during the site visit were simple in design, and they were quite similar. The cooking devices consisted of a rectangular box, about 10-15 cm deep that holds burning charcoal with a cooking grill that sits on top of it. Some of the cooking units had side and back walls and a hood with a stack on top of the wall. Instead of fabricating a charcoal cooking unit simulating the Mexican version, a commercial charcoal barbecue grill (BBQ -PRO, Model No.8402, K-mart Corporation) was obtained and modified by adding side and back walls and a hood with a stack (Figure 2-2). The modification was made mainly to contain emissions to be collected for analysis.

Figure 2-2. Modified Charcoal Barbecue Grill Used in the Test

2.2 Meat and Charcoal

Obtaining the same meat used in Mexico was not practical for this study. Both beef and chicken were purchased from a local supermarket in batches that were sufficient for one or two tests. The beef samples used for the test were a cut designated as flank steak with the fat portions trimmed. The beef samples used for cooking tests were approximately one (1) cm in thickness with 10 x 15 cm sides. Visually, it appeared that the fat content of each sample piece was reasonably constant. The chicken sample used was boned thigh meat without skin. Although the meat vendors in Mexico indicated that they usually marinate meat before cooking, both the beef and chicken meat were tested with and without marinade. The marinade recipe used for the beef and chicken samples is as follows:

Marinade for 5 lbs of flank steak

3/4 of whole garlic, peeled and crushed
1/4 bunch of cilantro, finely diced
3/4 cup of olive oil
3/4 cup of lime juice
1 tablespoon salt
1/4 teaspoon black pepper

Marinade for 5 lbs of chicken thigh

3/4 of whole garlic, peeled and crushed
1/4 bunch of cilantro, finely diced
3/4 cup of olive oil
3/4 cup of lime juice
1 tablespoon salt or 1/8 cup soy sauce
1/4 teaspoon black pepper
1/4 cup sugar

The fat content of the beef and the chicken was randomly sampled both with and without marination and sent to a commercial testing laboratory. The laboratory analyzed the samples with ether extraction method AOAC 960.39[7] for fat content. The results of analysis are attached in Appendix A .

Approximately 5-6 kg of charcoal made from wood was used for each test. Initially, a supply of charcoal was obtained from Mexicali, Mexico and was used for the first three cooking tests. However, obtaining a sufficient supply of the Mexican charcoal for the entire testing program was difficult. An additional supply of wood charcoal was obtained from a local specialty store and used for the remainder of

the testing. Samples of both Mexican charcoal and local charcoal were sent to a commercial laboratory for proximate analysis. (The results of analysis are attached in Appendix B .) Proximate analysis of both samples, amount of moisture, volatile matter and fixed carbon content were almost identical. However, the ash contents were significantly different. This is probably due to the difference in mineral content of the wood from different geographic locations. The ash content, although important in some studies, may not be a significant factor in the subject study where the ash remained in the grill as residue.

2.3 Test Conditions

A total of nine (9) tests were conducted as follows:

Unfiltered Emissions:

- Beef Test No. 1 - Cooking beef with marinade•
- Chicken Test No. 1 - Cooking chicken with marinade
- Beef Test No. 2 - Cooking beef without marinade
- Blank Charcoal Test No. 1 - Only charcoal (local) is burned
- Blank Charcoal Test No. 2 - Only charcoal (Mexican) is burned
- Beef Test No. 3 - Cooking beef with marinade
- Chicken Test No. 2 - Cooking chicken with marinade
- Beef Test No. 4 - Cooking beef without marinade

Filtered Emissions:

- Beef Test No. 5 - Cooking beef without marinade and with an emissions control screen

The test number with test conditions and date of testing are tabulated in Table 2-1.

2.4 Test Procedure

The following test procedures were used for all the tests performed:

1) Marinate (when the test requires) beef or chicken for 12 hours.
2) Start CEMs.
3) Load cooking grill with charcoal and note the weight of charcoal.
4) Ignite charcoal with a propane torch one hour prior to tests.
5) Note the CEM readings for transient condition.
6) Weigh meat.
7) Start sample trains.
8) Place meat on the grill.

9) Cook meat—noting times of turning the meat so anomalies in the weigh scale can be accounted for.

10) When meat is done, remove cooked meat and repeat steps 6 - 9 for total sampling duration.

11) Shut off sample trains.

12) Weigh unburned charcoal and ash after cooling.

13) Scrape residue from grill and weigh.

While the cooking operation was in progress, the oven door was left open to simulate the way cooking stoves are operated in Mexico.

Table 2-1. Summary of Test Condition

Test Number	Date of Test	Type of Meat	Marinade	Charcoal	Emission Control
MC1	09/08/98	Beef	Yes	Mexican	No
MC2	09/09/98	Chicken	Yes	Mexican	No
MC3	09/11/98	Beef	No	Mexican	No
MC4	09/16/98	None		Local	No
MC5	09/17/98	None		Mexican	No
MC6	09/21/98	Beef	Yes	Local	No
MC7	09/22/98	Chicken	Yes	Local	No
MC8	09/24/98	Beef	No	Local	No
MC9	09/29/98	Beef	No	Local	Yes

2.5 Emission Sampling and Measurement Procedure

2.5.1 Particulate and SVOC Sampling

Total PM and SVOC were sampled using the EPA MM5G (Modified Method 5G) Method. The EPA MM5G is basically EPA Method 5G with XAD trap added to catch condensable. In the MM5G procedure, sampling rates were approximately 0.5 CFM and were based on the maintenance of a constant proportionality ratio between dilution tunnel flow and sampling nozzle flow. Velocity head (DP) and temperature in the stack were monitored (at a point of average velocity as determined by preliminary velocity and temperature traverse) during the sampling run. When necessary, the sample flow was altered to maintain a constant proportion between the dilution duct flow and the sample flow. The temperature at the entrance to the second filter was not allowed to exceed 32 °C.

The MM5G sample was recovered by returning the tare weighed filters to their labeled petri dishes or foil wraps. The probe and filter glassware were triple-rinsed with acetone into a clean, tare-weighed beaker and placed into a fume hood for reduction. The filters and reduced rinse beakers were placed into a desiccator for 24 - 36 hours prior to final weighing.

Filters for the test program were desiccated and tare-weighed. Sample fractions from each MM5G train included:

- Acetone rinses of probe and filter halves
- First filter
- Second filter
- XAD-2 module

Although the method provides no specification, the glass surfaces exposed to the sample between the two filters were rinsed with acetone and added to the front-half acetone rinse bottle. Each MM5G train resulted in two extracts, one from filter and probe rinse and one from the XAD-2 cartridge. Aliquots of these extracts were analyzed for Total Chromatographable Organics (TCO), Gravimetric Analysis of Organic Extracts (GRAV) and PAHs.

The XAD-2 samples were removed and refrigerated before extraction. XAD-2 extracts were maintained separately from the filter extracts.

2.5.2 PM_{10} and $PM_{2.5}$ Sampling

PM with aerodynamic diameters equal to and below 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$) were evaluated using an Andersen Mark III inertial cascade impactor. A sample was pulled isokineticaly from the dilution stack, and PM with aerodynamic diameters above the appropriate size were removed by the pre-impactor and the preceding impactor stages. The impactor stages with D_{50} of 10 µm and below were collected at the completion of the sample run and desiccated. The weight of PM for each stage was determined by comparing the initial tare weights of the impactor substrates with posttest values. The sum of the weights of the 10 µm D_{50} stage and below would constitute the PM_{10} measurement. Similarly the sum of the 2.5 µm D_{50} impactor stage and below would constitute the $PM_{2.5}$ measurement. The PM with aerodynamic diameters greater than 10 µm were discarded. The MM5G measurements were used to determine total particulate loading and condensable particulate emissions.

2.5.3 VOC Sampling

VOCs were sampled using SUMMA canisters. Six liters of gas from the dilution tunnel were sampled during times when the meat was actively cooking. This would constitute one canister per test, and the sampling rate was determined during the pre-test trial.

2.5.4 Aldehyde Sampling

The gas from the cooking grill was sampled for general level of aldehydes with an adsorption tube technique, Modified Method 1P-6A for indoor air. Between 10 and 15 liters of gas were pulled through a Waters DNPH (Dinitro Phenol Hydrazine) on Silica Gel cartridge at a sampling rate of one liter per minute.

2.6 Continuous Emission Monitor Measurements

2.6.1 CO, CO_2 and O_2 Measurements

CO in the stack and dilution tunnel was monitored using a Rosemount Analytical Model 880 nondispersive infrared analyzer with calibrated ranges of 0-1000 ppm and 0-0.5%. CO_2 in the stack was monitored with a similar Model 880 instrument calibrated in the 0-20% range. The stack oxygen analyzer used was a Rosemount Model 755 paramagnetic instrument used on its 0-25% range. The gas sample for these analyzers was extracted from the flue at the eight feet elevation using a stainless-steel probe turned downstream to the gas flow. A glass fiber filter mounted at the sampling platform was used to remove particulate material. The instruments were leak checked and calibrated according to EPA Method 3A[8] for O_2 and CO_2 and EPA Method 10[9] for CO. A two-point calibration was made daily with zero and span gases. A calibration drift check with zero and span gases was made at the end of each day. The sample system bias check was performed as specified in EPA Method 6C[10] by introducing calibration gases at a calibration valve installed at the outlet of the sampling probe.

2.6.2 NO_x Analyzer

A chemiluminescence analyzer containing an NO_2 to NO converter was used for the project. The instrument and sampling system were leak checked and calibrated according to EPA Method 7E[11]. A three-point calibration was made daily with zero and span gases. A calibration drift check and span gases were made at the end of each day. A weekly sample system bias check was performed as specified in EPA Method 6C by introducing calibration gases at the outlet of the sampling probe.

2.6.3 THC Measurement

The THC was measured by a flame ionization detector analyzer. The sample line was heated and maintained at a temperature of 200 °C. The measurement and calibration procedures were carried out according to EPA Method 25A[12]. Two-point calibration and calibration drift checks were made daily, and a weekly system bias check was made as specified in EPA Method 6C.

2.6.4 SO_2 Analyzer

A Dupont Photometric Model 400 analyzer is used to measure the SO_2 concentration in the stack. The basic principle of operation of this type of analyzer involves the quantification of the decay or absorption of light at a specific wavelength by the sample material. SO_2, colorless in visible light, is strongly absorbent in the region of ultraviolet light (300 nm wavelength). Radiation from a light source in the analyzer passes through the sample (flue gas in this situation) where some of it is absorbed. Light transmitted through the sample is divided by a transparent mirror into two beams. Each beam then passes through its own filter which permits only a particular wavelength to reach its associated phototube. Optical filter in one beam permits only radiation at the measuring wavelength which is chosen so light intensity reaching the measuring photo detector varies significantly with a change in concentration. The optical filter in the other beam only permits light at the reference wavelength to pass through, so light intensity reaching the reference phototube varies relatively little with a change in concentration. Electronic signal processing transfers the light energy impinging on the detectors into a voltage which is in direct proportion to the SO_2 concentration in the sample stream being analyzed.

2.7 Analytical Procedures

2.7.1 SVOC Analysis

Filter samples and probe rinsates were weighed according to Method 5 procedures. They were then extracted and analyzed for TCO, GRAV and PAH as described in the EPA Guidance for Total Organics[13]. Organic compounds with boiling points greater than 300 °C were determined using the GRAV method. The TCO method is based on separating the components of a gas or liquid mixture in a gas chromatography column and measuring the separated components with a suitable detector. The method provides semi-quantitative data for organic compounds with boiling points between 100 and 300 °C. The upper end of applicability is limited by column overloading and detector saturation. The typical range is 1 to 20 mg/ml. Extracts were analyzed for PAH by SW-846 Method 8270C[14].

2.7.2 VOC Analysis

SUMMA canisters were analyzed according to SW-846 Method 8260B[15] using a purge and trap concentrator loaded by pulling a sample from the canister onto the adsorbent trap. Field blank canister samples were obtained by filling a canister with zero grade nitrogen or air. Compound identifications were based on retention time and the agreement of the mass spectra of the unknown to mass spectra of known standards. A multi-point calibration was performed before analysis for previously determined targeted

groups of analytes to establish response factors. Quantification was then based on an internal standard method using these response factors and the integrated responses for each identified compound.

2.7.3 Aldehyde Analysis

The DNPH-Silica Gel cartridges were analyzed using Method 1P6A. Formaldehyde, acetaldehyde, propanal, benzaldehyde, pentanal and hexanal were identified and quantified from the HPLC analysis.

3.0 RESULTS

The following sections describe the results of VOCs, SVOCs, aldehydes, NO, CO, THC, total PM and particle size distribution (PM_{10} and $PM_{2.5}$). The results are summarized and tabulated as emissions based on total cooking time, emissions per unit weight of meat and charcoal used, and emissions per unit weight of meat cooked.

Other results used in calculations of the emissions numbers or other results germane to the tests can be found in the appendices. Appendix C is a tabulated summary of charcoal and meat weights along with the weight of grill scraping after the test. Appendix D summarizes the average temperatures at various points in the grill, stack and dilution tunnel with the ambient temperature and average CEM values for the total duration of the test when charcoal was burning. Appendix E summarizes the average temperature measurements and CEM values during the time meat was cooking. Appendix F tabulates the details of particulate size distributions. CEM concentration data for CO, CO_2, O_2, NO, THC and SO_2 during the test run, the time temperature history and time weight history of all nine test runs are included in Appendix G.

SO_2 emission data are not included in the summary results due to the suspected malfunction problem of SO_2 analyzer during the test runs. Recordings of SO_2 concentration during test runs (Appendix G) indicated that SO_2 level fluctuated in random manor throughout the duration of test runs, regardless of very significant cooking events, such as the lighting of charcoal fire and the cooking of meat. Unless charcoal and meat used were totally devoid of sulfur compounds, the absence of SO_2 concentration change during the test run indicated a malfunctioning or insensitive measuring instrument.

SO_2 measurement was initially considered for this study because SO_2 is one of the important pollutants from any system involving combustion of sulfur containing fuel. However, amount of sulfur contained in the natural wood charcoal used in Mexicali or in the meat is relatively small compared with coal or fuel oil.

3.1 VOC Results

The results of VOC analysis are summarized in Appendix H. Only a few targeted compounds were detected. The most prevalent compounds were benzene, toluene and styrene. Table 3-1 summarizes the emissions of the target compounds found in the VOC analysis based on total cooking time per cooking unit, per unit weight of meat cooked plus charcoal consumed and per unit weight of meat cooked.

Total VOC emissions of the detected target compounds per unit weight of meat and charcoal burned (grams of total VOC/kg of meat plus charcoal) for each test run are plotted against test variables used. The test variables were as follows: blank tests where no meat was cooked, presence of the control device, beef or chicken as test meat and use of marinade or no marinade.

Figure 3-1 illustrates the effects of meat cooking with no emission control device and presence of a control screen on the total VOC emission. Comparing the VOCs from the charcoal only burning and the cooking meat with no control device, it is evident that the act of cooking meat emitted the majority of VOCs. The simple control device placed above the grill appeared to be very effective in reducing VOC emission (MC9), but the result is not conclusive because only one test was done with the screen. In some cases, the control device reduced VOC concentration to half and in other cases to a quarter of that by means of uncontrolled cooking.

There were no significant differences in VOC emissions between chicken and beef as illustrated in Figure 3-2. When the meat is marinated, the VOC emissions increased measurably compared to the non-marinated meat (see Figure 3-3). Increased emissions of VOC may be attributed to some of ingredients used in the marinade mixture such as garlic, cilantro, lime juice and/or olive oil.

Table 3-1. Summary of VOC Results (Target Compounds)

Emission Rate (g/hr)

	grams/hour								
Target	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
dichloromethane	0.022	ND	ND	0.021	0.032	ND	0.041	0.043	0.053
1,2-	0.035	0.033	0.058	ND	0.008	0.040	0.050	0.035	0.071
benzene	1.176	1.235	1.054	0.166	0.294	1.422	1.735	1.318	0.543
toluene	0.414	0.541	0.446	0.018	0.085	0.545	0.620	0.471	0.185
ethyl benzene	0.079	0.099	0.069	ND	0.009	0.120	0.138	0.090	0.047
m,p-xylene	0.063	0.080	0.072	0.014	0.025	0.064	0.072	0.060	0.090
o-xylene	0.053	0.074	0.060	ND	0.009	0.105	0.117	0.080	0.141
styrene	0.491	0.322	0.412	0.034	0.024	0.645	0.833	0.501	0.028

Estimated Emissions (g/kg of meat + charcoal)

	grams/kg of meat and charcoal								
Target	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
dichloromethane	0.011	ND	ND	0.009	0.020	ND	0.012	0.011	0.013
1,2-	0.017	0.016	0.023	ND	0.005	0.012	0.014	0.009	0.017
benzene	0.576	0.589	0.415	0.076	0.185	0.437	0.499	0.343	0.131
toluene	0.203	0.258	0.175	0.008	0.053	0.167	0.178	0.122	0.045
ethyl benzene	0.038	0.047	0.027	ND	0.005	0.037	0.040	0.023	0.011
m,p-xylene	0.031	0.038	0.028	0.006	0.016	0.020	0.021	0.016	0.022
o-xylene	0.026	0.035	0.023	ND	0.006	0.032	0.034	0.021	0.034
styrene	0.241	0.153	0.162	0.016	0.015	0.198	0.240	0.130	0.007

Estimated Emissions (g/kg)/meat only

	grams/kg of meat only								
Target	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
dichloromethane	0.010	ND	ND	NA	NA	ND	0.012	0.012	0.015
1,2-	0.016	0.013	0.023	NA	NA	0.013	0.015	0.010	0.020
benzene	0.531	0.478	0.414	NA	NA	0.472	0.530	0.369	0.152
toluene	0.187	0.209	0.175	NA	NA	0.181	0.190	0.132	0.052
ethyl benzene	0.035	0.038	0.027	NA	NA	0.040	0.042	0.025	0.013
m,p-xylene	0.029	0.031	0.028	NA	NA	0.021	0.022	0.017	0.025
o-xylene	0.024	0.029	0.023	NA	NA	0.035	0.036	0.022	0.040
styrene	0.222	0.124	0.162	NA	NA	0.214	0.255	0.140	0.008

Figure 3-1. Effect of the Control Device on Total VOC Emission

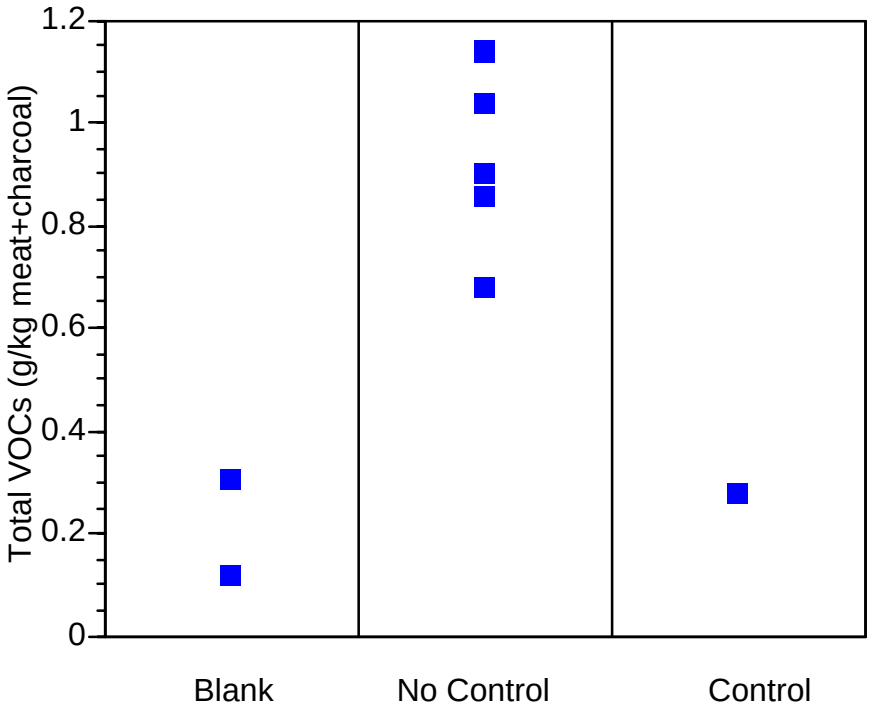


Figure 3-2. Effects of Meat Types on Total VOC Emission

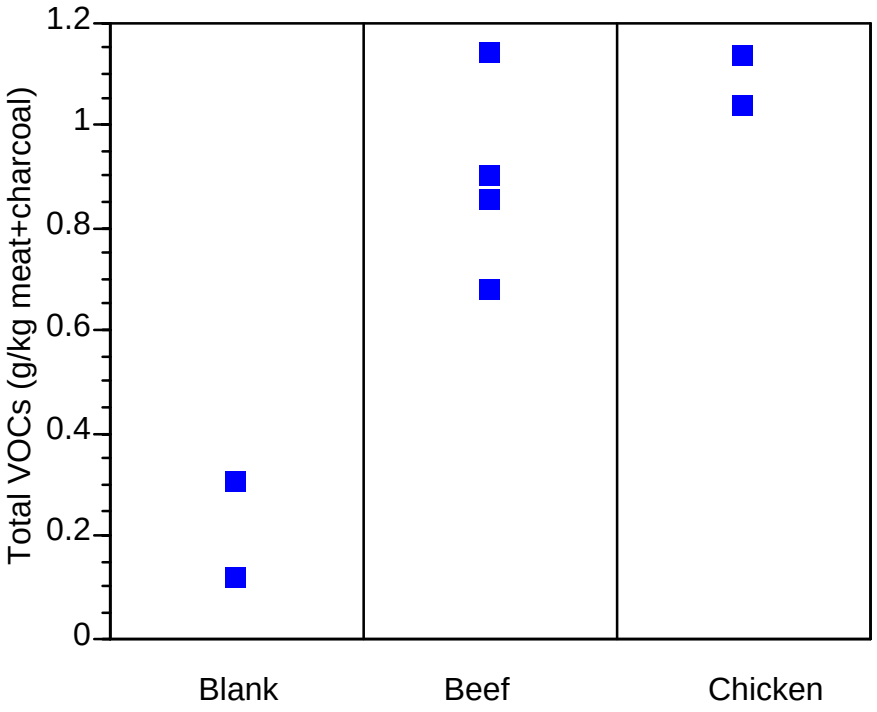
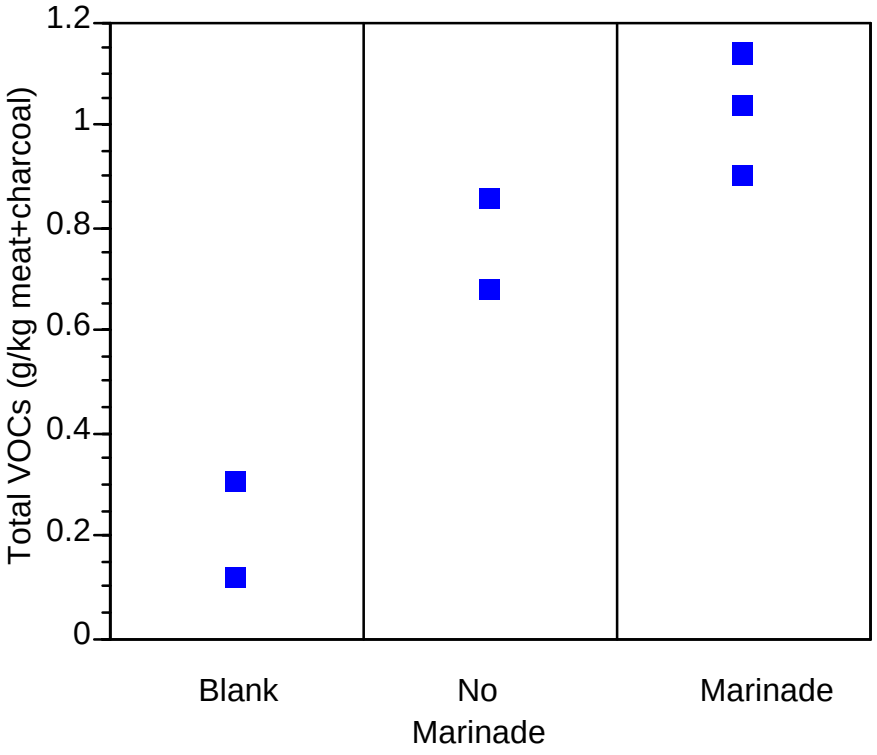


Figure 3-3. Effect of Marinade on Total VOC Emission



3.2 SVOC Results

Results of SVOC analysis from filters and XAD cartridges are summarized in Appendix I. Table 3-2 (a-c) summarizes the estimated emissions of the target compounds found in the SVOC analysis from filters based on total cooking time per cooking unit, per unit weight of meat cooked plus charcoal consumed and per weight of meat cooked. Similarly, Table 3-3 (a-c) summarizes the estimated emissions of the target compounds found in the SVOC analysis of XAD cartridges based on total cooking time per cooking unit, per weight of meat cooked and charcoal consumed and per weight of meat cooked.

Total SVOC emission (filters and XAD) of the detected target compounds per unit weight of meat and charcoal burned (grams of total SVOC/kg of meat plus charcoal) for each test run are plotted against test variables used. The test variables were: blank tests where no meat was cooked, presence of the control device, beef or chicken and use of marinade or no marinade.

As illustrated in Figure 3-4, there were undetectable SVOC emissions when only charcoal was burned (blank). Measurable amounts of SVOCs were emitted when beef or chicken was cooked. However, no SVOCs were detected with the control device in place while meat was cooked. This may indicate that the control device is very effective in removing SVOCs while cooking meat; however, more tests are required to confirm the finding.

Figure 3-5 compares SVOC emissions from cooking chicken and beef. It suggests that cooking chicken emits slightly more SVOCs than cooking beef, but more tests are necessary to substantiate the conclusion. Similarly, there were indications that cooking marinated meat may increase SVOC emissions (see Figure 3-6), but the finding is inconclusive without additional testing.

Table 3-2. SVOC from Filter Emissions Based on Cooking Time (a), Meat Plus Charcoal Weight (b) and Meat Weight (c)

(a) Emission Rate (g/hr)

	g/hr								
Target Compounds	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzyl alcohol	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
acetophenone	ND	ND	ND	ND	ND	ND	ND	ND	ND
methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	2.67E-03	4.41E-03	2.21E-03	ND	ND	4.56E-03	5.67E-03	2.99E-03	ND
fluoranthene	1.34E-03	2.20E-03	1.66E-03	ND	ND	1.43E-03	1.89E-03	ND	ND
pyrene	1.56E-03	1.65E-03	1.66E-03	ND	ND	ND	1.18E-03	ND	ND
diethyl phathalate	ND	1.43E-02	9.67E-03	ND	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	1.65E-03	ND	ND	ND	ND	ND	ND	ND
benzene butyl phthalate	ND	1.65E-03	ND	ND	ND	ND	ND	ND	ND

(b) Estimated Emissions (g/hg) meat + charcoal

	g/kg of meat and charcoal								
Target Compounds	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzyl alcohol	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
acetophenone	ND	ND	ND	ND	ND	ND	ND	ND	ND
methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	1.31E-03	2.10E-03	8.69E-04	ND	ND	1.40E-03	1.63E-03	7.78E-04	ND
fluoranthene	6.54E-04	1.05E-03	6.52E-04	ND	ND	4.38E-04	5.44E-04	ND	ND
pyrene	7.64E-04	7.88E-04	6.52E-04	ND	ND	ND	3.40E-04	ND	ND
diethyl phathalate	ND	6.83E-03	3.80E-03	ND	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	7.88E-04	ND	ND	ND	ND	ND	ND	ND
benzene butyl phthalate	ND	7.88E-04	ND	ND	ND	ND	ND	ND	ND

(c) Estimated Emissions (g/kg) / meat only

Target Compounds	g/kg of meat								
	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	ND	ND	ND	NA	NA	ND	ND	ND	ND
benzyl alcohol	ND	ND	ND	NA	NA	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	NA	NA	ND	ND	ND	ND
2-methyl phenol	ND	ND	ND	NA	NA	ND	ND	ND	ND
acetophenone	ND	ND	ND	NA	NA	ND	ND	ND	ND
methyl phenol	ND	ND	ND	NA	NA	ND	ND	ND	ND
naphthalene	ND	ND	ND	NA	NA	ND	ND	ND	ND
2-methylnaphthalene	ND	ND	ND	NA	NA	ND	ND	ND	ND
acenaphthylene	ND	ND	ND	NA	NA	ND	ND	ND	ND
dibenzofuran	ND	ND	ND	NA	NA	ND	ND	ND	ND
fluorene	ND	ND	ND	NA	NA	ND	ND	ND	ND
phenanthrene	1.21E-03	1.70E-03	8.68E-04	NA	NA	1.51E-03	1.73E-03	8.38E-04	ND
fluoranthene	6.04E-04	8.52E-04	6.51E-04	NA	NA	4.73E-04	5.78E-04	ND	ND
pyrene	7.04E-04	6.39E-04	6.51E-04	NA	NA	ND	3.61E-04	ND	ND
diethyl phthalate	ND	5.54E-03	3.80E-03	NA	NA	ND	ND	ND	ND
di-n-butyl phthalate	ND	6.39E-04	ND	NA	NA	ND	ND	ND	ND
benzene butyl phthalate	ND	6.39E-04	ND	NA	NA	ND	ND	ND	ND

Table 3-3. SVOC from XAD Emissions Based on Cooking Time (a), Meat Plus Charcoal Weight (b) and Meat Weight (c)

(a) Emission Rate (g/hr)

	g/hr								
Target Compounds	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	5.12E-02	6.61E-02	4.14E-02	1.69E-01	2.01E-02	5.42E-02	6.38E-02	5.65E-02	2.18E-01
benzyl alcohol	ND	ND	1.66E-03	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	2.29E-03	ND	ND	ND	ND
2-methyl phenol	3.34E-03	4.41E-03	2.76E-03	ND	ND	3.14E-03	5.44E-03	2.66E-03	ND
acetophenone	9.35E-03	9.36E-03	7.18E-03	2.59E-02	ND	3.71E-03	4.02E-03	2.99E-03	1.54E-03
4-methyl phenol	5.79E-03	1.21E-02	4.97E-03	ND	2.03E-03	5.13E-03	7.09E-03	5.65E-03	1.54E-03
naphthalene	5.79E-02	6.06E-02	5.25E-02	4.41E-02	1.37E-02	7.41E-02	7.33E-02	7.98E-02	2.80E-02
2-methylnaphthalene	1.29E-02	1.57E-02	1.19E-02	ND	1.78E-03	1.11E-02	1.28E-02	8.31E-03	2.77E-03
acenaphthylene	3.56E-03	4.41E-03	3.04E-03	ND	ND	3.71E-03	4.73E-03	3.99E-03	ND
dibenzofuran	7.13E-03	7.44E-03	6.35E-03	2.33E-02	4.07E-03	5.70E-03	5.67E-03	3.99E-03	2.46E-03
fluorene	1.34E-03	1.65E-03	ND	ND	ND	2.28E-03	3.31E-03	ND	ND
phenanthrene	4.45E-03	4.68E-03	4.70E-03	ND	2.80E-03	4.85E-03	6.15E-03	2.66E-03	2.15E-03
2-nitrophenol	8.91E-03	2.04E-02	1.02E-02	1.82E-02	3.30E-03	2.28E-03	ND	ND	ND
4-nitrophenol	ND	1.71E-02	ND	ND	1.78E-03	ND	ND	ND	ND
diethyl phthalate	ND	2.04E-02	ND	ND	ND	ND	ND	3.06E-02	ND
di-n-butyl phthalate	ND	3.31E-03	1.66E-03	ND	ND	ND	ND	4.99E-03	ND
n-nitrosodi-n-butylamine	ND	ND	2.49E-03	ND	ND	ND	ND	ND	ND
2-naphthylamine	ND	ND	2.76E-03	ND	ND	ND	ND	ND	ND
diethyl phthalate	ND	ND	1.38E-02	ND	ND	ND	ND	ND	ND
methyl methanesulfonate	ND	ND	ND	ND	ND	4.56E-03	ND	ND	ND
4-chloroaniline	ND	ND	ND	ND	ND	ND	ND	ND	1.26E-02

(b) Estimated Emissions (g/kg) / meat + charcoal

Target Compounds	g/kg of meat and charcoal								
	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	2.51E-02	3.15E-02	1.63E-02	7.66E-02	1.27E-02	1.66E-02	1.84E-02	1.47E-02	5.26E-02
benzyl alcohol	ND	ND	6.52E-04	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	1.44E-03	ND	ND	ND	ND
2-methyl phenol	1.64E-03	2.10E-03	1.09E-03	ND	ND	9.63E-04	1.56E-03	6.92E-04	ND
acetophenone	4.58E-03	4.46E-03	2.83E-03	1.18E-02	ND	1.14E-03	1.16E-03	7.78E-04	3.70E-04
4-methyl phenol	2.84E-03	5.78E-03	1.96E-03	ND	1.28E-03	1.58E-03	2.04E-03	1.47E-03	3.70E-04
naphthalene	2.84E-02	2.89E-02	2.06E-02	2.00E-02	8.65E-03	2.28E-02	2.11E-02	2.08E-02	6.74E-03
2-methylnaphthalene	6.33E-03	7.48E-03	4.67E-03	ND	1.12E-03	3.41E-03	3.67E-03	2.16E-03	6.67E-04
acenaphthylene	1.75E-03	2.10E-03	1.20E-03	ND	ND	1.14E-03	1.36E-03	1.04E-03	ND
dibenzofuran	3.49E-03	3.55E-03	2.50E-03	1.06E-02	2.56E-03	1.75E-03	1.63E-03	1.04E-03	5.93E-04
fluorene	6.54E-04	7.88E-04	ND	ND	ND	7.00E-04	9.52E-04	ND	ND
phenanthrene	2.18E-03	2.23E-03	1.85E-03	ND	1.76E-03	1.49E-03	1.77E-03	6.92E-04	5.19E-04
2-nitrophenol	4.36E-03	9.72E-03	4.02E-03	8.25E-03	2.08E-03	7.00E-04	ND	ND	ND
4-nitrophenol	ND	8.14E-03	ND	ND	1.12E-03	ND	ND	ND	ND
diethyl phthalate	ND	9.72E-03	ND	ND	ND	ND	ND	7.96E-03	ND
di-n-butyl phthalate	ND	1.58E-03	6.52E-04	ND	ND	ND	ND	1.30E-03	ND
n-nitrosodi-n-butylamine	ND	ND	9.78E-04	ND	ND	ND	ND	ND	ND
2-naphthylamine	ND	ND	1.09E-03	ND	ND	ND	ND	ND	ND
diethyl phthalate	ND	ND	5.43E-03	ND	ND	ND	ND	ND	ND
methyl methanesulfonate	ND	ND	ND	ND	ND	1.40E-03	ND	ND	ND
4-chloroaniline	ND	ND	ND	ND	ND	ND	ND	ND	3.04E-03

(c) Estimated Emissions (g/kg) / meat only

	g/kg of meat								
Target Compounds	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	2.31E-02	2.56E-02	1.63E-02	NA	NA	1.80E-02	1.95E-02	1.58E-02	6.12E-02
benzyl alcohol	ND	ND	6.51E-04	NA	NA	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	NA	NA	ND	ND	ND	ND
2-methyl phenol	1.51E-03	1.70E-03	1.09E-03	NA	NA	1.04E-03	1.66E-03	7.45E-04	ND
acetophenone	4.23E-03	3.62E-03	2.82E-03	NA	NA	1.23E-03	1.23E-03	8.38E-04	4.31E-04
4-methyl phenol	2.62E-03	4.69E-03	1.95E-03	NA	NA	1.70E-03	2.17E-03	1.58E-03	4.31E-04
naphthalene	2.62E-02	2.34E-02	2.06E-02	NA	NA	2.46E-02	2.24E-02	2.24E-02	7.84E-03
2-methylnaphthalene	5.84E-03	6.07E-03	4.67E-03	NA	NA	3.69E-03	3.90E-03	2.33E-03	7.76E-04
acenaphthylene	1.61E-03	1.70E-03	1.19E-03	NA	NA	1.23E-03	1.44E-03	1.12E-03	ND
dibenzofuran	3.22E-03	2.88E-03	2.50E-03	NA	NA	1.89E-03	1.73E-03	1.12E-03	6.89E-04
fluorene	6.04E-04	6.39E-04	ND	NA	NA	7.57E-04	1.01E-03	ND	ND
phenanthrene	2.01E-03	1.81E-03	1.84E-03	NA	NA	1.61E-03	1.88E-03	7.45E-04	6.03E-04
2-nitrophenol	4.03E-03	7.88E-03	4.02E-03	NA	NA	7.57E-04	ND	ND	ND
4-nitrophenol	ND	6.60E-03	ND	NA	NA	ND	ND	ND	ND
diethyl phthalate	ND	7.88E-03	ND	NA	NA	ND	ND	8.57E-03	ND
di-n-butyl phthalate	ND	1.28E-03	6.51E-04	NA	NA	ND	ND	1.40E-03	ND
n-nitrosodi-n-butylamine	ND	ND	9.77E-04	NA	NA	ND	ND	ND	ND
2-naphthylamine	ND	ND	1.09E-03	NA	NA	ND	ND	ND	ND
diethyl phthalate	ND	ND	5.43E-03	NA	NA	ND	ND	ND	ND
methyl methanesulfonate	ND	ND	ND	NA	NA	1.51E-03	ND	ND	ND
4-chloroaniline	ND	ND	ND	NA	NA	ND	ND	ND	3.53E-03

Figure 3-4. Effect of Control Device on Total SVOC Emission

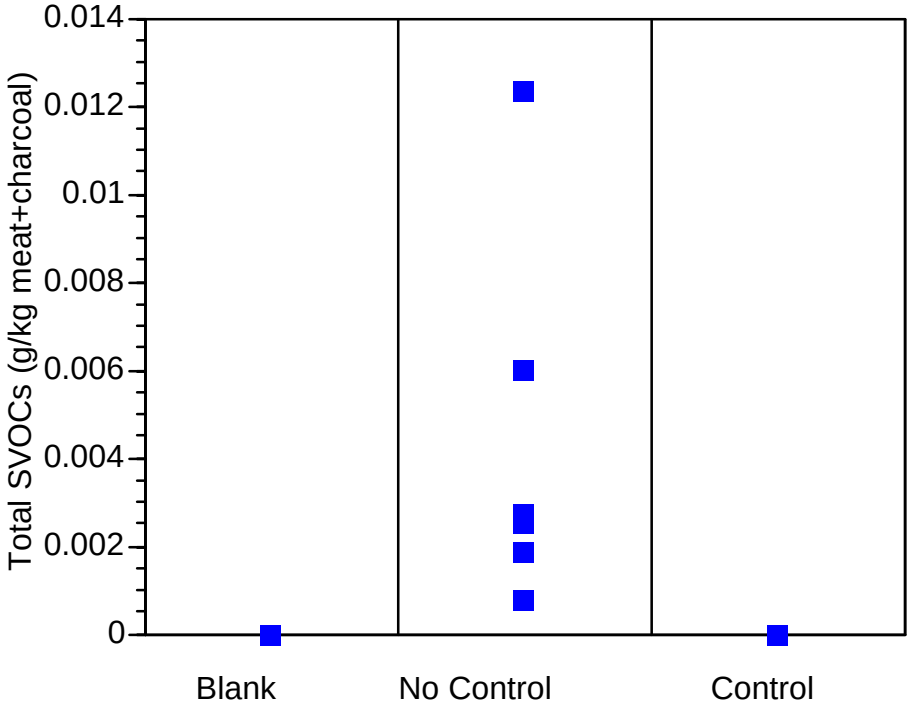


Figure 3-5. Effects of Meat Types on Total SVOC Emission

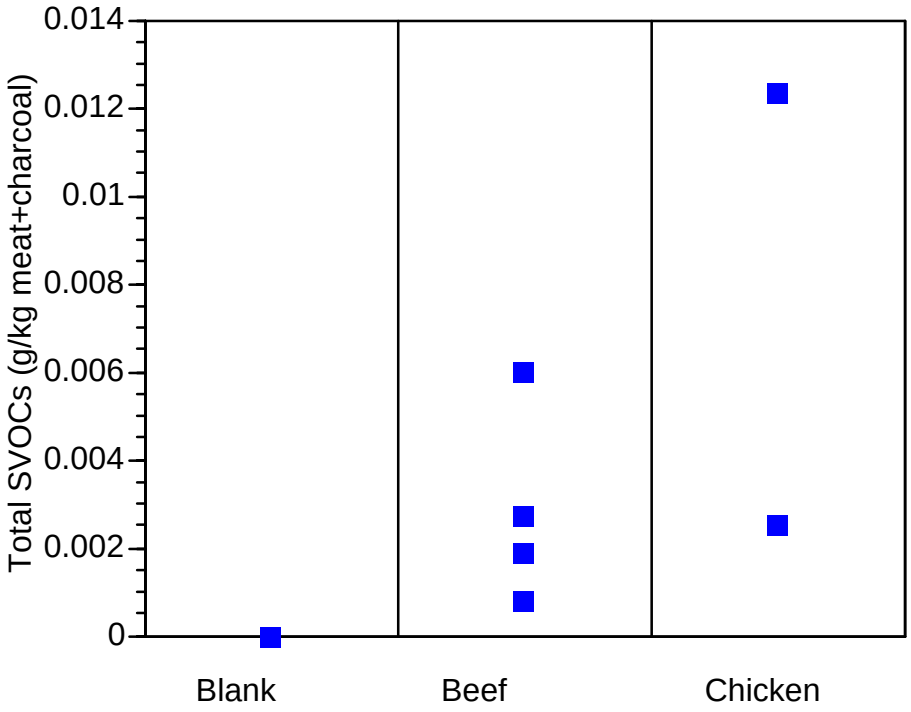
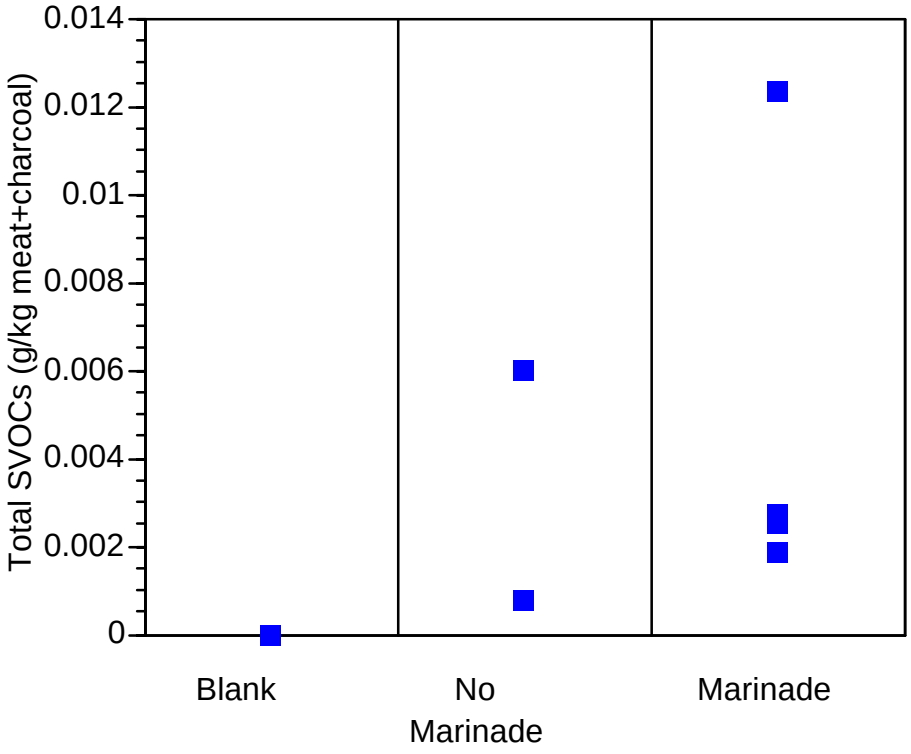


Figure 3-6. Effect of Marinade on Total SVOC Emission



3.3 Aldehyde Results

The results of aldehyde analysis are listed in Table 3-4. The emissions of aldehydes found per hour per cooking unit, per weight of meat and charcoal and per meat cooked are summarized in the table.

Total aldehyde emissions per unit weight of meat plus charcoal burned for different test runs are compared in Figures 3-7, 3-8 and 3-9, respectively. Figure 3-7 illustrates the effect of meat cooking with no emission control and the effect of a control screen on the total aldehyde emissions. The majority of aldehyde emissions was from cooking meat and not from burning charcoal. The control screen removed most of the aldehydes emitted from cooking meat; however, it must be emphasized that this finding is based on only one test, and further tests are necessary to verify it.

Figure 3-8 compares total aldehyde emissions from cooking beef and chicken. No significant differences can be seen between the beef and the chicken tests. However, there was a measurable effect of marinade on the total aldehydes emissions as illustrated in Figure 3-9. Increased emissions of aldehydes were probably due to the some of ingredients used in the marinade mixture such as lime juice or olive oil.

Table 3-4. Aldehyde Emissions

(a) Emission Rates (g/hr)

Test No.	Formaldehyde	Acetaldehyde	Propanal	Benzaldehyde	Pentanal	Hexanal
Test MC1	1.19	0.79	0.19	0.08	0.18	0.17
Test MC2	0.83	0.74	0.18	0.08	0.16	0.17
Test MC3	0.79	0.69	0.18	0.06	0.14	0.12
Test MC4	0.24	0.06	BDL	0.02	0.02	0.02
Test MC5	0.31	0.03	BDL	BDL	BDL	BDL
Test MC6	1.55	0.91	0.25	0.06	0.22	0.18
Test MC7	1.52	0.91	0.26	0.07	0.24	0.27
Test MC8	1.30	0.83	0.23	0.05	0.21	0.19
Test MC9	0.88	0.48	0.13	0.04	0.14	0.11

(b) Estimated Emissions (g/kg) Mass Burned

Test No.	Formaldehyde	Acetaldehyde	Propanal	Benzaldehyde	Pentanal	Hexanal
Test MC1	0.581	0.386	0.092	0.037	0.086	0.081
Test MC2	0.395	0.354	0.087	0.037	0.074	0.083
Test MC3	0.309	0.270	0.071	0.023	0.056	0.048
Test MC4	0.111	0.026	BDL	0.009	0.010	0.007
Test MC5	0.197	0.021	BDL	BDL	BDL	BDL
Test MC6	0.477	0.279	0.077	0.018	0.068	0.056
Test MC7	0.438	0.261	0.076	0.021	0.069	0.079
Test MC8	0.339	0.217	0.059	0.014	0.055	0.049
Test MC9	0.213	0.114	0.031	0.011	0.034	0.026

(c) Estimated Emissions (g/kg) Meat Cooked

Test No.	Formaldehyde	Acetaldehyde	Propanal	Benzaldehyde	Pentanal	Hexanal
Test MC1	0.536	0.356	0.085	0.034	0.080	0.075
Test MC2	0.320	0.287	0.070	0.030	0.060	0.067
Test MC3	0.309	0.269	0.071	0.023	0.056	0.048
Test MC4	NA	NA	NA	NA	NA	NA
Test MC5	NA	NA	NA	NA	NA	NA
Test MC6	0.516	0.302	0.083	0.019	0.073	0.061
Test MC7	0.466	0.277	0.081	0.022	0.073	0.084
Test MC8	0.365	0.233	0.064	0.015	0.060	0.053
Test MC9	0.247	0.133	0.036	0.012	0.039	0.030

Figure 3-7. Effects of the Control Device on Total Aldehyde Emissions

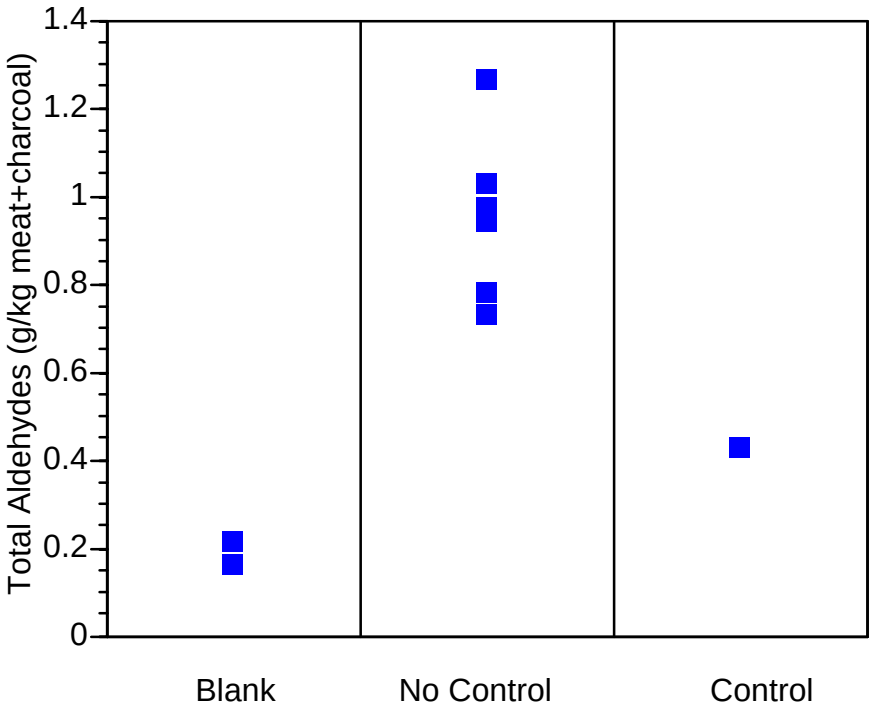


Figure 3-8. Effects of Meat Types on Total Aldehyde Emissions

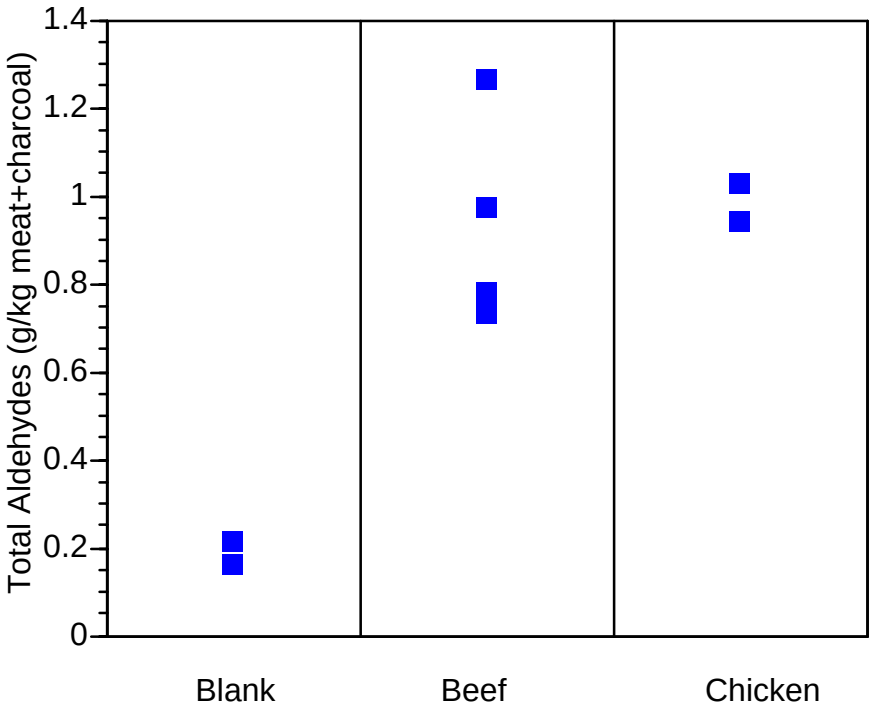
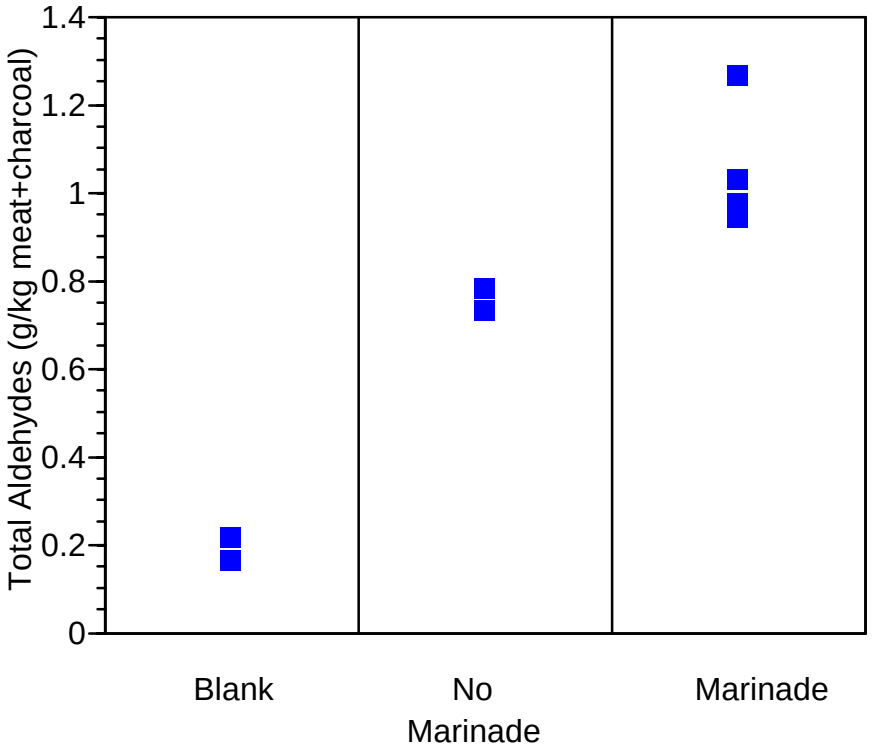


Figure 3-9. Effect of Marinade on Total Aldehyde Emissions



3.4 Total PM, CO, NO and THC

The amount of total PM emissions measured during the cooking is listed in Table 3-5. Similarly, emissions of CO, NO and THC are listed in Tables 3-6, 3-7 and 3-8, respectively. Total emissions were recalculated based on per unit of meat cooked, charcoal burned and per unit of meat cooked, as before.

Figure 3-10 compares CO emissions from the charcoal only runs (blank) with meat cooking runs with and without the control device in place. It is evident that practically all CO emissions come from the charcoal burning and not from the cooking of meat. The type of meat or marinade had no effect on CO emission, as shown in Figure 3-11 and Figure 3-12. Similarly, neither the cooking of meat or marinade made any contribution to NO emissions, as shown in Figures 3-13 and 3-14.

Figure 3-15 illustrates the effects of cooking meat with and without a control device on the emission of total PM. PM emission from the charcoal burning is low enough to be negligible. Total PM emission is almost entirely due to the act of cooking meat. The control device reduced but did not eliminate the PM emissions. However, this observation is based on only one test, and additional tests must be made in order to reach a firm conclusion on the control device. No clear difference in PM emission can be seen between beef and chicken cooking (see Figure 3-16), but there was a slight increase in PM emission when marinade was added to the meat (see Figure 3-17).

The effect of the cooking meat, the effect of marinade and the difference between beef and chicken concerning the THC emission is not very conclusive as indicated in the Figures 3-18, 3-19 and 3-20, respectively. Cooking meat seems to increase THC emission over the baseline level of charcoal burning, but it was not consistent over all the test runs. It appears that the control screen reduced THC emissions but further testing is needed to verify the finding.

The CEM traces of THC during the entire test run period as shown in Appendix G indicated that the practically all of the THC were emitted within the initial 30 minutes of lighting the charcoal. After the initial 30 minutes of burning, all of hydrocarbon contained in the charcoal burned off, and only carbon in the charcoal remained to sustain the fire. This may explain why the cooking of meat has very little effect on the total emission of THC.

Table 3-5. Total Particulate Emissions*

***Method 5**

Test No.	Emission Rate (g/hr)	Estimated Emissions meat + charcoal loss (g/kg)	Estimated Emissions meat cooked (g/kg)
MC1	18.1	8.8	8.2
MC2	22.7	10.8	8.8
MC3	19.5	7.7	7.7
MC4	1.3	0.6	NA
MC5	2.8	1.8	NA
MC6	32.5	10.0	10.8
MC7	34.9	10.1	10.7
MC8	30.4	7.9	8.5
MC9	23.7	5.7	6.6

Table 3-6. Carbon Monoxide Emissions*

***Average Dilution Tunnel Gas Concentration**

Test No.	**Emission Rate (g/hr)**	**Estimated Emissions meat + charcoal loss (g/kg)**	**Estimated Emissions meat cooked (g/kg)**
MC1	385.6	188.9	174.3
MC2	376.3	179.4	145.5
MC3	462.9	182.1	181.8
MC4	435.7	198.1	NA
MC5	494.3	311.5	NA
MC6	484.3	148.7	160.8
MC7	556.7	160.2	170.2
MC8	518.1	134.8	145.2
MC9	574.5	138.5	161.1

Table 3-7. Nitric Oxide Emissions*

***Average gas concentration**

Test No.	Emission Rate (g/hr)	Estimated Emissions meat + charcoal loss (g/kg)	Estimated Emissions meat cooked (g/kg)
MC1	5.2	2.6	2.4
MC2	16.5	7.8	6.4
MC3	8.5	3.3	3.3
MC4	13.1	6.0	NA
MC5	16.3	10.3	NA
MC6	14.2	4.3	4.7
MC7	6.6	1.9	2.0
MC8	5.2	1.3	1.4
MC9	6.3	1.5	1.8

Table 3-8. Total Hydrocarbon Emissions*

***Average gas concentration**

***THC as methane**

Test No.	Emission Rate (g/hr)	Estimated Emissions meat + charcoal loss (g/kg)	Estimated Emissions meat cooked (g/kg)
MC1	20.4	10.0	9.2
MC2	20.2	9.6	7.8
MC3	13.2	5.2	5.2
MC4	1.4	0.7	NA
MC5	4.5	2.9	NA
MC6	6.9	2.1	2.3
MC7	3.5	1.0	1.1
MC8	14.5	3.8	4.1
MC9	1.2	0.3	0.3

Figure 3-10. CO Emissions from Charcoal Burning Alone Compared with Meat Cooking

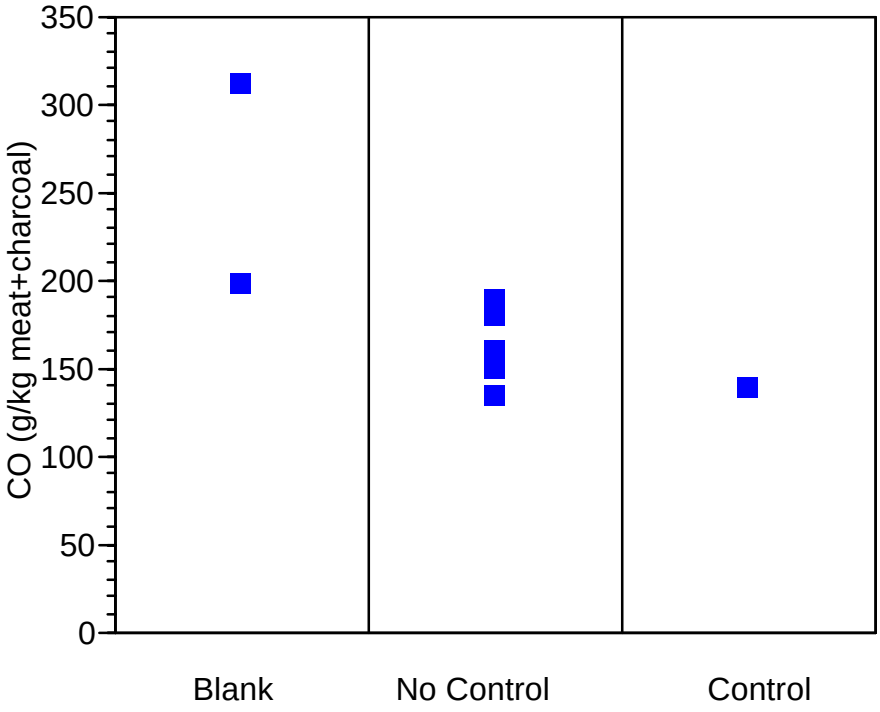


Figure 3-11. Effects of Meat Types on CO Emissions

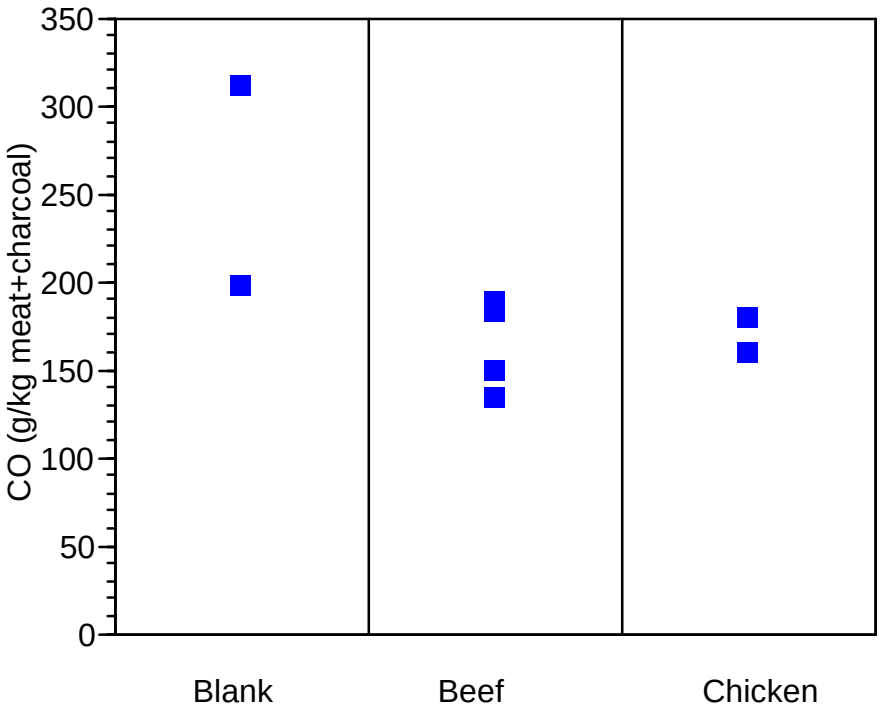


Figure 3-12. Effects of Marinade on CO Emissions

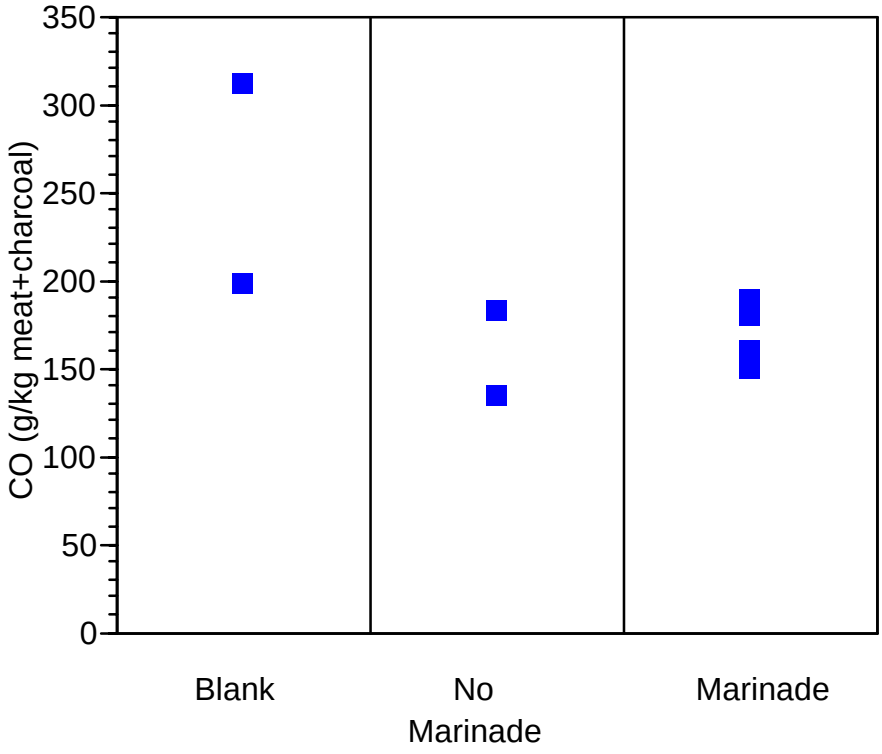


Figure 3-13. NO Emissions from Charcoal Burning Alone and Cooking Meat

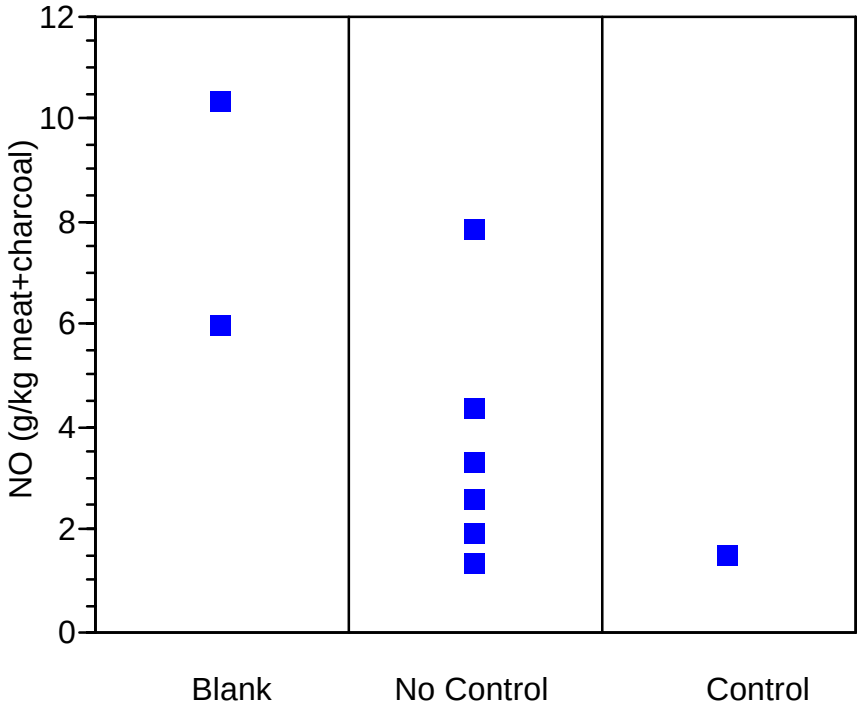


Figure 3-14. Effects of Marinade on NO Emissions

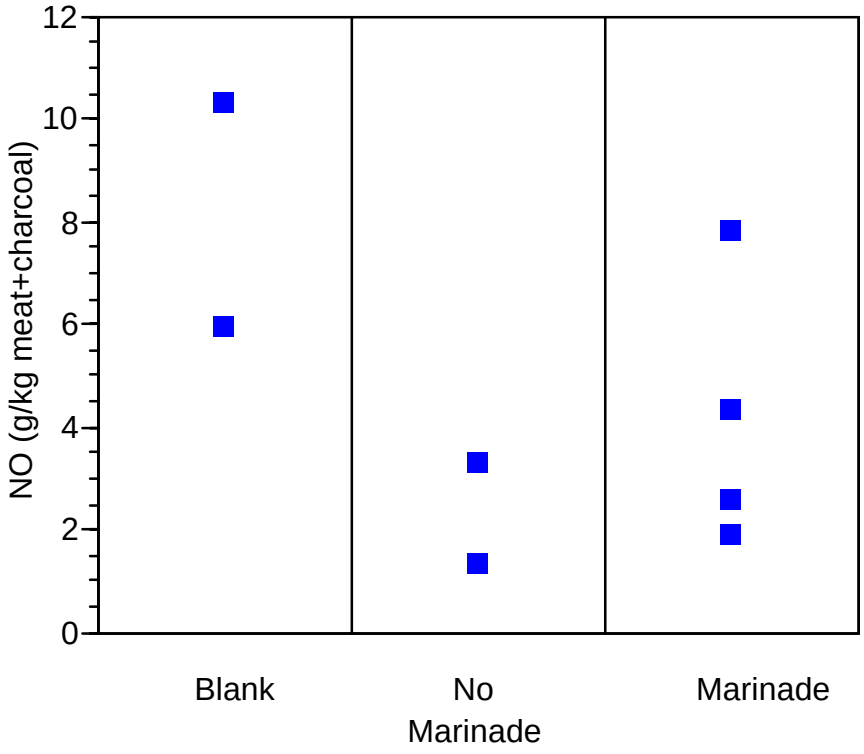


Figure 3-15. Effects of Cooking Meat with and without the Control Device on Total PM Emissions

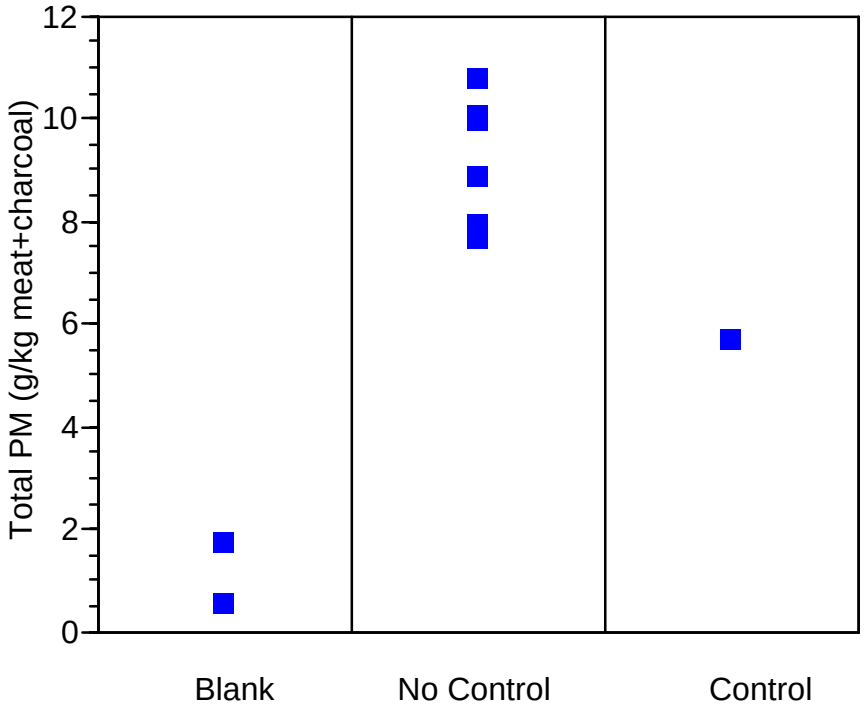


Figure 3-16. Effects of Meat Types on Total PM Emissions

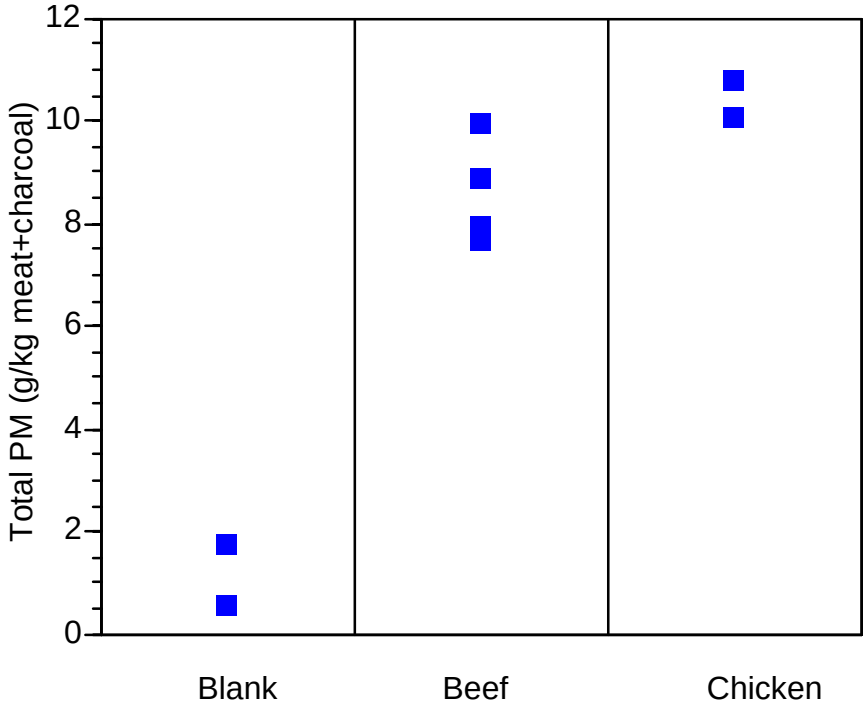


Figure 3-17. Effect of Marinade on Total PM Emissions

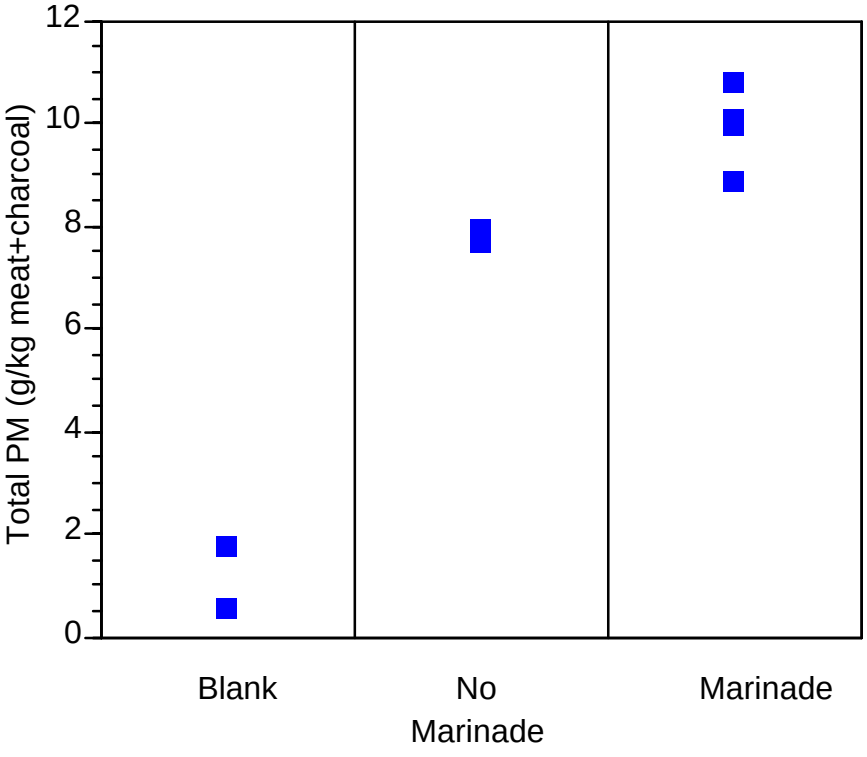


Figure 3-18. THC Emissions from Charcoal Burning, Meat Cooking With and without the Control Device

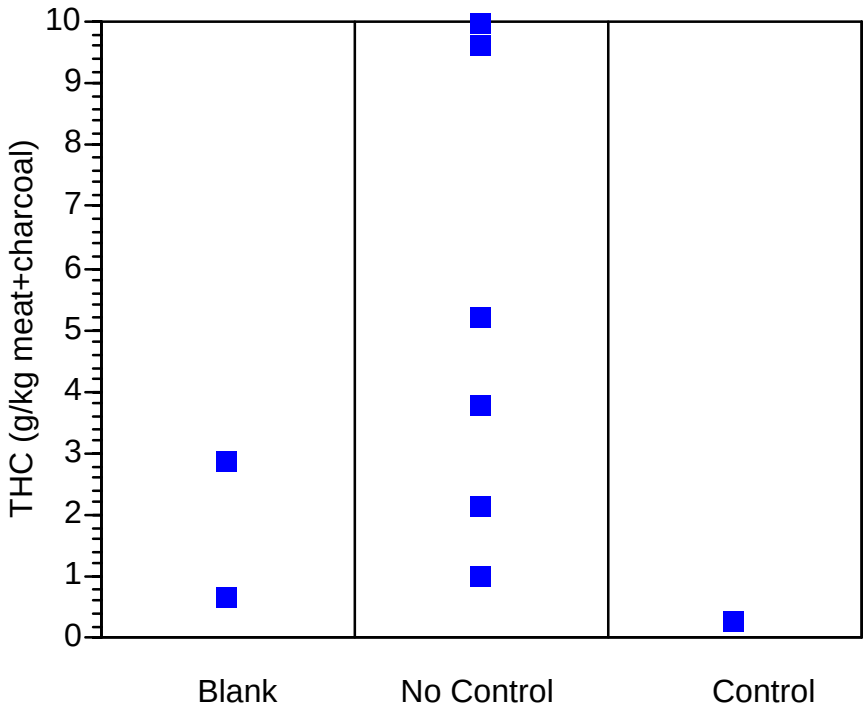


Figure 3-19. Effects of Type of Meat on THC Emissions

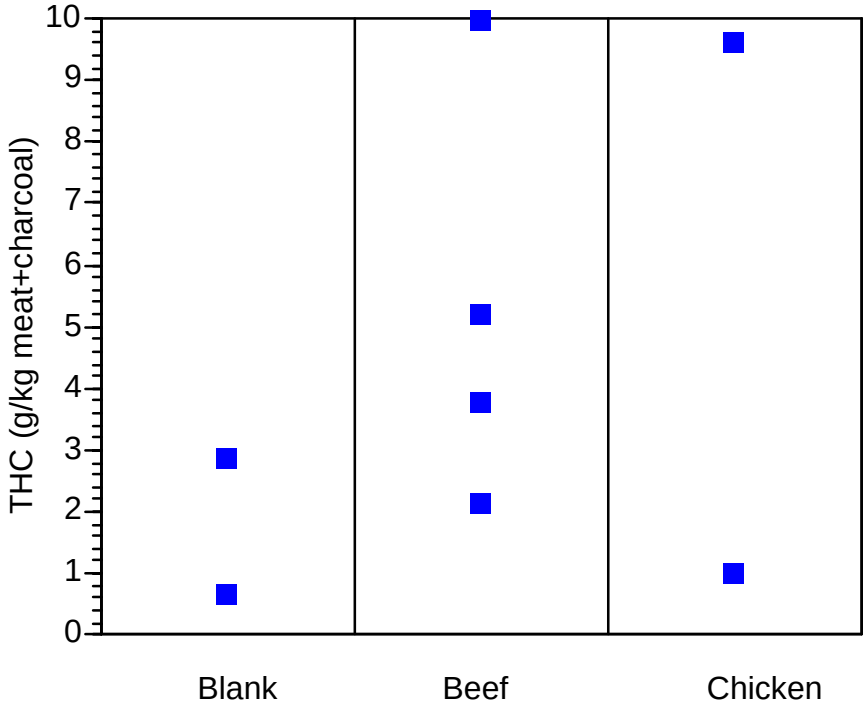
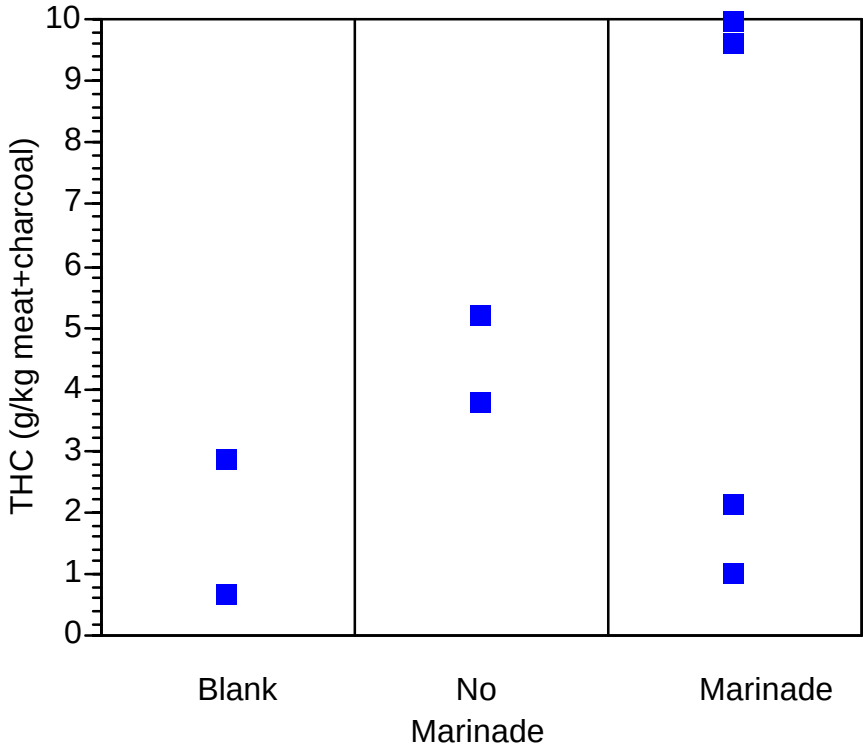


Figure 3-20. Effects of Marinade on THC Emissions



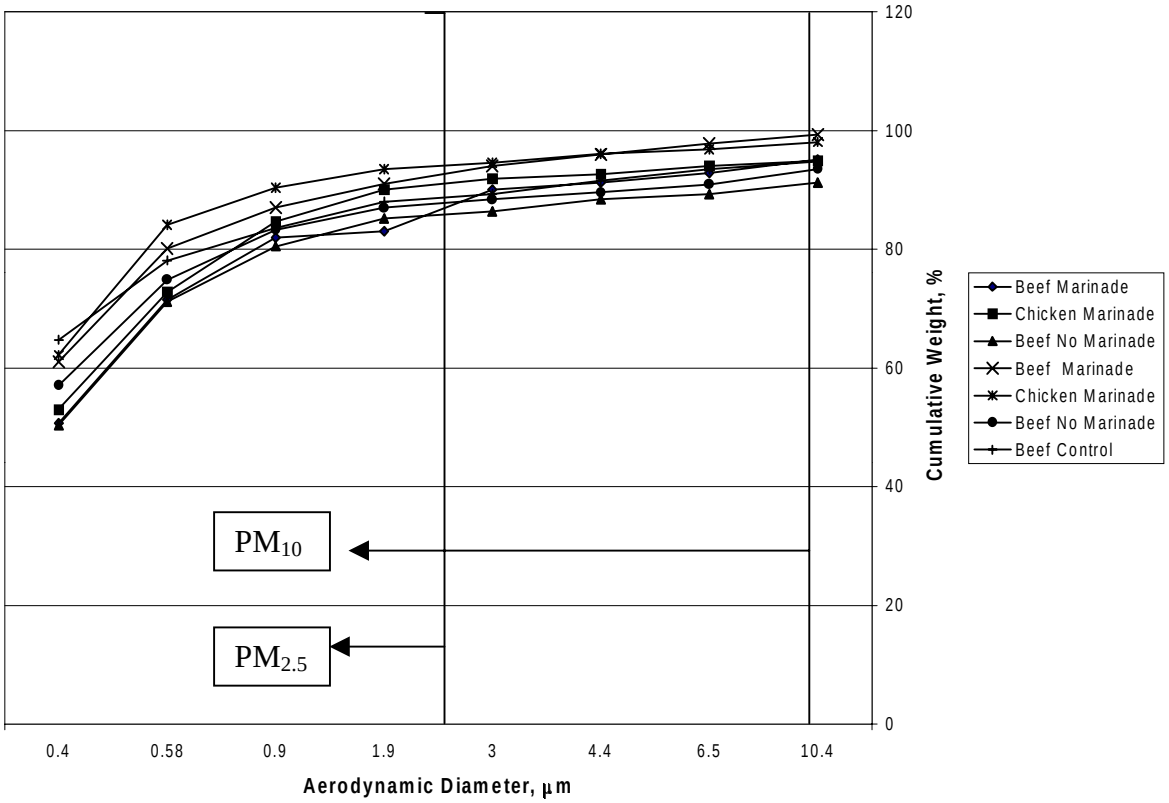
3.5 Particle Size Distribution (PM_{10} and $PM_{2.5}$)

The result of particle size distribution measurements is summarized in Table 3-9 and graphically illustrated in Figure 3-21. Particle size distributions of all the runs made with meat—regardless of the type of meat or use of marinade—were quite similar. The majority of the particles were very small. Over 80% of the particles had an aerodynamic diameter less than 2.5 μm ($PM_{2.5}$). Only 20% of the particles had an aerodynamic diameter between 10 μm and 2.5 μm.

Table 3-9. Summary of Particle Size Distributions

Particula	Cumulative Weight, %								
Diamete	Run	Run	Run	Run	Run	Run	Run	Run	Run
10.4 μm	95.1	94.9	91.2	100.0	101.3	99.3	98.1	93.5	94.8
6.5 μm	92.8	94.0	89.3	100.0	102.5	97.8	96.8	90.9	93.5
4.4 μm	91.2	92.6	88.5	102.1	100.0	96.0	96.1	89.6	91.6
3.0 μm	90.1	91.9	86.4	101.0	97.5	94.0	94.6	88.4	89.3
1.9 μm	83.1	90.0	85.2	21.6	97.5	91.0	93.5	87.0	88.0
0.9 μm	82.0	84.6	80.5	24.7	92.4	87.0	90.4	83.3	83.6
0.58 μm	71.5	72.8	71.2	26.8	86.1	80.1	84.1	74.9	78.1
0.4 μm	50.7	53.0	50.4	21.6	72.2	61.1	62.2	57.1	64.8

Figure 3-21 Particulate Size Distributions.



4.0 CONCLUSIONS

Based on the results discussed in the previous sections, the following conclusions can be made:

- Emissions of total PM, total VOCs, total SVOCs and THC from the street vendor cooking are basically the result of cooking meat; i.e., charcoal does not contribute to these emissions.
- Marinated meat yielded an increased total VOC and total PM emissions compared to non-marinated meat.
- There were no significant differences in emission rates between chicken and beef.
- Emissions of CO and NO derive from charcoal fire rather than the cooking of meat.
- Based on very limited observations, the simple screen placed in the stack (emission control device) appeared to be very effective in reducing emissions of PM, VOCs, SVOCs and THC from the street vendor cooking devices; but, only one test was performed to evaluate this device, therefore no conclusive results were obtained.
- Particulate size distribution of all the test runs was very similar. The majority of the particles (80%) had an aerodynamic diameter less than 2.5 μm ($PM_{2.5}$). Only 20% of the particles had an aerodynamic diameter between 10 μm and 2.5 μm.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

The QA/QC activities planned for this project were described in the approved Category III QA Project Plan (QAPP), titled *QAPP for Emissions from Street Vendor Cooking Devices,* dated July 1998. Some deviations from the QAPP occurred during implementation and are documented below:

The blank burn was not performed prior to testing as indicated in the test matrix described in the QAPP.

This was necessary because there were only limited amounts of charcoal available at start of the test series, and it was felt that the maximum number of testing would yield more useful information than a blank with only charcoal burning. Subsequently, two blank burns were made with the Mexican charcoal and a local charcoal.

The test sequence has been changed from QAPP.

The QA review suggested randomizing the test sequence.

The QAPP stated that charcoal will be ignited with charcoal lighter fluid, but a propane torch was used to ignite the charcoal.

A propane torch was used because it was felt that the torch with hot flame would contaminate charcoal much less than the lighter fluid soaking into the charcoal. In Mexico, they light the charcoal with piece of burning wood or rolled up paper. Although it simulates the actual field condition, it is a hit-or-miss process and would have required a lengthy waiting period before the meat cooking could start.

The QAPP stated that burning charcoal would be quenched by spraying water on it.

Quenching burning charcoal with water would have resulted in the formation of steam and scattering of ash, resulting in an error in weight measurements.

The QAPP stated that a three-point calibration would be made for the NO_X analyzer, but only two point calibrations were made.

The measured NO values ranged from 0 to less than 20 ppm. It was felt that only zero and span gas calibrations were sufficient for these ranges.

Turning times of meat were not recorded.

Due to the uneven nature of the charcoal bed temperature, the meat had to be moved from

one location to the other, and the meat had to be turned in random fashion due to the non-uniform nature of thickness of the meat. Under these circumstances, it was decided that noting the turning times would add very little to the quality of the data, and it would only complicate the test procedure. All of these actions were taken in order to simulate the Mexican cooking process as closely as possible in this study.

Sample ID system detailed in the QAPP was not used.

Only one test was done for each day of testing, and only one sample was obtained for each type of analysis. Therefore, identification of a sample by either run number or the date of testing was sufficient for the identification.

5.1 Data Quality Indicator Goals

The data quality indicator goals (DQIGs) established in the QAPP for the critical measurements are shown in Table 5-1.

Accuracy is expressed as percent bias and calculated by comparing a measured concentration with a known concentration. Precision is assessed by taking replicate measurements. Completeness is defined as the number of valid measurements compared to the number of total measurements taken and is expressed as a percentage. Completeness goals were met for all measurements except for SO_X. No SO_X values were reported due to problems with the instrument.

All the weight measurements for particulate sampling, particulate analysis, PM_{10} and $PM_{2.5}$ were within established DQIGs. The accuracy of the balance was assessed by taking daily weights of a NIST traceable standard.

The percent recovery of volatiles and aldehydes were well within the 50-150% specified. The percent recoveries of semivolatiles were within the 18-120%.

All CEM measurements including CO, CO_2, O_2 and NO had less than ±2% error in calibration, checks less than ±3% drift, and less than ±5% error in bias checks.

Temperature measurements were within the ±2%, and both charcoal weight and meat weight measurements were within ±50 grams and ±0.1 gram, respectively.

Galbraith Laboratories, Inc. performed the fuel analysis, and their precision is not known since no replicate samples were analyzed. Southern Testing & Research Laboratories, Inc. analyzed the fat content of the meat tested. Since no replicate sample was analyzed, the precision of their analysis is not known. The size of the meat samples was sufficiently large so that the result of analysis represents an average fat content value for beef and chicken.

5.2 Data Limitations

The only CEM measurement which did not meet the DQIG was SO_2 measurements. The instrument was not stable during most runs, and frequent excursions shown during the run indicated the data were not reliable.

Table 5-1. Data Quality Indicator Goals for Critical Measurements

Parameter	Method	Accuracy (% Bias)	Precision (% Difference)	Completeness (%)
Particulate Sampling	40 CFR 60 Method 5G	±0.1 mg	<±4 0.02 CFM	>90
Particulate Analysis	40 CFR 60 Method 5G	±0.1 mg	±0.2 mg	100
PM_{10}	Cascade Impactor	±0.1 mg	<20	>70
$PM_{2.5}$	Cascade Impactor	±0.1 mg	<20	>70
Semivolatiles	40 CFR 60 Method 5G	18-120 (% Recovery)	<30	>70
Volatiles	Summa Canister GC/MS Analysis	50-150 (%Recovery)	<30	>70
Aldehydes	Modified Method 1P-6A	50-150 (%Recovery)	<30	>70
Stack NO	Method 7E	calibration <±2 Drift <±3 System bias<±5	<5	>90
Stack SO_x	Draft Performance	Same as above	<5	>90
Stack O_2	Method 3A	Same as above	<5	>90
Stack CO	Method 10	Same as above	<5	>90
Dilution Tunnel CO	Method 10	Same as above	<5	>90
Dilution Tunnel Flow	Method 2C	<±5	<5	>90
Temperatures	Thermocouple	<±2	<5	>90
Fuel Analysis	Ultimate and	<±5	<5	>90
Fuel Weight	Method 28	<±2	<5	>90
Meat Weight	Method 28	<±2	<5	>90
Percent Fat	Health Dept. Method	>10	>10	>90

5.3 Audits

The ARCADIS Geraghty & Miller QA Officer performed an internal systems audit on September 9, 1998. A checklist was prepared by the ARCADIS Geraghty & Miller QA Officer using the *QAPP for Emissions from Street Vendor Cooking Devices*. Calibration, start-up, cooking and sampling (CEMs, VOCs, aldehyde and particulate) activities for the test evaluation for marinated chicken were observed. Project documentation was also reviewed for completeness and adequacy. An internal audit report detailing findings and observations was submitted to the ARCADIS Geraghty & Miller Work Assignment Leader on September 16, 1998.

5.3.1 Audit Summary

Project documentation by ARCADIS Geraghty & Miller staff was very good. Personnel demonstrated that they were familiar with methods used to perform their assigned task(s). It was evident that personnel were familiar with the approved QAPP even though there were some deviations from the document. It was not apparent that deviations had been formally documented.

The majority of the observations noted during the audit were related to the deviations from the QAPP. There were also some concerns regarding QC checks of the CEM system. These checks are not currently done on a routine basis. It was noted in the audit that the SO_2 monitor showed considerable drift during the first day of testing but was fairly stable on the day of the audit.

5.3.2 Findings/Observations

The following specific findings and observations were included in the internal audit report:

- Finding 1: No CEM bias checks or independent calibration checks on the CEMs have been performed.
- Finding 2: A blank burn was not conducted prior to testing.
- Observation 1: Breakthrough for Aldehydes has not been demonstrated.
- Observation 2: There is no documented criterion for determining when meat is “done.”
- Observation 3: There was evidence of paint burn-off from the grill that may contribute to emissions.
- Observation 4: Due to removal of the grill door, there is some loss of emissions to the room.

5.3.3 Corrective Actions

As a result of the audits, a run was performed of aldehyde cartridges placed in series to demonstrate there was no breakthrough to the back cartridge.

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3. EPA Method 5G, "Determination of Particulate Emissions from Wood Heaters from a Dilution Tunnel Sampling Location," Code of Federal Regulations, Title 40, Part 60, Appendix A, 1991.

4. Harris, D. B., "Procedures for Cascade Impactor Calibration and Operation in Process Streams," EPA-600/2-77-004 (NTIS PB263-623), January, 1997.

5. Riggin, R. M., Winberry, W.T. and Murphy, N.T, "Determination of Volatile Organic Compounds in Ambient Air Using SUMMA Canister," Method TO-14, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA-600/4-89/017 (NTIS PB90-116989), June, 1988.

6. EPA Method IP-6A, "Determination of Formaldehyde and Other Aldehydes in Indoor Air Using a Solid Absorbent Cartridge," Compendium of Methods for the Determination of Air Pollutants in Indoor Air, EPA-600/4-90/010 (NTIS PB90-200288), 1990.

7. AOAC 960.39, "Fat Content by Ether Extraction," Compendium of Official Methods of Analysis, Association of Official Analytical Chemist International, 16th Edition, 4th Revision, Vol. I and II, 1998.

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9. EPA Method 10, "Determination of Carbon Monoxide Emissions from Stationary Sources," Code of Federal Regulations, Title 40, Part 60, Appendix A, 1997.

10. EPA Method 6C, “Determination of Sulfur Dioxide Emissions from Stationary Sources,” Code of Federal Regulations, Title 40, Part 60, Appendix A, 1997.

11. EPA Method 7E, “Determination of Nitrogen Oxides Emissions from Stationary Sources,” Code of Federal Regulations, Title 40, Part 60, Appendix A, 1997.

12. EPA Method 25A, “Determination of Total Gaseous Organic Concentration Using Flame Ionization Analyzer,” Code of Federal Regulations, Title 40, Part 60, Appendix A, 1997.

13. Martz, R.F., Coppedge, E.A., and Johnson, L.D., “Guidance for Total Organics,” EPA/600/R-96-036 (NTIS PB97- 118533), EPA, National Exposure Research Laboratory, Research Triangle Park, NC, November 1996.

14. EPA SW Method 8270C, “Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique,” in Test Methods for Evaluating Solid Wastes, Revision 3, Volume 1, EPA SW-846 (NTIS PB88-239223), EPA , OSW, Washington, DC, December 1996.

15. EPA SW Method 8260B, “Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS),” in Test Methods for Evaluating Solid Wastes, Revision 2, Volume 1, EPA SW-846 (NTIS PB88-239223), EPA , OSW, Washington, DC, December 1996.

APPENDIX A

Report of Fat Analysis

Southern Testing & Research Laboratories, Inc.
3809 Airport Drive • Wilson, NC 27896 • (252) 237-4175 • Fax: (252) 237-9341 • www.STRLabs.com

REPORT OF ANALYSIS

LAB SAMPLE NO.(s): H1558-001-002

DATE OF REPORT: 9/24/98

RECEIVED FROM

DATE RECEIVED : 9/22/98

NAM : CATHIE HINTON
ORG : ARCADIS GERAGHTY & MILLER
ADD : 4915 PROSPECTUS DRIVE, SUITE F
CSZ : DURHAM NC 27713

ACCOUNT NO.:

TELEPHONE : 919-544-2260

SAMPLE(s) of:

MARKED A: MARINATED BEEF

B: NON-MARINATED BEEF

C:

D:

-----SAMPLE/TEST NO.------->		A:H1558-001	B:H1558-002	C:	D:
ANALYSIS	UNITS				
FAT, Ether Extract According to AOAC 960.39	(%)	19.08	6.95		

COMMENTS:

LAB USE ONLY----------
ANALYSTs: LO
PICKUP: RUSH:
TIME: MILES:
T: D:

Reviewed and Approved

Name: Lisa L. Oehrl, M.S.
Title: Section Head, Food Chemistry Dept.

Southern Testing & Research Laboratories, Inc.
3809 Airport Drive • Wilson, NC 27896 • (252) 237-4175 • Fax: (252) 237-9341 • www.STRLabs.com

REPORT OF ANALYSIS

LAB SAMPLE NO.(s): H1558-003-004

DATE OF REPORT: 9/24/98

RECEIVED FROM

DATE RECEIVED : 9/22/98

NAM : CATHIE HINTON
ORG : ARCADIS GERAGHTY & MILLER
ADD : 4915 PROSPECTUS DRIVE, SUITE F
CSZ : DURHAM NC 27713

ACCOUNT NO.:

TELEPHONE : 919-544-2260

SAMPLE(s) of:

MARKED A: MARINATED CHICKEN

B: NON-MARINATED CHICKEN

C:

D:

-----SAMPLE/TEST NO.-------->		A:H1558-003	B:H1558-004	C:	D:
ANALYSIS	UNITS				
FAT, Ether Extract According to AOAC 960.39	(%)	12.05	18.42		

COMMENTS:

LAB USE ONLY----------
ANALYSTs: LO
PICKUP: RUSH:
TIME: MILES:
T: D:

Reviewed and Approved

Name: Lisa L. Oehrl, M.S.
Title: Section Head, Food Chemistry Dept.

APPENDIX B

Charcoal Analysis

GALBRAITH® LABORATORIES, INC.

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LABORATORY REPORT

Peter Kariher
Arcadis Geraghty & Miller
4915 Prospectus Drive
Durham NC 27713

Report Date: 09/28/98
Sample Received: 09/21/98
Purchase Order #: CH43910E
Fax Number: 919-544-5690

SAMPLE ID	LAB ID	ANALYSIS	DRY BASIS		AS RECEIVED	
1) WS-Charcoal	Z-3901	Proximate:				
		Moisture			4.59	%
		Volatile Matter	25.94	%	24.75	%
		Ash	0.90	%	0.86	%
		Fixed Carbon (by diff)	73.16	%	69.80	%
2) MC-Charcoal	Z-3902	Proximate:				
		Moisture			4.43	%
		Volatile Matter	25.73	%	24.59	%
		Ash	4.61	%	4.47	%
		Fixed Carbon (by diff)	69.66	%	66.57	%

CM:le D8

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APPENDIX C

Weight Data for Charcoal and Meat, kg (lb)

Weight Data for Charcoal and Meat, kg (lb)

TEST NO.	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
Initial Charcoal	5.13(11.30)	5.44(12.00)	5.62(12.40)	6.03(13.30)	5.31(11.70)	6.08(13.40)	6.49(14.30)	6.49(14.3)	5.35(11.8)
Final Charcoal	2.18(4.80)	3.13(6.90)	2.31(5.09)	1.68(3.70)	2.09(4.61)	2.31(5.09)	2.00(4.41)	2.68(5.91)	0.54(1.19)
Change	2.18(4.8)	2.31(5.10)	3.31(7.30)	4.35(9.6)	3.22(7.1)	3.72(8.2)	4.49(9.9)	3.81(3.91)	4.81(10.6)
Initial Meat	5.31(11.71)	5.30(11.69)	5.01(11.04)	N/A	N/A	5.27(11.62)	6.87(15.15)	5.29(11.67)	5.59(12.32)
Final Meat	3.39(7.47)	3.33(7.34)	3.37(7.42)	N/A	N/A	3.28(7.23)	4.07(8.98)	3.46(7.63)	3.9(8.59)
Change	1.92(4.23)	1.97(4.35)	1.64(3.62)	N/A	N/A	1.99(4.40)	2.8(6.16)	1.83(4.04)	1.69(3.74)
Scraping (grams)	13.75	20.12	18	N/A	N/A	8.83	10.14	3.91	18.5

APPENDIX D

Average Grill Temperatures and Average CED Data for Total Run

Average Temperatures for Total Run

Location Test No.	Coal degC	Grate degC	Grill Hood degC	Stack degC	Dilution Tunnel degC	Ambient degC
MC1	245.8	152.8	94.5	88.3	51.3	26.9
MC2	240.5	175.4	107.9	93.8	52.7	26.0
MC3	245.2	180.0	103.1	91.6	53.1	27.5
MC4	255.5	207.8	144.0	122.0	67.0	31.6
MC5	182.0	154.1	107.4	96.0	57.1	31.1
MC6	303.8	222.8	149.9	119.8	65.6	31.1
MC7	265.9	206.0	139.0	112.4	64.7	32.9
MC8	337.3	293.0	161.5	117.4	62.8	27.3
MC9	361.4	254.6	154.7	111.0	65.0	28.1

Average CEM Data for Total Run

CEM Test No.	CO Stack, %	CO Dilution T., ppm	O2 %	CO2 %	THC ppm	NO ppm	SO2 ppm
MC1	0.092	464.3	19.2	0.73	47.7	6.8	113.9
MC2	0.104	459.9	19.4	0.90	74.9	18.1	28.0
MC3	0.112	539.1	19.6	0.80	62.2	10.5	17.5
MC4	0.114	524.5	19.5	1.20	43.1	15.1	3.2
MC5	0.112	575.7	19.9	0.80	32.9	15.9	0.0
MC6	0.128	610.6	19.2	1.20	58.7	16.3	0.0
MC7	0.126	636.6	18.9	1.10	24.8	6.9	19.5
MC8	0.131	641.2	19.2	1.30	55.7	6.8	10.6
MC9	0.118	688.5	19.1	1.20	37.4	7.0	14.2

APPENDIX E

Average Grill Temperatures and Average CED Data During Grilling

Average Temperatures During Grilling

Location Test No.	Coal degC	Grate degC	Grill Hood degC	Stack degC	Dilution Tunnel degC	Ambient degC
MC1	242.0	147.2	94.0	88.4	52.7	28.7
MC2	268.0	189.4	108.9	91.8	52.5	26.5
MC3	267.0	184.0	99.9	88.2	52.5	28.3
MC4*	263.7	210.5	142.3	116.8	66.6	31.6
MC5*	204.3	170.3	112.3	101.7	60.5	32.9
MC6	306.1	222.8	142.1	111.2	63.4	32.4
MC7	286.6	221.1	143.4	113.9	66.5	34.2
MC8	357.9	308.9	160.3	113.1	61.7	28.1
MC9	355.3	261.2	157.4	109.4	66.0	29.8

* During sampling

Average CEM Data During Grilling

CEM Test No.	CO Stack, %	CO Dilution T., ppm	O2 %	CO2 %	THC ppm	NO ppm	SO2 ppm
MC1	0.093	459.7	19.2	0.72	42.5	5.8	157.0
MC2	0.097	438.3	19.4	0.80	41.1	17.9	30.3
MC3	0.104	539.1	19.6	0.70	26.9	9.2	17.0
MC4*	0.111	521.9	19.5	1.10	3.0	14.7	3.6
MC5*	0.110	586.5	19.8	0.80	9.4	18.1	0.0
MC6	0.116	578.7	19.4	1.10	14.4	15.8	2.1
MC7	0.130	666.8	18.9	1.10	7.4	7.4	23.1
MC8	0.124	611.9	19.3	1.20	29.9	5.7	8.9
MC9	0.116	688.1	19.1	1.20	2.5	7.0	16.0

* During sampling

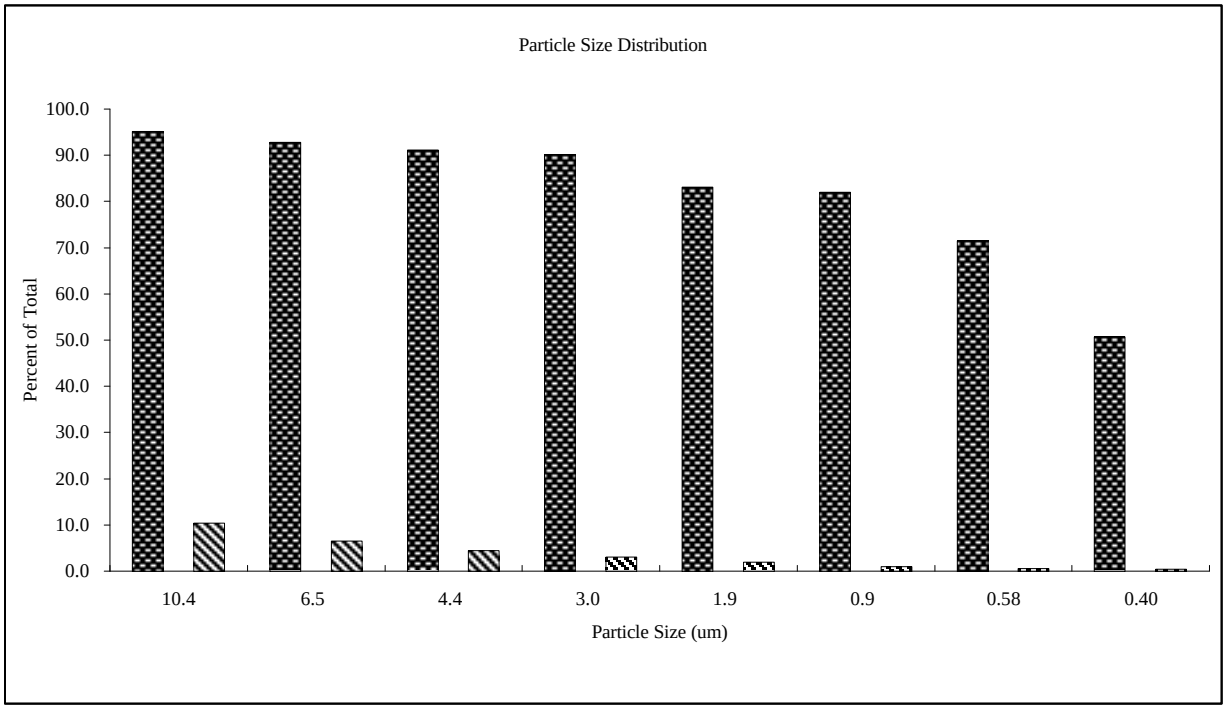
APPENDIX F

Particle Size Distributions

PARTICLE SIZE SAMPLING RESULTS

SOURCE: Mexican Charcoal / Beef With Marinade
DATE: 03-Sep-98
RUN: MC1
CONDITION:

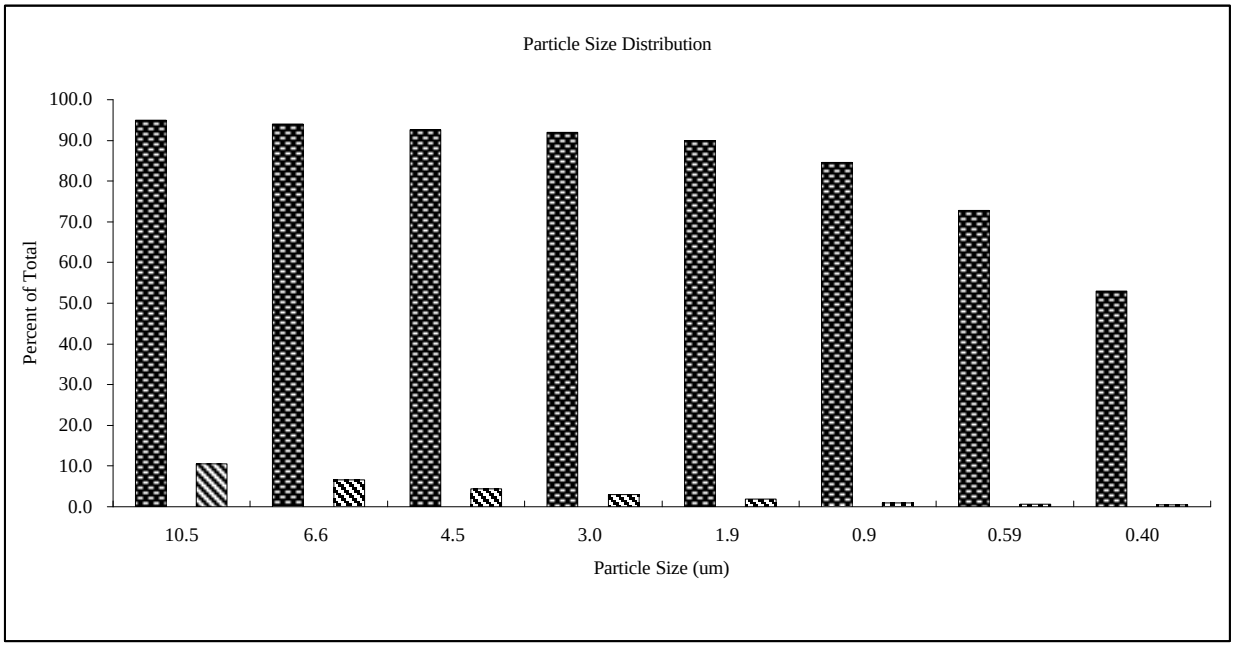
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	144	1	3.2	4.9	95.1	10.4
Vm=	111.417	2	1.5	2.3	92.8	6.5
Pb=	29.4	3	1.1	1.7	91.2	4.4
Ts=	126.86	4	0.7	1.1	90.1	3.0
Pstat=	-4	5	4.6	7.0	83.1	1.9
Tm=	106.3	6	0.7	1.1	82.0	0.9
Delta h=	1.8	7	6.9	10.5	71.5	0.58
Delta p=	0.50	8	13.7	20.9	50.7	0.40
Dn=	0.25	Backup	33.3	50.7	0.0	
Y=	0.981	Total	65.7	100.0	-	-
% Isokin=	95.5					
Imp ACFM=	0.83					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Mexican Charcoal / Chicken With Marinade
DATE: 09-Sep-98
RUN: MC2
CONDITION:

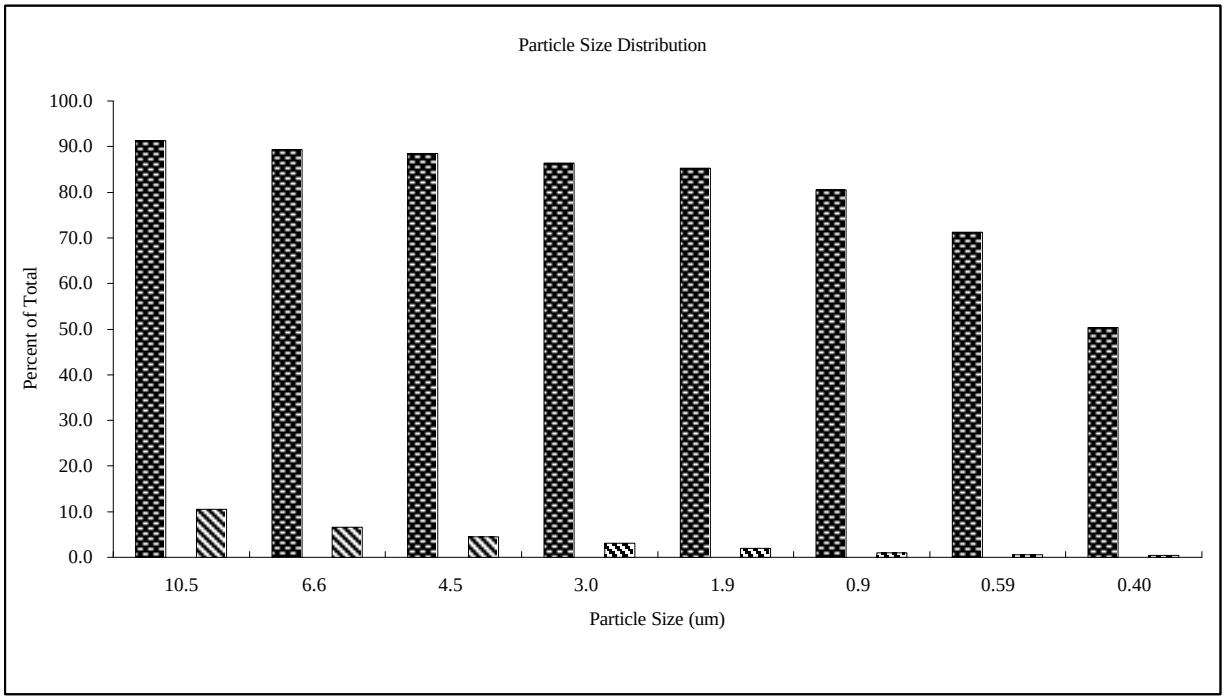
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	123	1	2.9	5.1	94.9	10.5
Vm=	93.342	2	0.5	0.9	94.0	6.6
Pb=	29.4	3	0.8	1.4	92.6	4.5
Ts=	126.5	4	0.4	0.7	91.9	3.0
Pstat=	-4	5	1.1	1.9	90.0	1.9
Tm=	104.7	6	3.1	5.4	84.6	0.9
Delta h=	1.8	7	6.7	11.8	72.8	0.59
Delta p=	0.50	8	11.3	19.8	53.0	0.40
Dn=	0.25	Backup	30.2	53.0	0.0	
Y=	0.981	Total	57	100.0	-	-
% Isokin=	93.8					
Imp ACFM=	0.82					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Mexican Charcoal / Beef wo Marinade
DATE: 11-Sep-98
RUN: MC3
CONDITION:

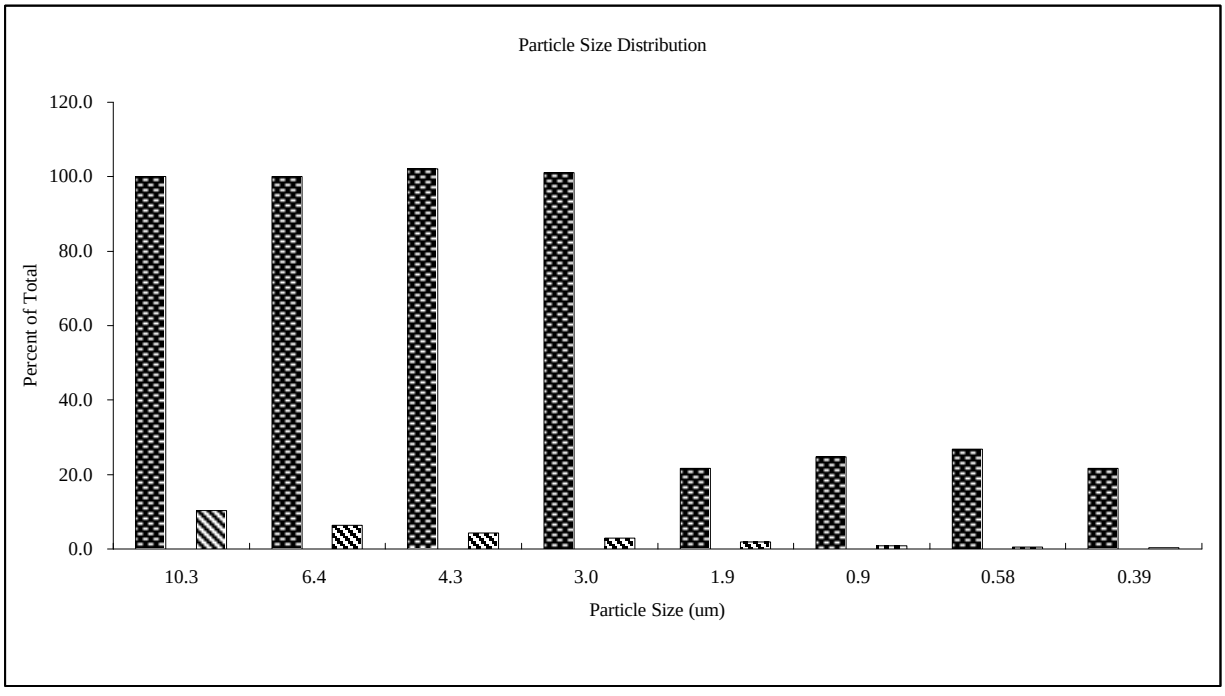
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	118	1	4.5	8.8	91.2	10.5
Vm=	89.45	2	1.0	1.9	89.3	6.6
Pb=	29.7	3	0.4	0.8	88.5	4.5
Ts=	126.5	4	1.1	2.1	86.4	3.0
Pstat=	-4	5	0.6	1.2	85.2	1.9
Tm=	103.7	6	2.4	4.7	80.5	0.9
Delta h=	1.8	7	4.8	9.3	71.2	0.59
Delta p=	0.50	8	10.7	20.8	50.4	0.40
Dn=	0.25	Backup	25.9	50.4	0.0	
Y=	0.981	Total	51.4	100.0	-	-
% Isokin=	94.4					
Imp ACFM=	0.82					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Whole Foods Charcoal / No Meat
DATE: 16-Sep-98
RUN: MC4
CONDITION:

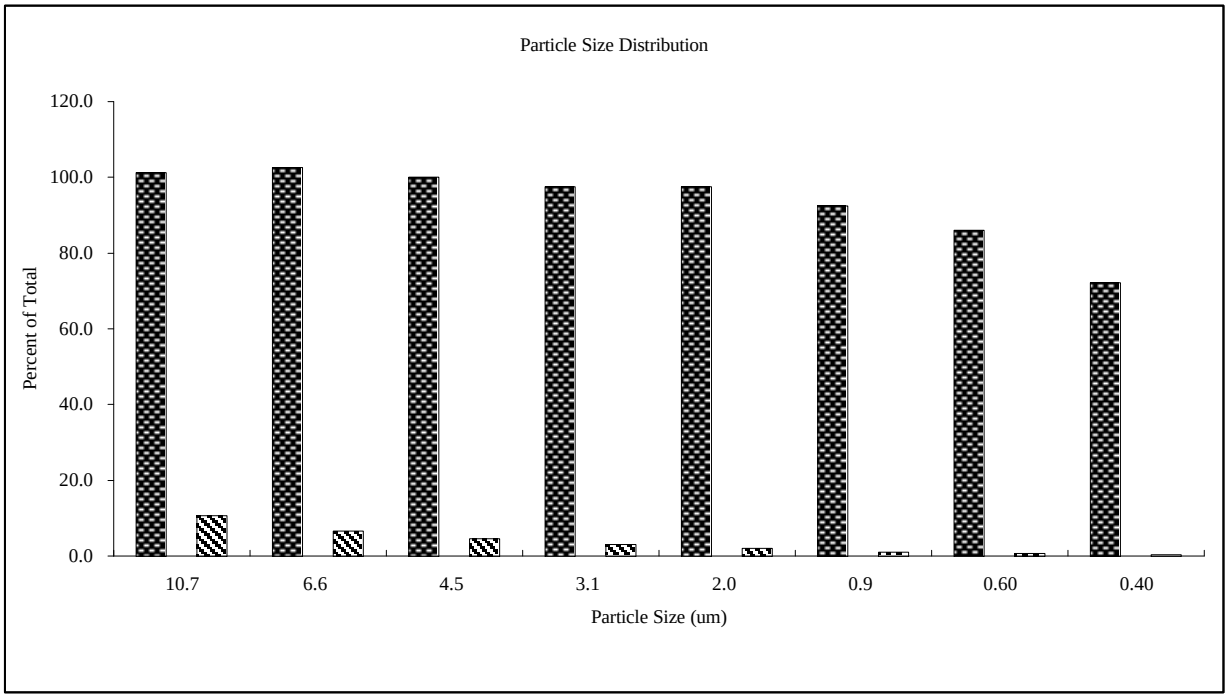
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	120	1	0.0	0.0	100.0	10.3
Vm=	91.775	2	0.0	0.0	100.0	6.4
Pb=	29.7	3	-0.2	-2.1	102.1	4.3
Ts=	151.88	4	0.1	1.0	101.0	3.0
Pstat=	-4	5	7.7	79.4	21.6	1.9
Tm=	106.7	6	-0.3	-3.1	24.7	0.9
Delta h=	1.8	7	-0.2	-2.1	26.8	0.58
Delta p=	0.50	8	0.5	5.2	21.6	0.39
Dn=	0.25	Backup	2.1	21.6	0.0	
Y=	0.981	Total	9.7	100.0	-	-
% Isokin=	96.7					
Imp ACFM=	0.85					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Mexican Charcoal / No Meat
DATE: 17-Sep-98
RUN: MC5
CONDITION:

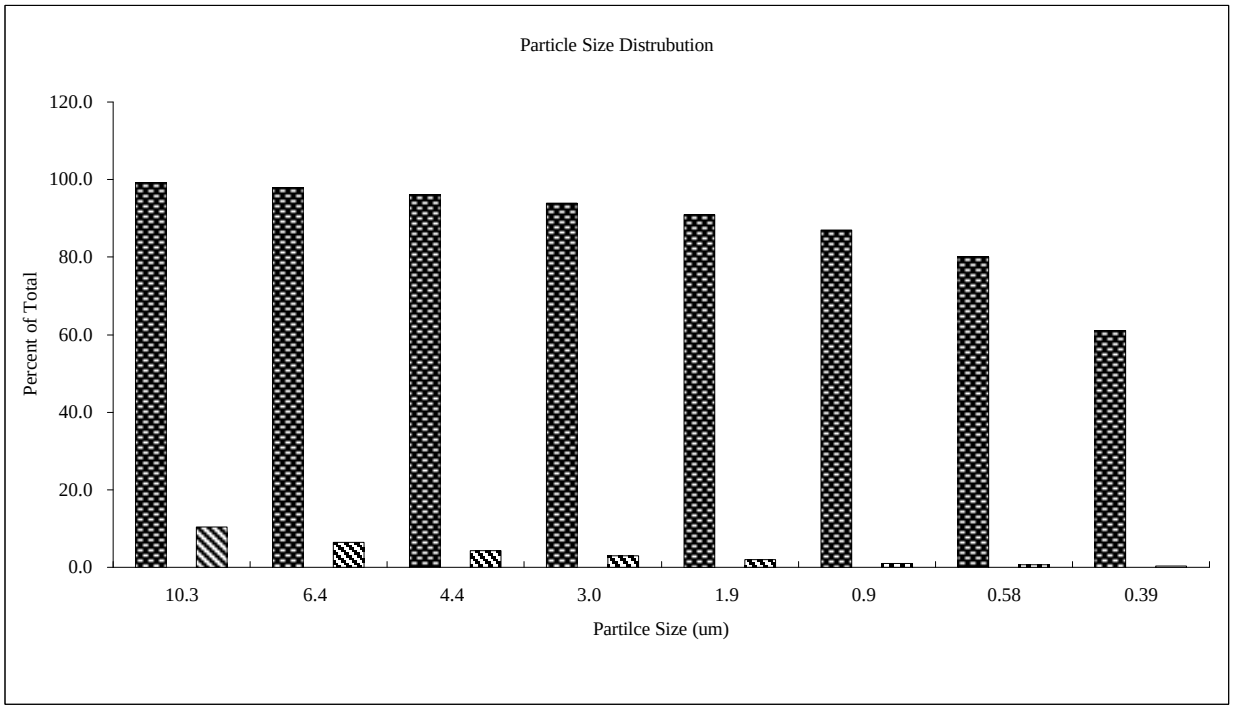
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	121	1	-0.1	-1.3	101.3	10.7
Vm=	87.811	2	-0.1	-1.3	102.5	6.6
Pb=	29.6	3	0.2	2.5	100.0	4.5
Ts=	140.9	4	0.2	2.5	97.5	3.1
Pstat=	-4	5	0.0	0.0	97.5	2.0
Tm=	107.3	6	0.4	5.1	92.4	0.9
Delta h=	1.8	7	0.5	6.3	86.1	0.60
Delta p=	0.50	8	1.1	13.9	72.2	0.40
Dn=	0.25	Backup	5.7	72.2	0.0	
Y=	0.981	Total	7.9	100.0	-	-
% Isokin=	90.7					
Imp ACFM=	0.79					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Whole Foods Charcoal / Marinated Beef
DATE: 21-Sep-98
RUN: MC6
CONDITION:

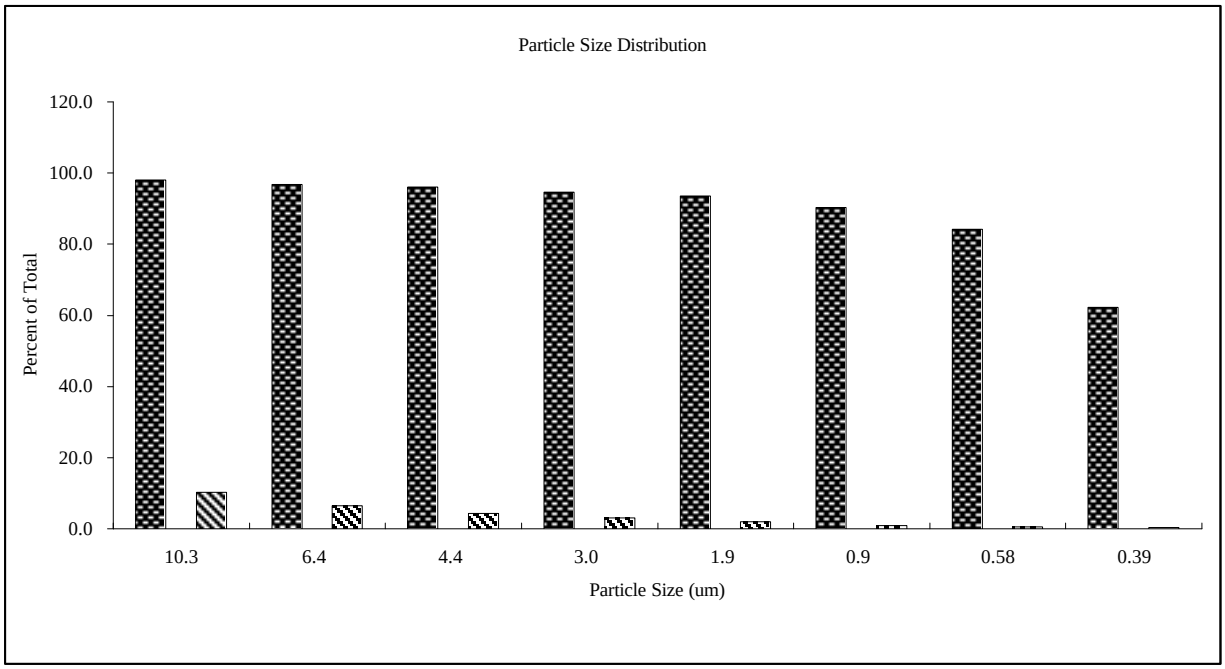
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD (microns)
E-time=	105	1	0.6	0.7	99.3	10.3
Vm=	80.429	2	1.2	1.4	97.8	6.4
Pb=	29.5	3	1.5	1.8	96.0	4.4
Ts=	146.12	4	1.7	2.0	94.0	3.0
Pstat=	-4	5	2.5	3.0	91.0	1.9
Tm=	107.7	6	3.3	4.0	87.0	0.9
Delta h=	1.8	7	5.7	6.9	80.1	0.58
Delta p=	0.50	8	15.8	19.0	61.1	0.39
Dn=	0.25	Backup	50.7	61.1	0.0 <	
Y=	0.981	Total	83	100.0	-	-
% Isokin=	96.0					
Imp ACFM=	0.85					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Whole Foods Charcoal / Marinated Chicken
DATE: 22-Sep-98
RUN: MC7
CONDITION:

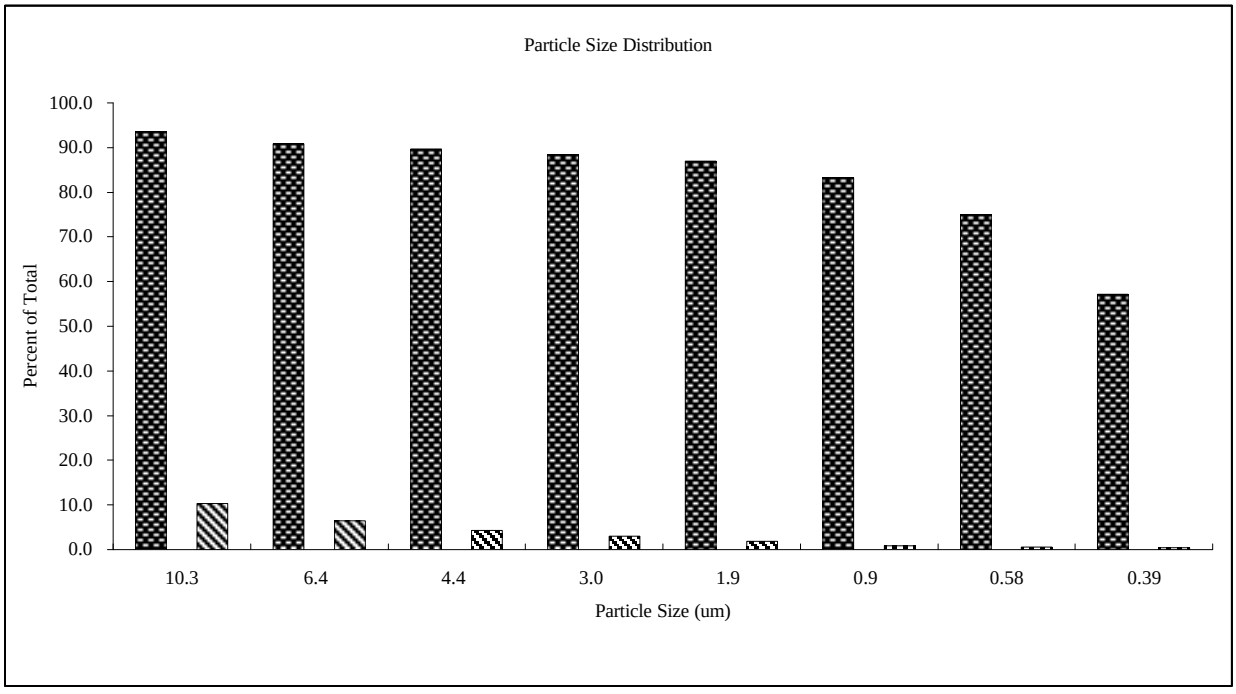
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD :m
E-time=	126	1	2.0	1.9	98.1	10.3
Vm=	95.923	2	1.4	1.3	96.8	6.4
Pb=	29.4	3	0.7	0.7	96.1	4.4
Ts=	151.7	4	1.6	1.5	94.6	3.0
Pstat=	-4	5	1.1	1.0	93.5	1.9
Tm=	106.7	6	3.3	3.1	90.4	0.9
Delta h=	1.8	7	6.6	6.3	84.1	0.58
Delta p=	0.50	8	23.0	21.9	62.2	0.39
Dn=	0.25	Backup	65.4	62.2	0.0	
Y=	0.981	Total	105.1	100.0	-	-
% Isokin=	95.8					
Imp ACFM=	0.85					



PARTICLE SIZE SAMPLING RESULTS

SOURCE: Whole Foods Charcoal / Beef wo Marinade
DATE: 24-Sep-98
RUN: MC8
CONDITION:

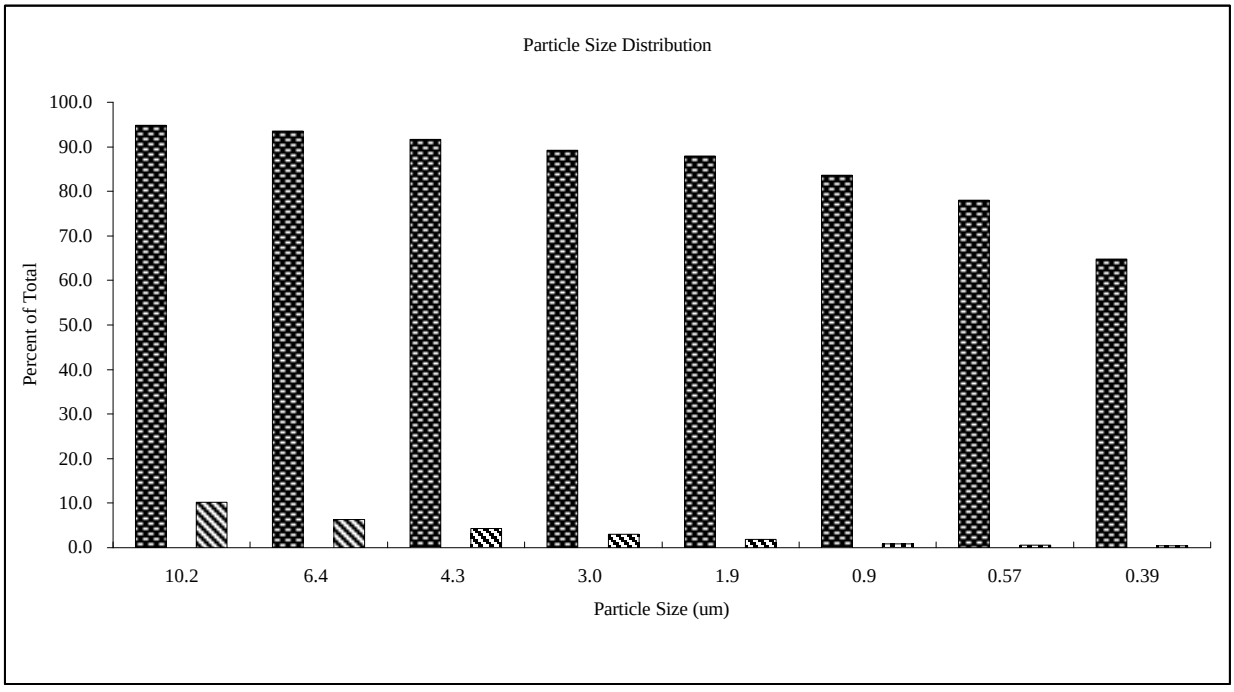
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD : m
E-time=	89	1	4.2	6.5	93.5	10.3
Vm=	68.193	2	1.7	2.6	90.9	6.4
Pb=	29.8	3	0.8	1.2	89.6	4.4
Ts=	143.06	4	0.8	1.2	88.4	3.0
Pstat=	-4	5	0.9	1.4	87.0	1.9
Tm=	103.3	6	2.4	3.7	83.3	0.9
Delta h=	1.8	7	5.4	8.4	74.9	0.58
Delta p=	0.50	8	11.5	17.8	57.1	0.39
Dn=	0.25	Backup	36.9	57.1	0.0	
Y=	0.981	Total	64.6	100.0	-	-
% Isokin=	97.0					
Imp ACFM=	0.85					



PARTICLE SIZE SAMPLING RESULTS

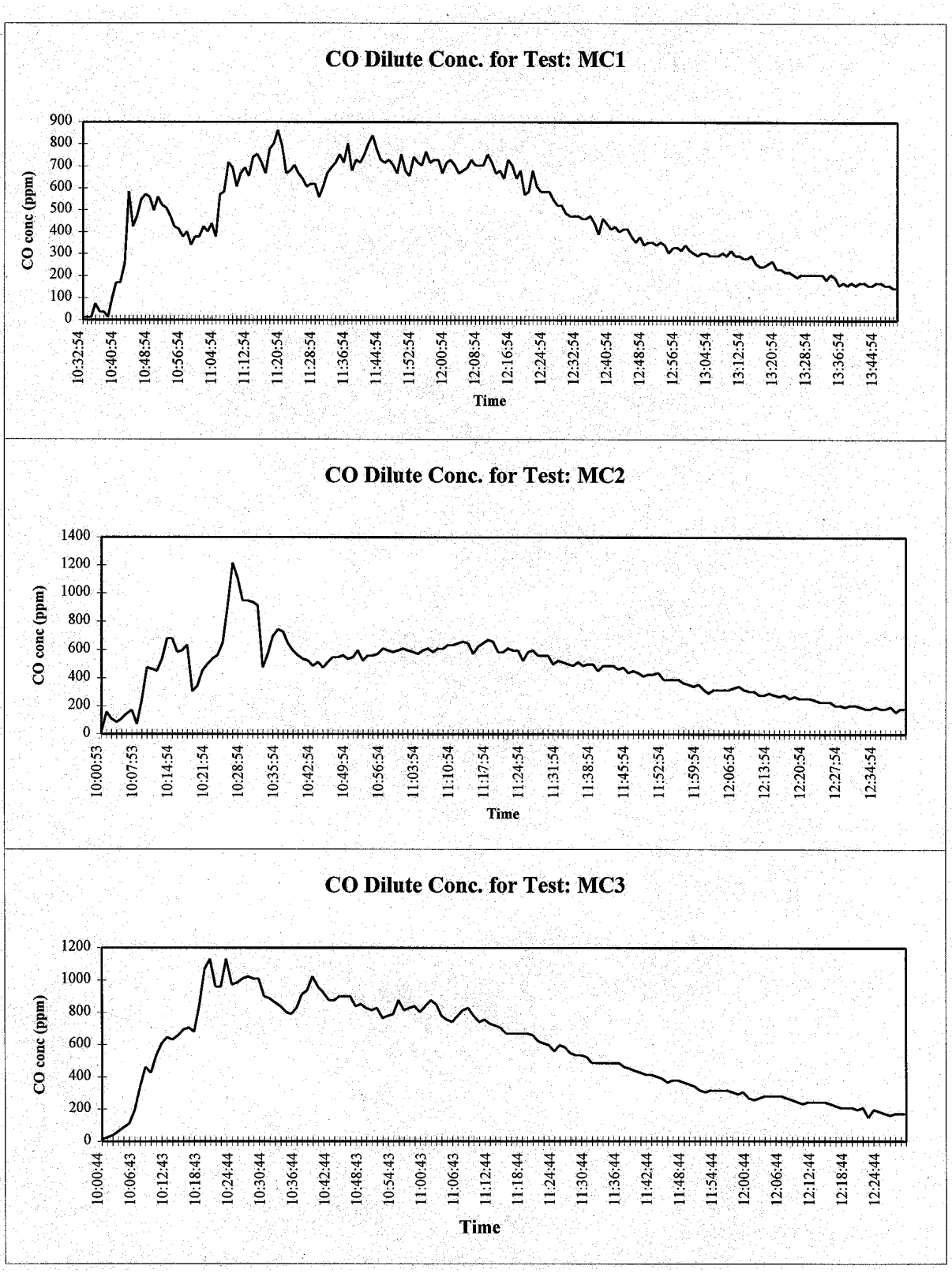
SOURCE: Whole Foods Charcoal / Beef wo Marinade / Control Device
DATE: 29-Sep-98
RUN: MC9
CONDITION:

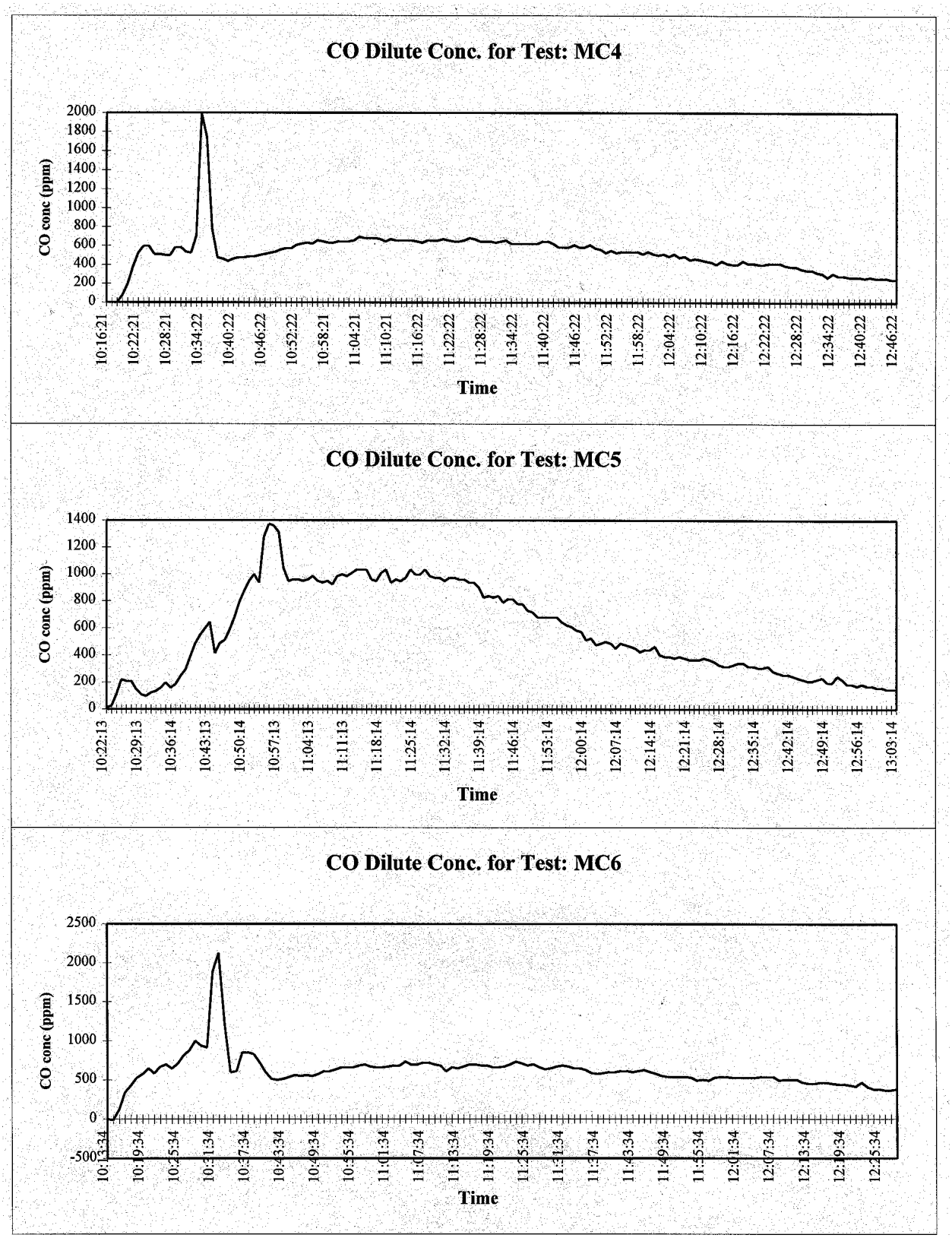
Sampling Data		Stage	Catch(mg)	% of Total	Cum. % Less Than	ECD µm
E-time=	94	1	2.0	5.2	94.8	10.2
Vm=	72.688	2	0.5	1.3	93.5	6.4
Pb=	29.6	3	0.7	1.8	91.6	4.3
Ts=	150.8	4	0.9	2.3	89.3	3.0
Pstat=	-4	5	0.5	1.3	88.0	1.9
Tm=	105.3	6	1.7	4.4	83.6	0.9
Delta h=	1.8	7	2.1	5.5	78.1	0.57
Delta p=	0.50	8	5.1	13.3	64.8	0.39
Dn=	0.25	Backup	24.8	64.8	0.0	
Y=	0.981	Total	38.3	100.0	-	-
% Isokin=	97.8					
Imp ACFM=	0.86					

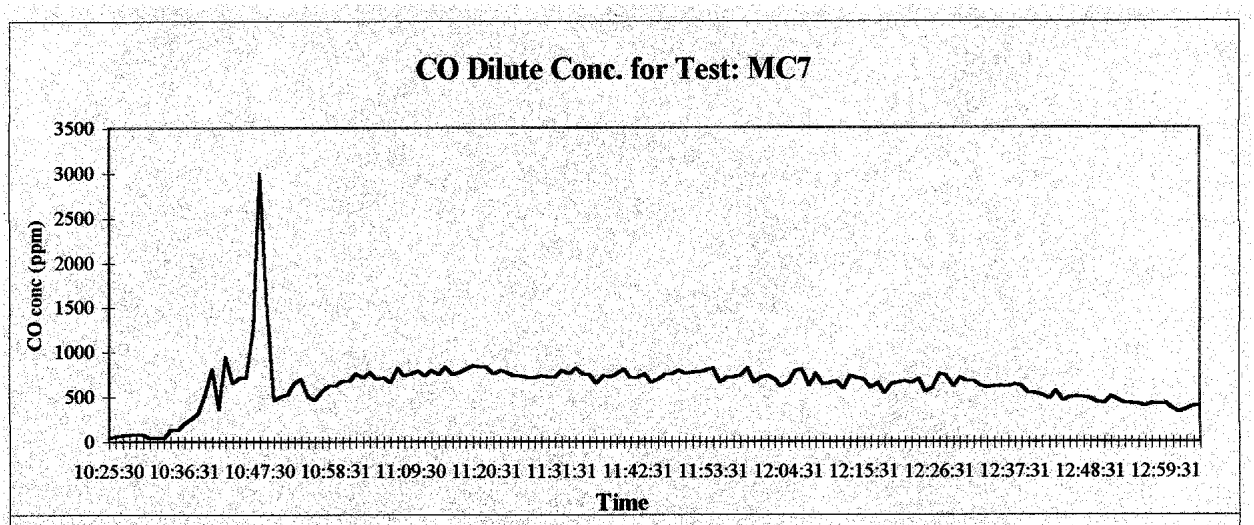


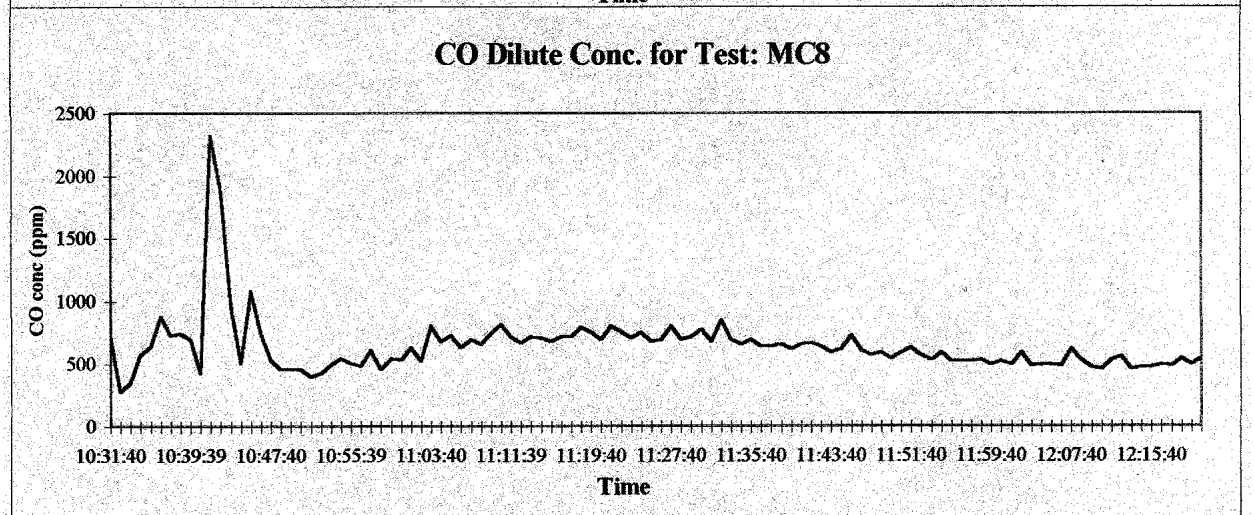
APPENDIX G

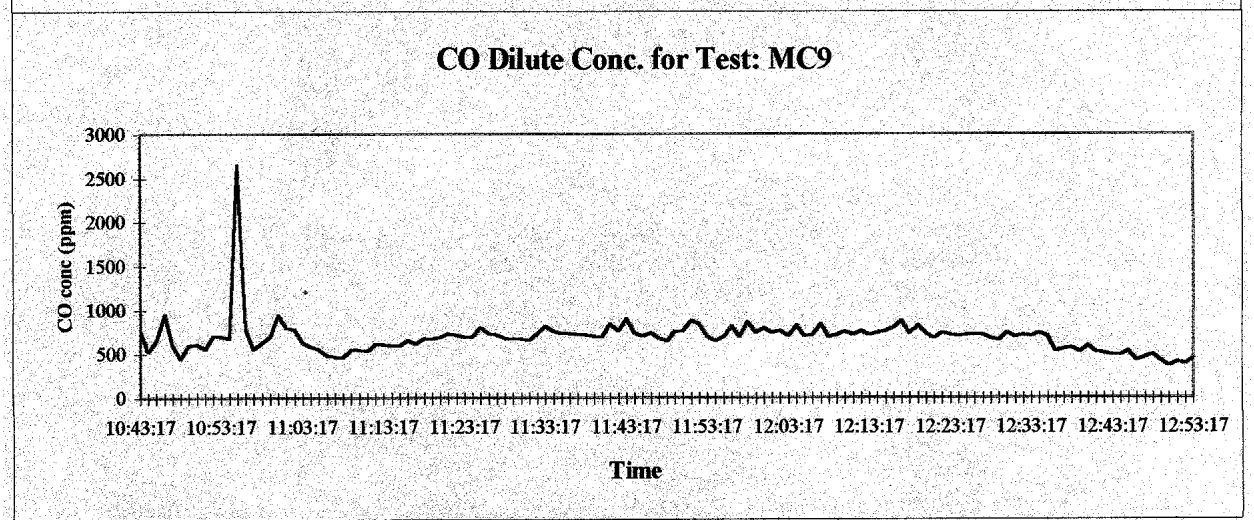
CEM Concentration Data During the Test Run

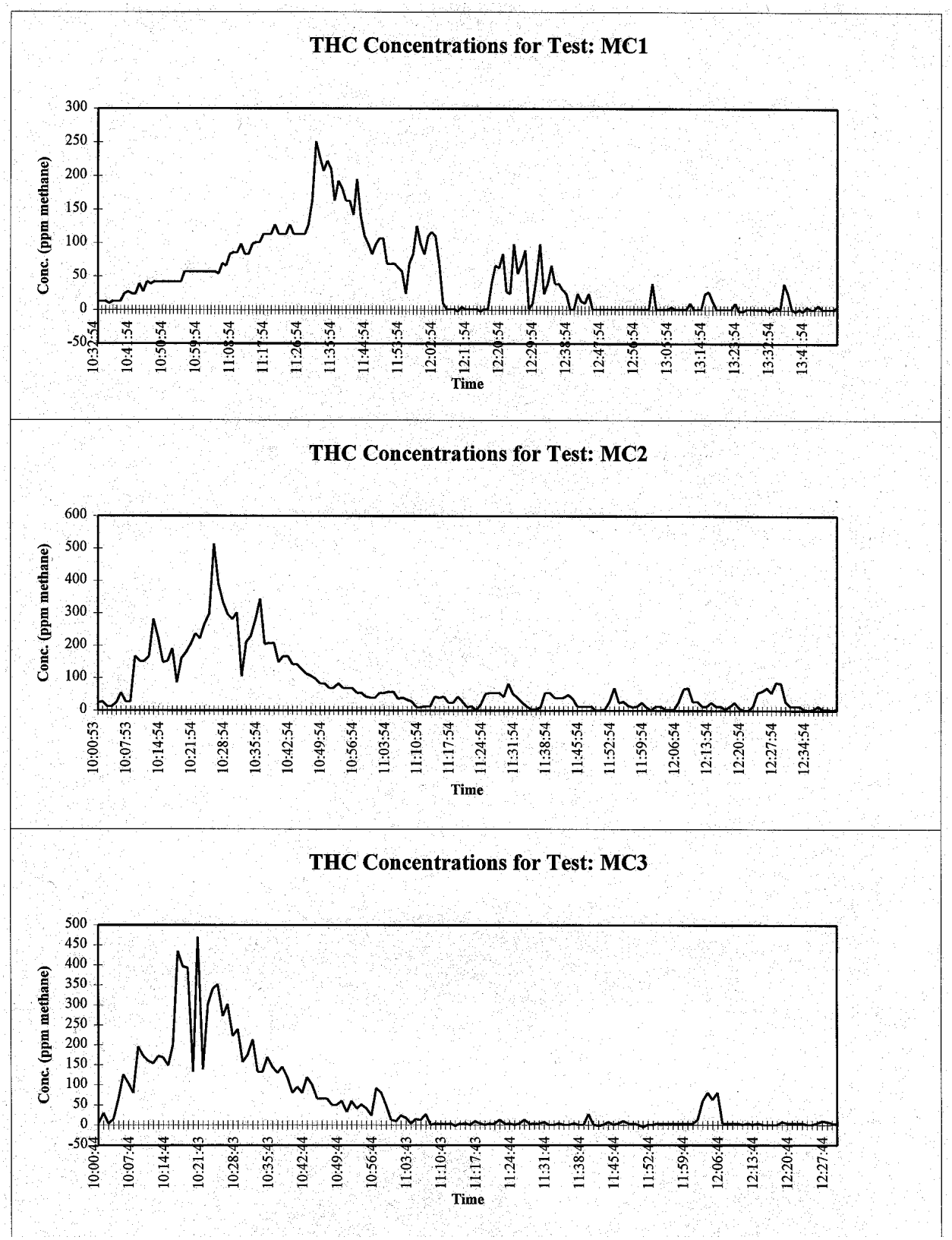

CO Dilute Conc. for Test: MC1
CO conc (ppm)
900
800
700
600
500
400
300
200
100
0
10:32:54
10:40:54
10:48:54
10:56:54
11:04:54
11:12:54
11:20:54
11:28:54
11:36:54
11:44:54
11:52:54
12:00:54
12:08:54
12:16:54
12:24:54
12:32:54
12:40:54
12:48:54
12:56:54
13:04:54
13:12:54
13:20:54
13:28:54
13:36:54
13:44:54
Time
CO Dilute Conc. for Test: MC2
CO conc (ppm)
1400
1200
1000
800
600
400
200
0
10:00:53
10:07:53
10:14:54
10:21:54
10:28:54
10:35:54
10:42:54
10:49:54
10:56:54
11:03:54
11:10:54
11:17:54
11:24:54
11:31:54
11:38:54
11:45:54
11:52:54
11:59:54
12:06:54
12:13:54
12:20:54
12:27:54
12:34:54
Time
CO Dilute Conc. for Test: MC3
CO conc (ppm)
1200
1000
800
600
400
200
0
10:00:44
10:06:43
10:12:43
10:18:43
10:24:44
10:30:44
10:36:44
10:42:44
10:48:43
10:54:43
11:00:43
11:06:43
11:12:44
11:18:44
11:24:44
11:30:44
11:36:44
11:42:44
11:48:44
11:54:44
12:00:44
12:06:44
12:12:44
12:18:44
12:24:44
Time

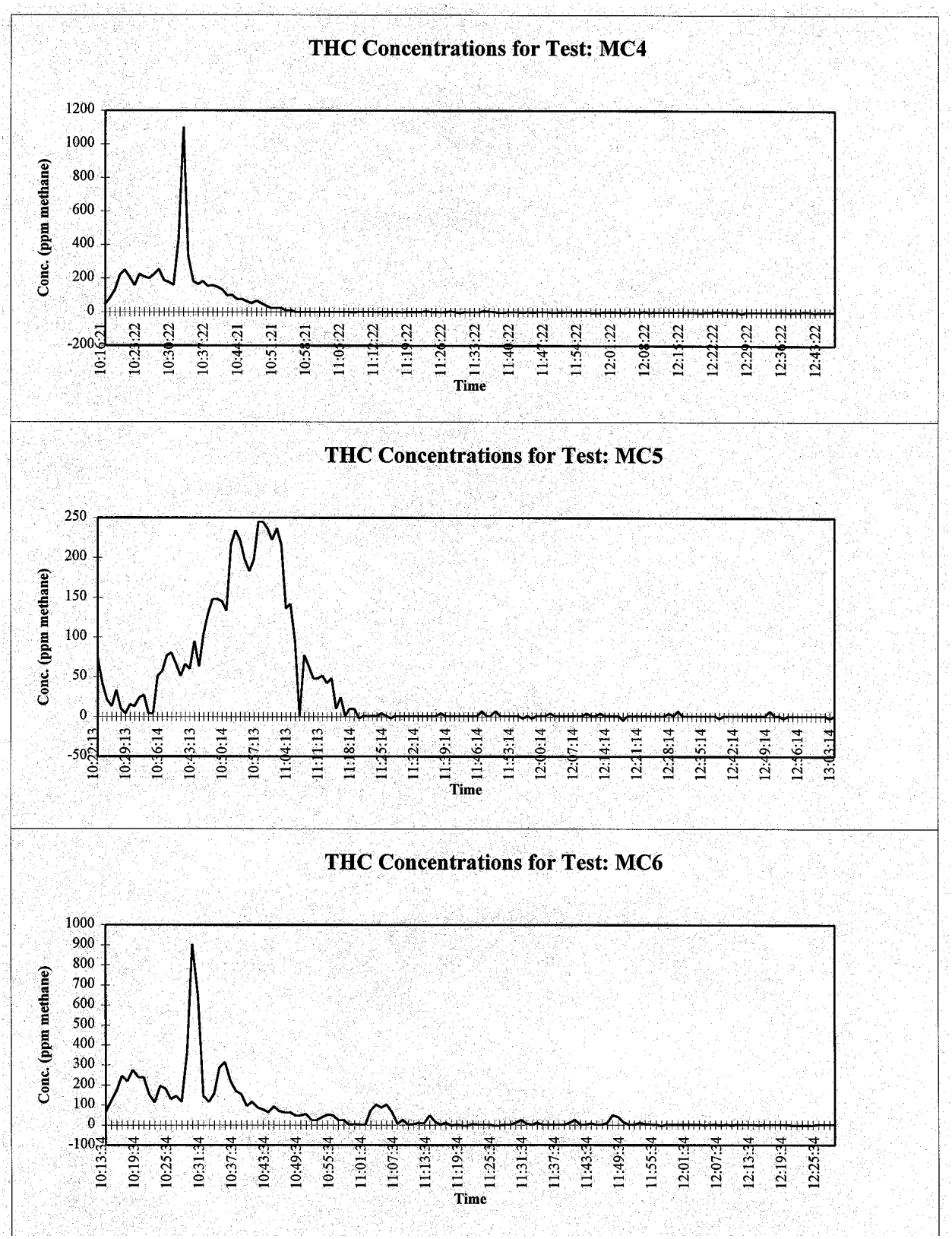

CO Dilute Conc. for Test: MC4
CO conc (ppm)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
10:16:21
10:22:21
10:28:21
10:34:22
10:40:22
10:46:22
10:52:22
10:58:21
11:04:21
11:10:21
11:16:22
11:22:22
11:28:22
11:34:22
11:40:22
11:46:22
11:52:22
11:58:22
12:04:22
12:10:22
12:16:22
12:22:22
12:28:22
12:34:22
12:40:22
12:46:22
Time
CO Dilute Conc. for Test: MC5
CO conc (ppm)
1400
1200
1000
800
600
400
200
0
10:22:13
10:29:13
10:36:14
10:43:13
10:50:14
10:57:13
11:04:13
11:11:13
11:18:14
11:25:14
11:32:14
11:39:14
11:46:14
11:53:14
12:00:14
12:07:14
12:14:14
12:21:14
12:28:14
12:35:14
12:42:14
12:49:14
12:56:14
13:03:14
Time
CO Dilute Conc. for Test: MC6
CO conc (ppm)
2500
2000
1500
1000
500
0
-500
10:13:34
10:19:34
10:25:34
10:31:34
10:37:34
10:43:34
10:49:34
10:55:34
11:01:34
11:07:34
11:13:34
11:19:34
11:25:34
11:31:34
11:37:34
11:43:34
11:49:34
11:55:34
12:01:34
12:07:34
12:13:34
12:19:34
12:25:34
Time

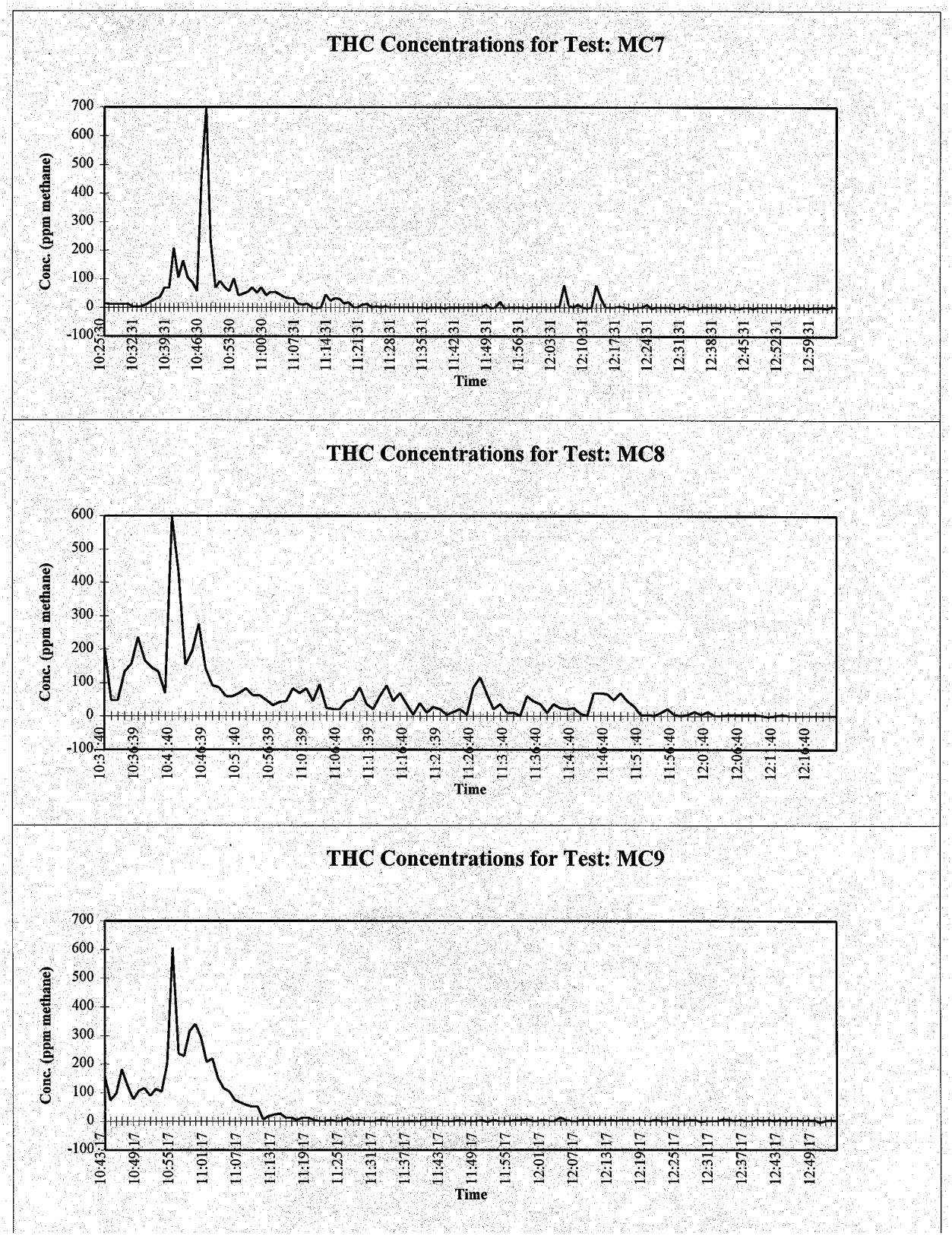

CO Dilute Conc. for Test: MC7
CO conc (ppm)
3500
3000
2500
2000
1500
1000
500
0
10:25:30 10:36:31 10:47:30 10:58:31 11:09:30 11:20:31 11:31:31 11:42:31 11:53:31 12:04:31 12:15:31 12:26:31 12:37:31 12:48:31 12:59:31
Time

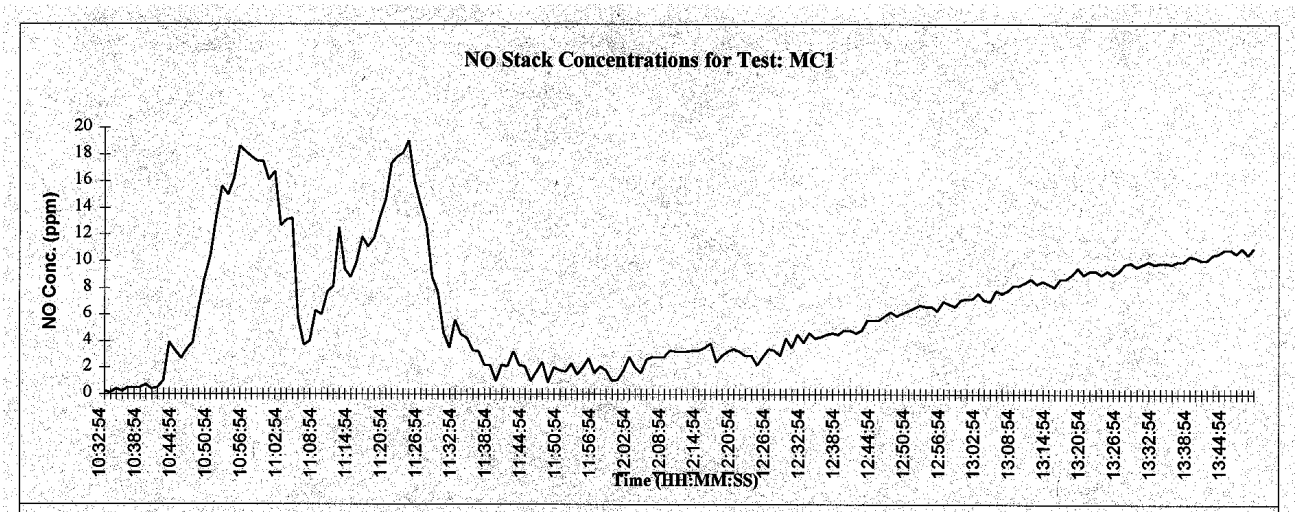

CO Dilute Conc. for Test: MC8
CO conc (ppm)
2500
2000
1500
1000
500
0
10:31:40 10:39:39 10:47:40 10:55:39 11:03:40 11:11:39 11:19:40 11:27:40 11:35:40 11:43:40 11:51:40 11:59:40 12:07:40 12:15:40
Time

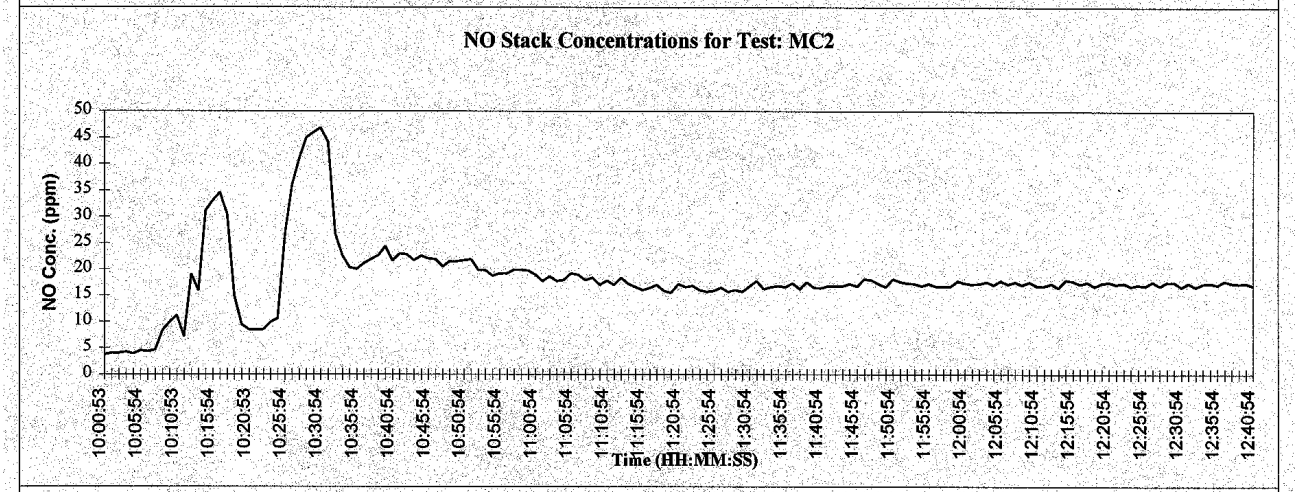

CO Dilute Conc. for Test: MC9
CO conc (ppm)
3000
2500
2000
1500
1000
500
0
10:43:17 10:53:17 11:03:17 11:13:17 11:23:17 11:33:17 11:43:17 11:53:17 12:03:17 12:13:17 12:23:17 12:33:17 12:43:17 12:53:17
Time

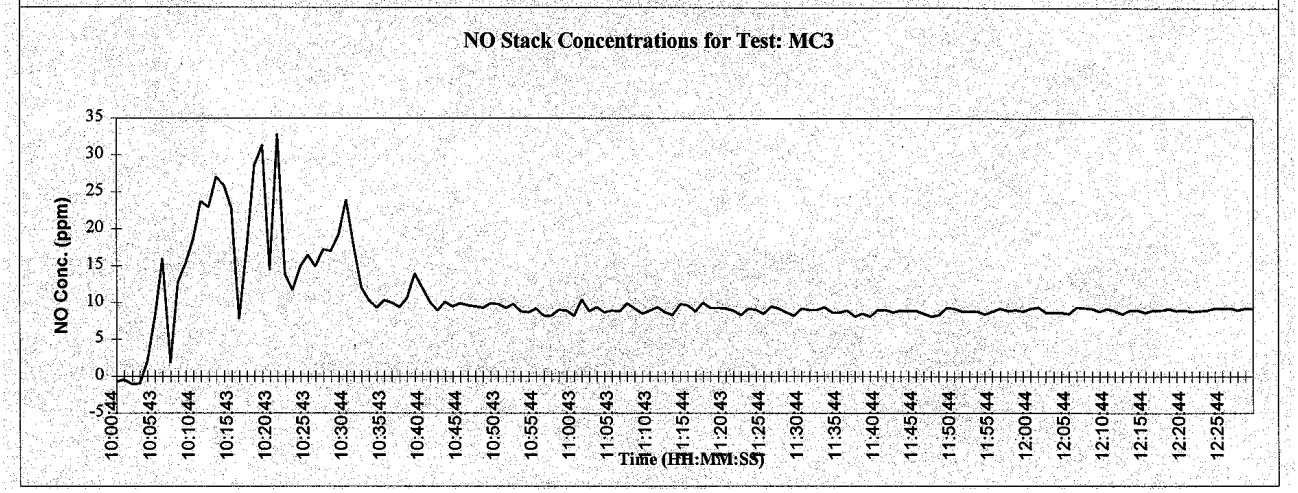

THC Concentrations for Test: MC1
Conc. (ppm methane)
300
250
200
150
100
50
0
-50
10:32:54
10:41:54
10:50:54
10:59:54
11:08:54
11:17:54
11:26:54
11:35:54
11:44:54
11:53:54
12:02:54
12:11:54
12:20:54
12:29:54
12:38:54
12:47:54
12:56:54
13:05:54
13:14:54
13:23:54
13:32:54
13:41:54
Time
THC Concentrations for Test: MC2
Conc. (ppm methane)
600
500
400
300
200
100
0
10:00:53
10:07:53
10:14:54
10:21:54
10:28:54
10:35:54
10:42:54
10:49:54
10:56:54
11:03:54
11:10:54
11:17:54
11:24:54
11:31:54
11:38:54
11:45:54
11:52:54
11:59:54
12:06:54
12:13:54
12:20:54
12:27:54
12:34:54
Time
THC Concentrations for Test: MC3
Conc. (ppm methane)
500
450
400
350
300
250
200
150
100
50
0
-50
10:00:44
10:07:44
10:14:44
10:21:43
10:28:43
10:35:43
10:42:44
10:49:44
10:56:44
11:03:43
11:10:43
11:17:43
11:24:44
11:31:44
11:38:44
11:45:44
11:52:44
11:59:44
12:06:44
12:13:44
12:20:44
12:27:44
Time

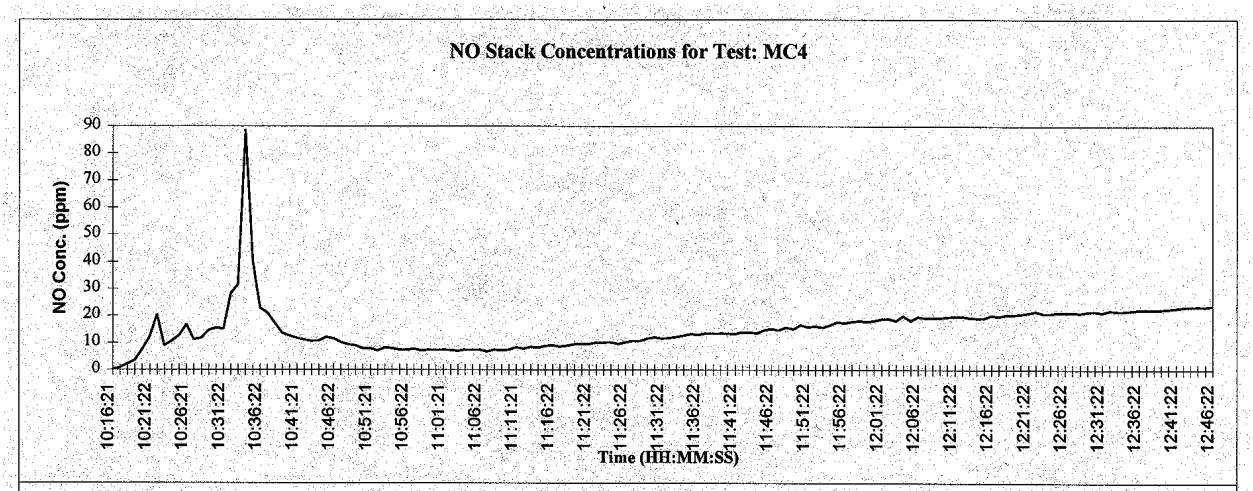

THC Concentrations for Test: MC4
Conc. (ppm methane)
1200
1000
800
600
400
200
0
-200
10:16:21
10:23:22
10:30:22
10:37:22
10:44:21
10:51:21
10:58:21
11:05:22
11:12:22
11:19:22
11:26:22
11:33:22
11:40:22
11:47:22
11:54:22
12:01:22
12:08:22
12:15:22
12:22:22
12:29:22
12:36:22
12:43:22
Time
THC Concentrations for Test: MC5
Conc. (ppm methane)
250
200
150
100
50
0
-50
10:22:13
10:29:13
10:36:14
10:43:13
10:50:14
10:57:13
11:04:13
11:11:13
11:18:14
11:25:14
11:32:14
11:39:14
11:46:14
11:53:14
12:00:14
12:07:14
12:14:14
12:21:14
12:28:14
12:35:14
12:42:14
12:49:14
12:56:14
13:03:14
Time
THC Concentrations for Test: MC6
Conc. (ppm methane)
1000
900
800
700
600
500
400
300
200
100
0
-100
10:13:34
10:19:34
10:25:34
10:31:34
10:37:34
10:43:34
10:49:34
10:55:34
11:01:34
11:07:34
11:13:34
11:19:34
11:25:34
11:31:34
11:37:34
11:43:34
11:49:34
11:55:34
12:01:34
12:07:34
12:13:34
12:19:34
12:25:34
Time

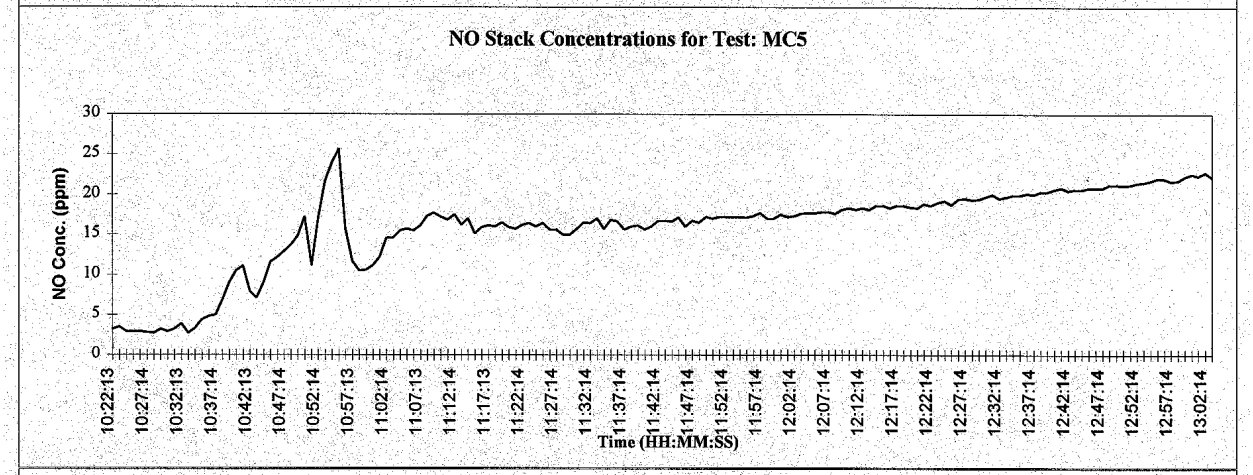

THC Concentrations for Test: MC7
Conc. (ppm methane)
Time
THC Concentrations for Test: MC8
Conc. (ppm methane)
Time
THC Concentrations for Test: MC9
Conc. (ppm methane)
Time

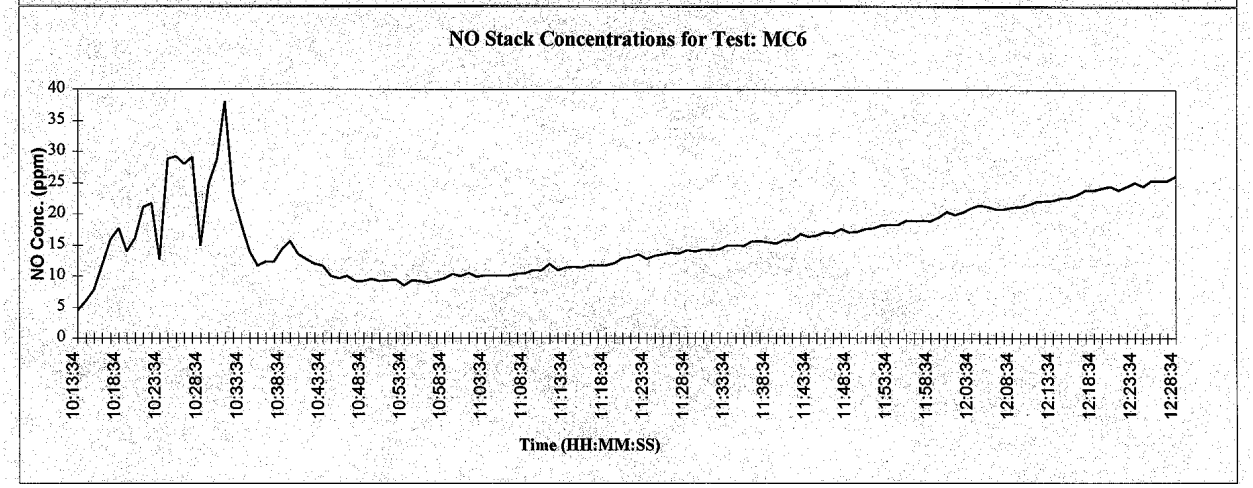

NO Stack Concentrations for Test: MC1
NO Conc. (ppm)
Time (HH:MM:SS)

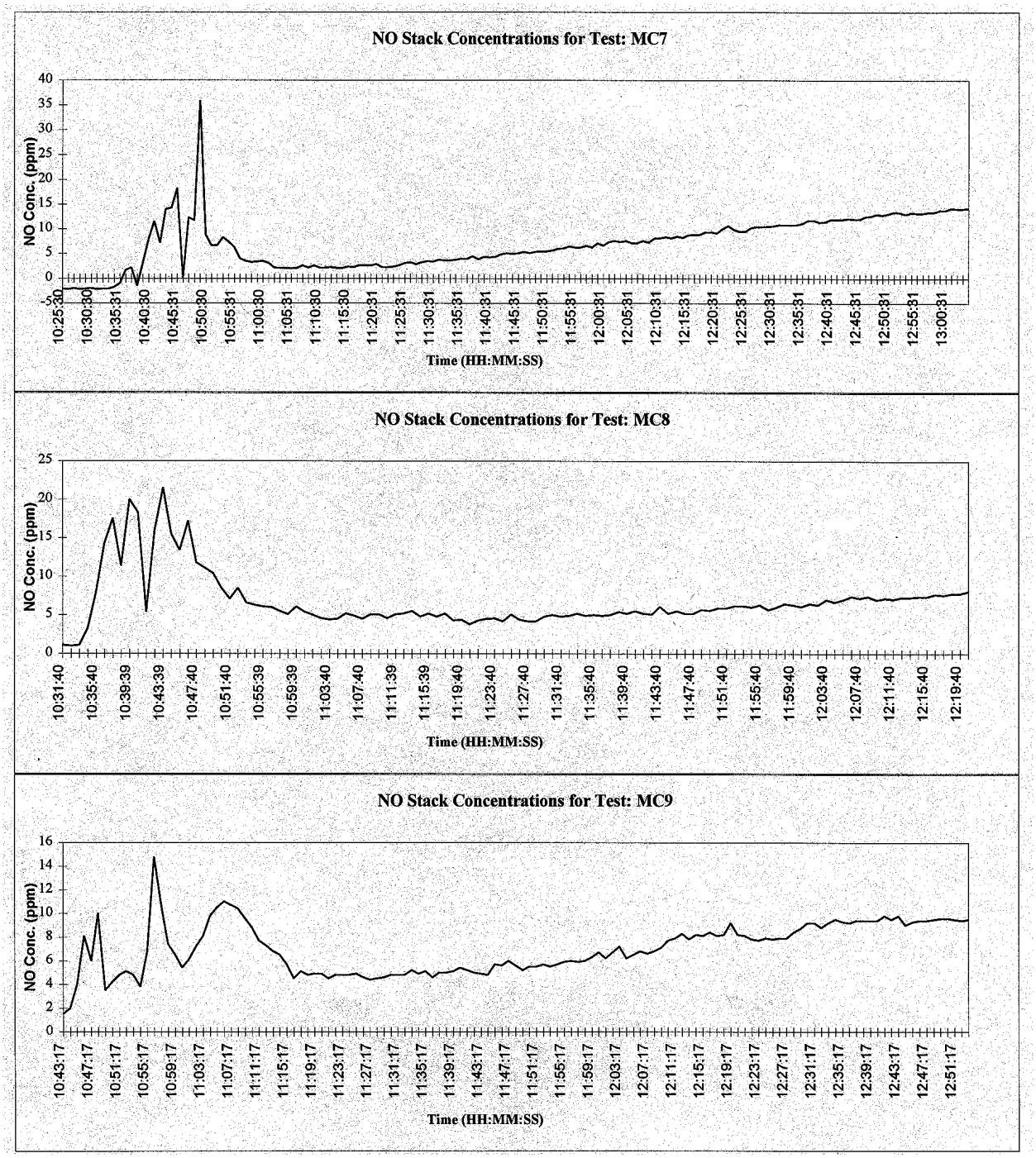

NO Stack Concentrations for Test: MC2
NO Conc. (ppm)
Time (HH:MM:SS)

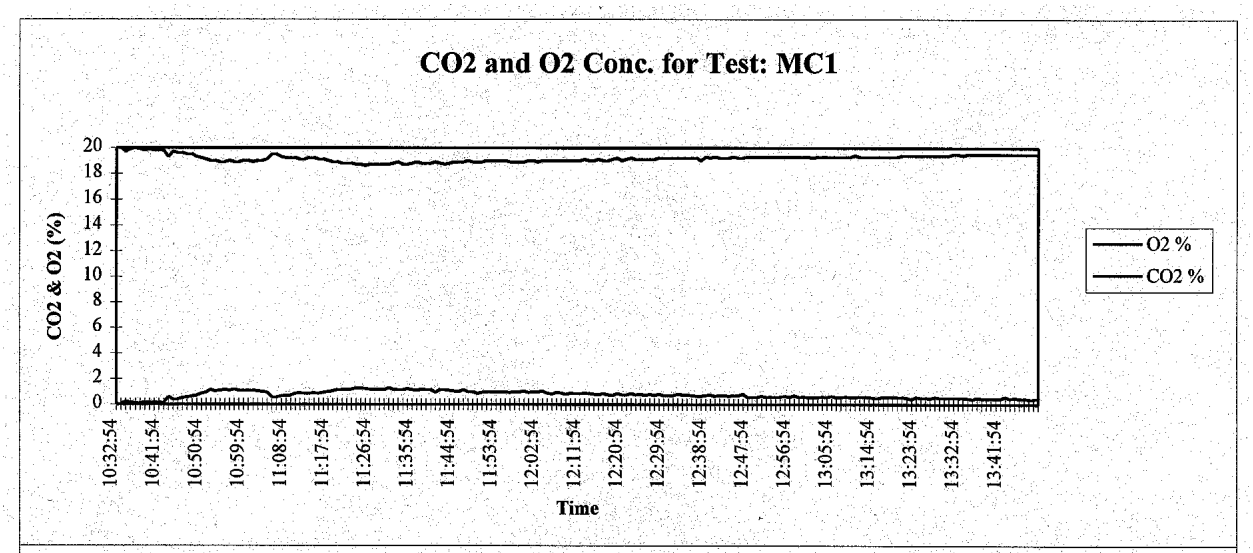

NO Stack Concentrations for Test: MC3
NO Conc. (ppm)
Time (HH:MM:SS)

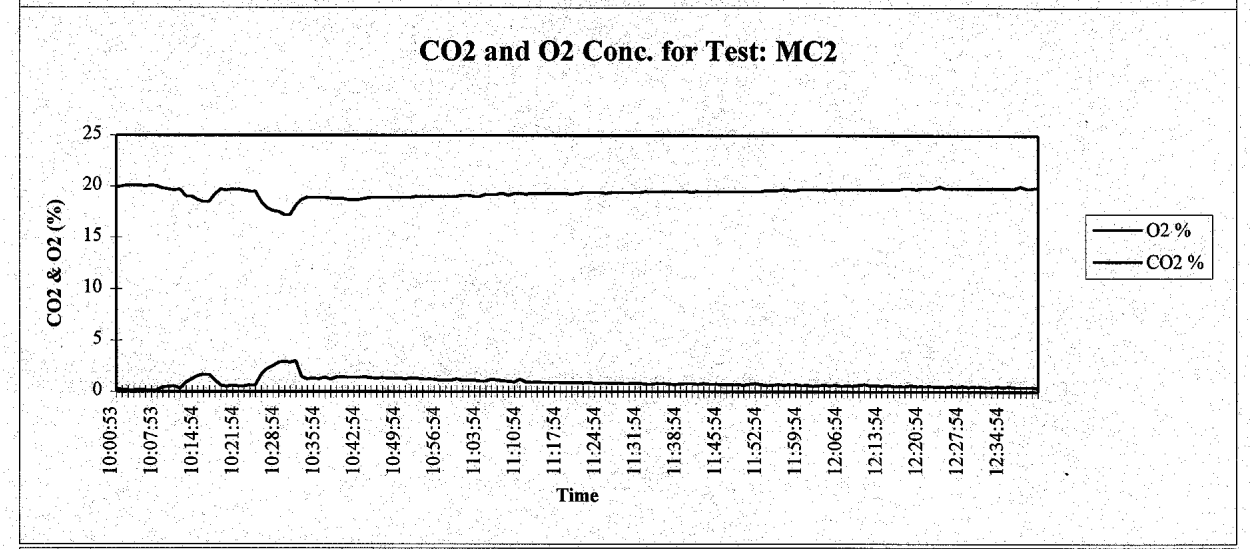

NO Stack Concentrations for Test: MC4
NO Conc. (ppm)
0
10
20
30
40
50
60
70
80
90
10:16:21
10:21:22
10:26:21
10:31:22
10:36:22
10:41:21
10:46:22
10:51:21
10:56:22
11:01:21
11:06:22
11:11:21
11:16:22
11:21:22
11:26:22
11:31:22
11:36:22
11:41:22
11:46:22
11:51:22
11:56:22
12:01:22
12:06:22
12:11:22
12:16:22
12:21:22
12:26:22
12:31:22
12:36:22
12:41:22
12:46:22
Time (HH:MM:SS)

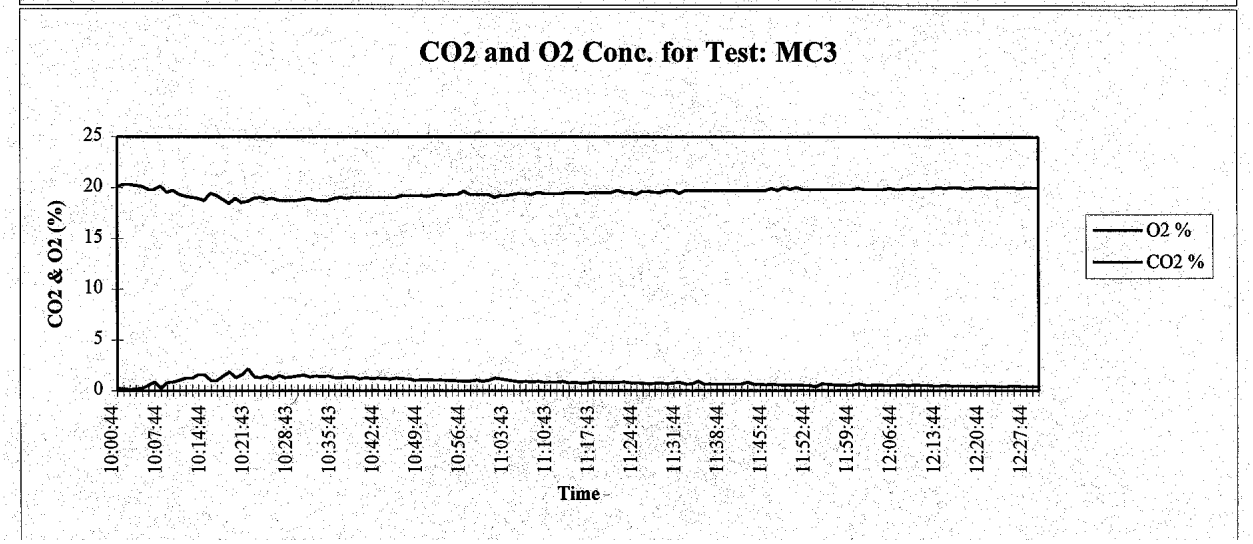

NO Stack Concentrations for Test: MC5
NO Conc. (ppm)
0
5
10
15
20
25
30
10:22:13
10:27:14
10:32:13
10:37:14
10:42:13
10:47:14
10:52:14
10:57:13
11:02:14
11:07:13
11:12:14
11:17:13
11:22:14
11:27:14
11:32:14
11:37:14
11:42:14
11:47:14
11:52:14
11:57:14
12:02:14
12:07:14
12:12:14
12:17:14
12:22:14
12:27:14
12:32:14
12:37:14
12:42:14
12:47:14
12:52:14
12:57:14
13:02:14
Time (HH:MM:SS)

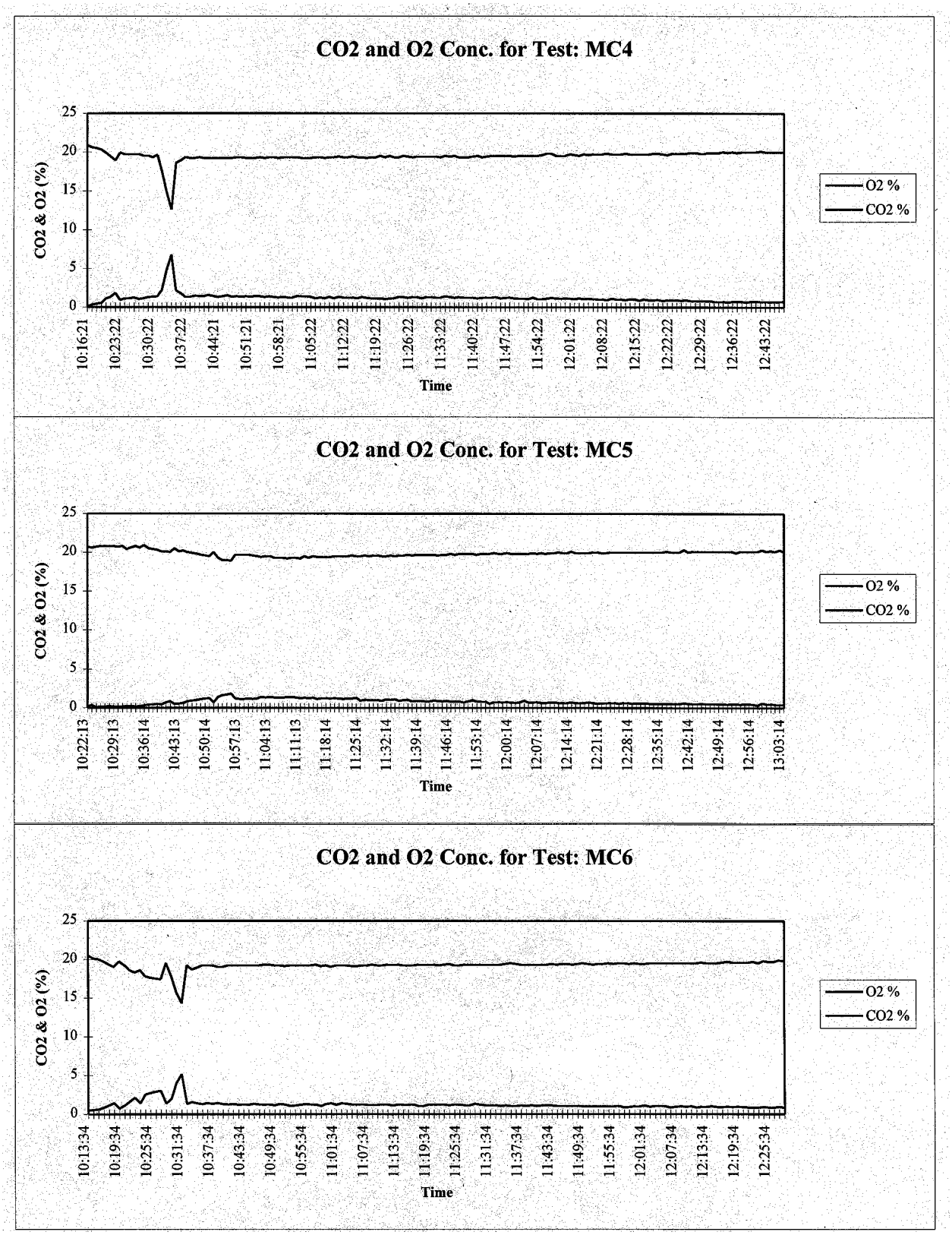

NO Stack Concentrations for Test: MC6
NO Conc. (ppm)
0
5
10
15
20
25
30
35
40
10:13:34
10:18:34
10:23:34
10:28:34
10:33:34
10:38:34
10:43:34
10:48:34
10:53:34
10:58:34
11:03:34
11:08:34
11:13:34
11:18:34
11:23:34
11:28:34
11:33:34
11:38:34
11:43:34
11:48:34
11:53:34
11:58:34
12:03:34
12:08:34
12:13:34
12:18:34
12:23:34
12:28:34
Time (HH:MM:SS)

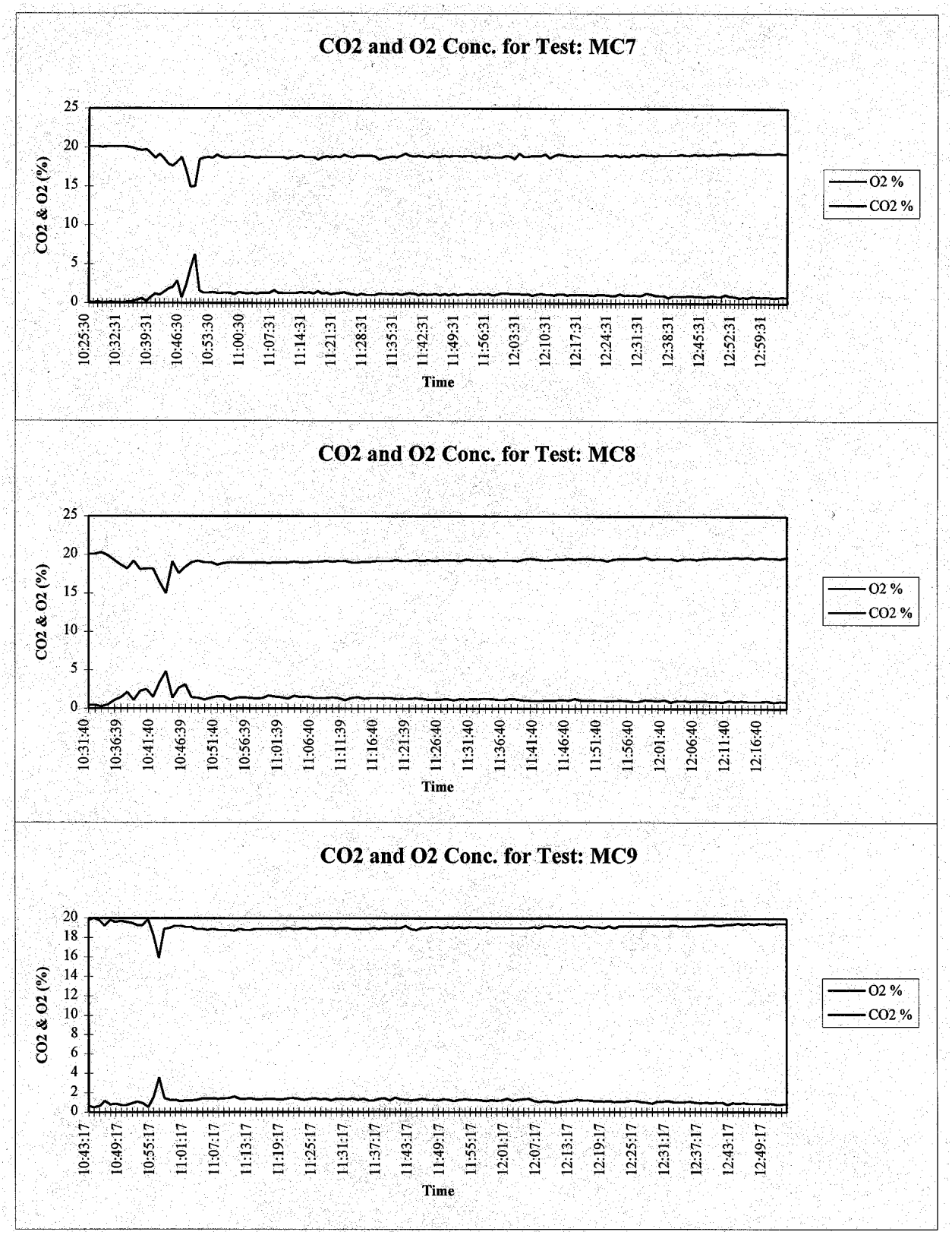

NO Stack Concentrations for Test: MC7
NO Conc. (ppm)
Time (HH:MM:SS)
NO Stack Concentrations for Test: MC8
NO Conc. (ppm)
Time (HH:MM:SS)
NO Stack Concentrations for Test: MC9
NO Conc. (ppm)
Time (HH:MM:SS)

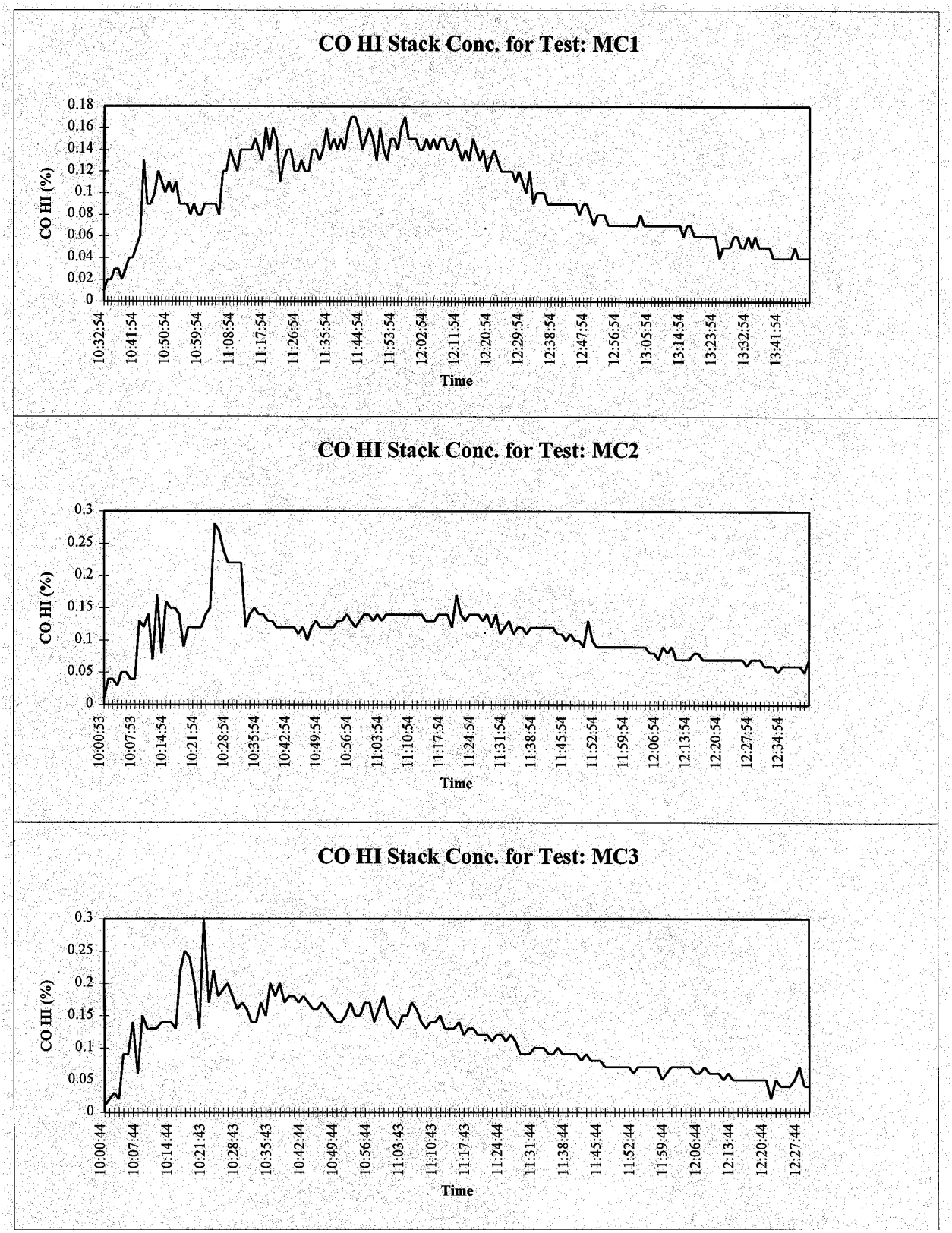

CO2 and O2 Conc. for Test: MC1
CO2 & O2 (%)
20
18
16
14
12
10
8
6
4
2
0
10:32:54
10:41:54
10:50:54
10:59:54
11:08:54
11:17:54
11:26:54
11:35:54
11:44:54
11:53:54
12:02:54
12:11:54
12:20:54
12:29:54
12:38:54
12:47:54
12:56:54
13:05:54
13:14:54
13:23:54
13:32:54
13:41:54
Time
O2 %
CO2 %

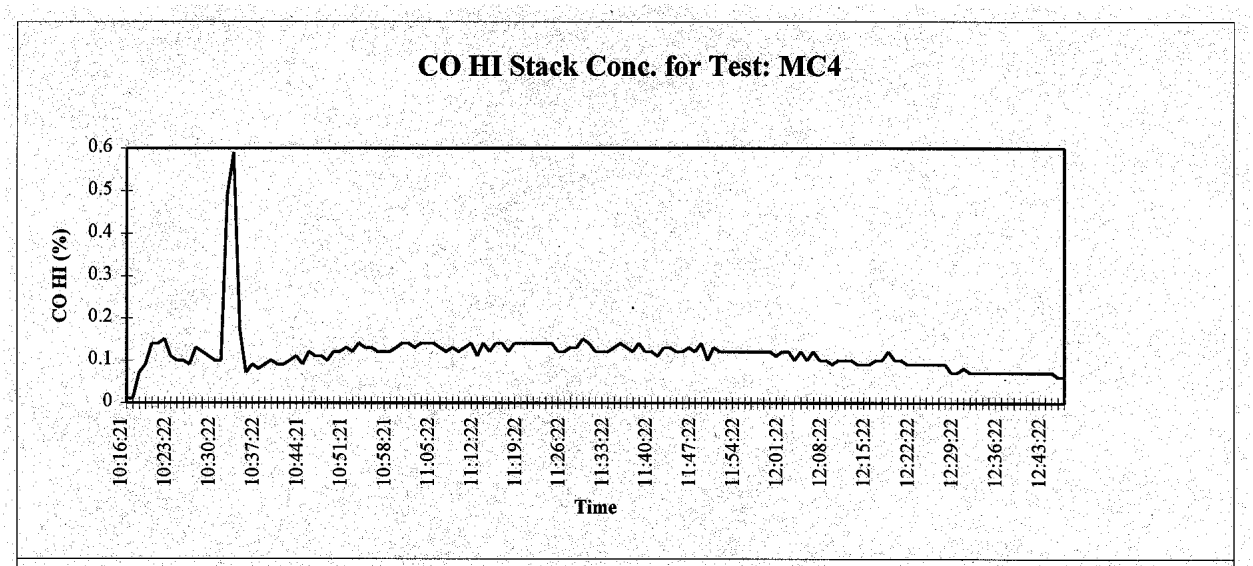

CO2 and O2 Conc. for Test: MC2
CO2 & O2 (%)
25
20
15
10
5
0
10:00:53
10:07:53
10:14:54
10:21:54
10:28:54
10:35:54
10:42:54
10:49:54
10:56:54
11:03:54
11:10:54
11:17:54
11:24:54
11:31:54
11:38:54
11:45:54
11:52:54
11:59:54
12:06:54
12:13:54
12:20:54
12:27:54
12:34:54
Time
O2 %
CO2 %

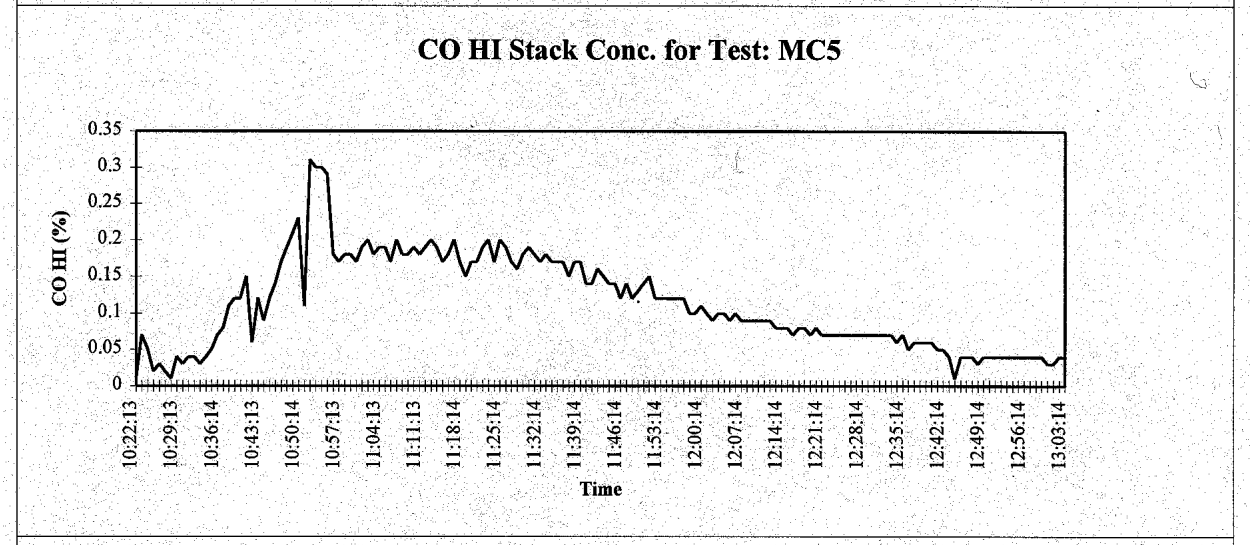

CO2 and O2 Conc. for Test: MC3
CO2 & O2 (%)
25
20
15
10
5
0
10:00:44
10:07:44
10:14:44
10:21:43
10:28:43
10:35:43
10:42:44
10:49:44
10:56:44
11:03:43
11:10:43
11:17:43
11:24:44
11:31:44
11:38:44
11:45:44
11:52:44
11:59:44
12:06:44
12:13:44
12:20:44
12:27:44
Time
O2 %
CO2 %

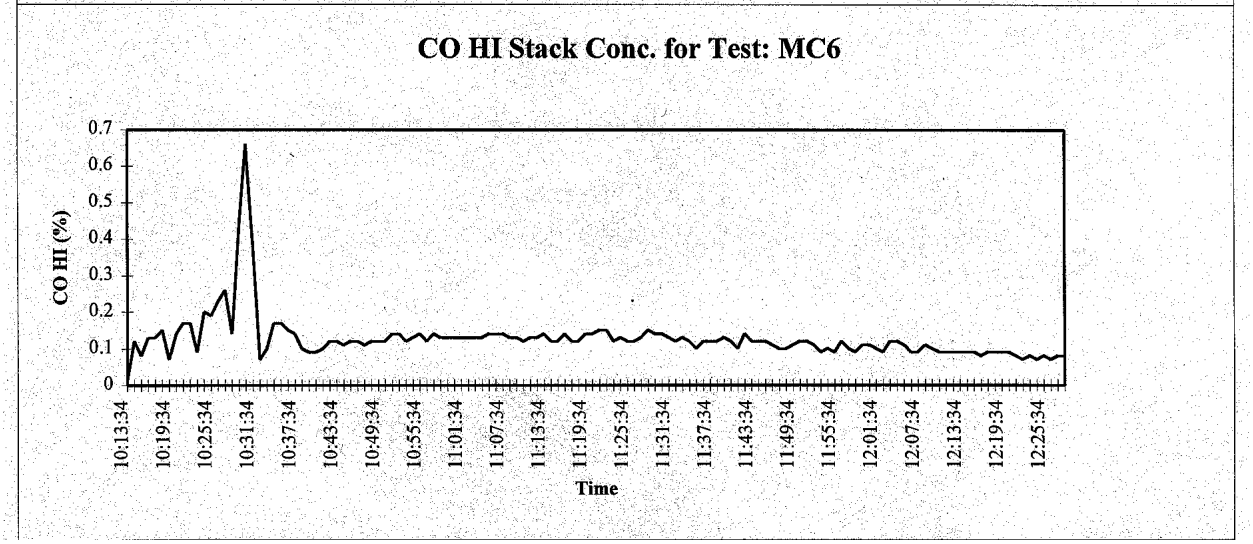

CO2 and O2 Conc. for Test: MC4
CO2 & O2 (%)
25
20
15
10
5
0
10:16:21
10:23:22
10:30:22
10:37:22
10:44:21
10:51:21
10:58:21
11:05:22
11:12:22
11:19:22
11:26:22
11:33:22
11:40:22
11:47:22
11:54:22
12:01:22
12:08:22
12:15:22
12:22:22
12:29:22
12:36:22
12:43:22
Time
O2 %
CO2 %
CO2 and O2 Conc. for Test: MC5
CO2 & O2 (%)
25
20
15
10
5
0
10:22:13
10:29:13
10:36:14
10:43:13
10:50:14
10:57:13
11:04:13
11:11:13
11:18:14
11:25:14
11:32:14
11:39:14
11:46:14
11:53:14
12:00:14
12:07:14
12:14:14
12:21:14
12:28:14
12:35:14
12:42:14
12:49:14
12:56:14
13:03:14
Time
O2 %
CO2 %
CO2 and O2 Conc. for Test: MC6
CO2 & O2 (%)
25
20
15
10
5
0
10:13:34
10:19:34
10:25:34
10:31:34
10:37:34
10:43:34
10:49:34
10:55:34
11:01:34
11:07:34
11:13:34
11:19:34
11:25:34
11:31:34
11:37:34
11:43:34
11:49:34
11:55:34
12:01:34
12:07:34
12:13:34
12:19:34
12:25:34
Time
O2 %
CO2 %

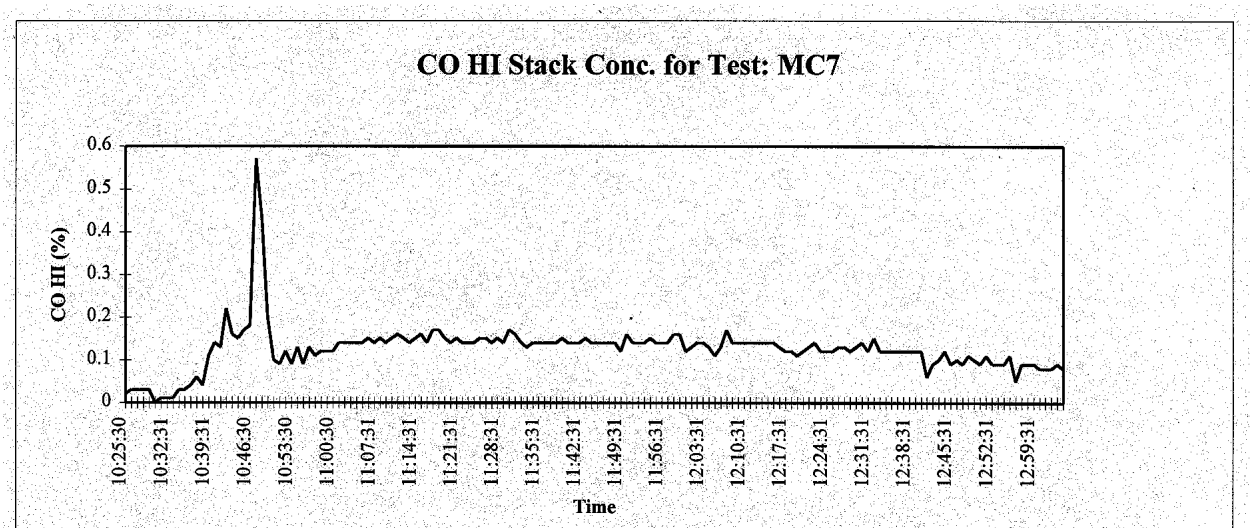

CO2 and O2 Conc. for Test: MC7
CO2 & O2 (%)
25
20
15
10
5
0
10:25:30
10:32:31
10:39:31
10:46:30
10:53:30
11:00:30
11:07:31
11:14:31
11:21:31
11:28:31
11:35:31
11:42:31
11:49:31
11:56:31
12:03:31
12:10:31
12:17:31
12:24:31
12:31:31
12:38:31
12:45:31
12:52:31
12:59:31
Time
O2 %
CO2 %
CO2 and O2 Conc. for Test: MC8
CO2 & O2 (%)
25
20
15
10
5
0
10:31:40
10:36:39
10:41:40
10:46:39
10:51:40
10:56:39
11:01:39
11:06:40
11:11:39
11:16:40
11:21:39
11:26:40
11:31:40
11:36:40
11:41:40
11:46:40
11:51:40
11:56:40
12:01:40
12:06:40
12:11:40
12:16:40
Time
O2 %
CO2 %
CO2 and O2 Conc. for Test: MC9
CO2 & O2 (%)
20
18
16
14
12
10
8
6
4
2
0
10:43:17
10:49:17
10:55:17
11:01:17
11:07:17
11:13:17
11:19:17
11:25:17
11:31:17
11:37:17
11:43:17
11:49:17
11:55:17
12:01:17
12:07:17
12:13:17
12:19:17
12:25:17
12:31:17
12:37:17
12:43:17
12:49:17
Time
O2 %
CO2 %

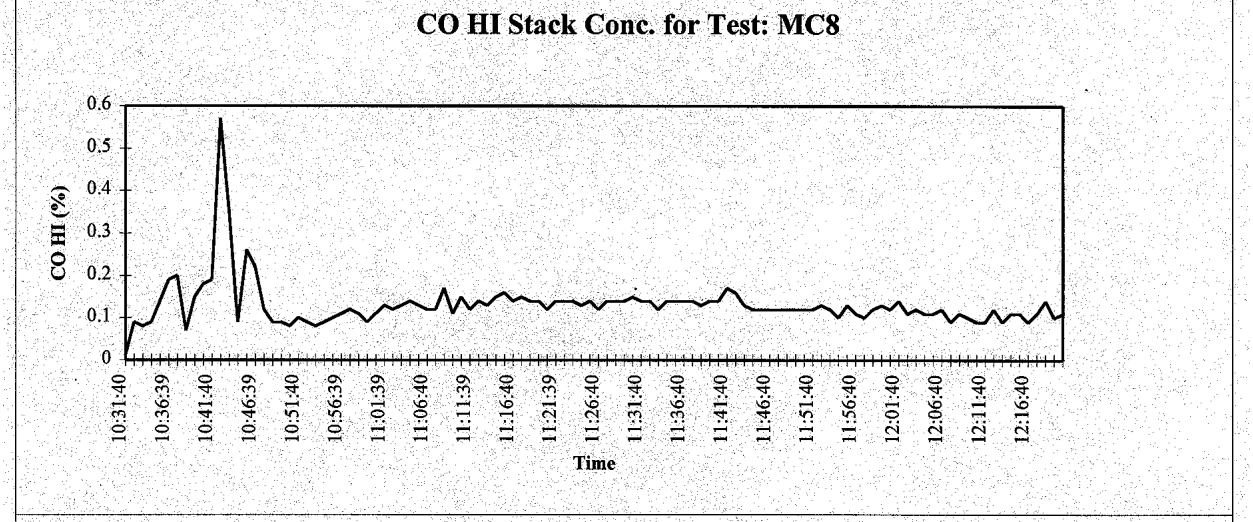

CO HI Stack Conc. for Test: MC1
CO HI (%)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10:32:54
10:41:54
10:50:54
10:59:54
11:08:54
11:17:54
11:26:54
11:35:54
11:44:54
11:53:54
12:02:54
12:11:54
12:20:54
12:29:54
12:38:54
12:47:54
12:56:54
13:05:54
13:14:54
13:23:54
13:32:54
13:41:54
Time
CO HI Stack Conc. for Test: MC2
CO HI (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
10:00:53
10:07:53
10:14:54
10:21:54
10:28:54
10:35:54
10:42:54
10:49:54
10:56:54
11:03:54
11:10:54
11:17:54
11:24:54
11:31:54
11:38:54
11:45:54
11:52:54
11:59:54
12:06:54
12:13:54
12:20:54
12:27:54
12:34:54
Time
CO HI Stack Conc. for Test: MC3
CO HI (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
10:00:44
10:07:44
10:14:44
10:21:43
10:28:43
10:35:43
10:42:44
10:49:44
10:56:44
11:03:43
11:10:43
11:17:43
11:24:44
11:31:44
11:38:44
11:45:44
11:52:44
11:59:44
12:06:44
12:13:44
12:20:44
12:27:44
Time

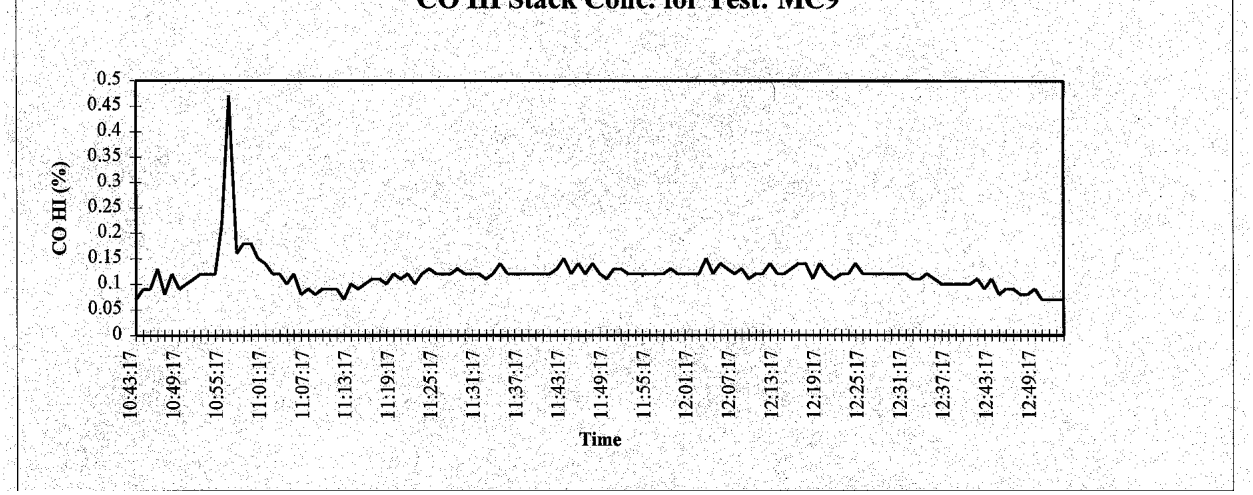

CO HI Stack Conc. for Test: MC4
CO HI (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
10:16:21
10:23:22
10:30:22
10:37:22
10:44:21
10:51:21
10:58:21
11:05:22
11:12:22
11:19:22
11:26:22
11:33:22
11:40:22
11:47:22
11:54:22
12:01:22
12:08:22
12:15:22
12:22:22
12:29:22
12:36:22
12:43:22
Time

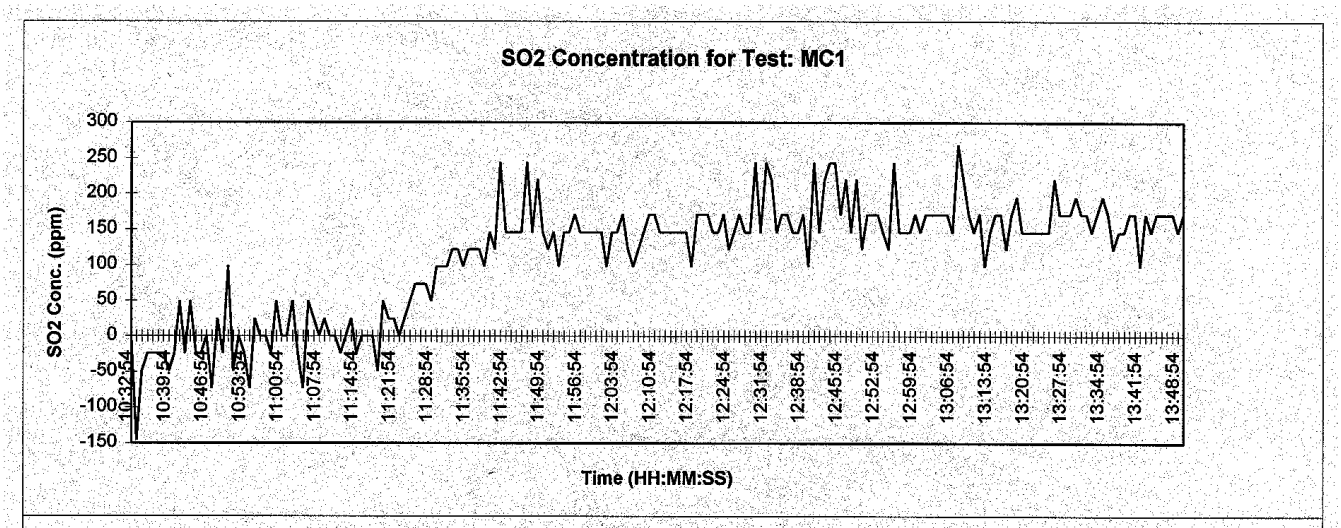

CO HI Stack Conc. for Test: MC5
CO HI (%)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10:22:13
10:29:13
10:36:14
10:43:13
10:50:14
10:57:13
11:04:13
11:11:13
11:18:14
11:25:14
11:32:14
11:39:14
11:46:14
11:53:14
12:00:14
12:07:14
12:14:14
12:21:14
12:28:14
12:35:14
12:42:14
12:49:14
12:56:14
13:03:14
Time

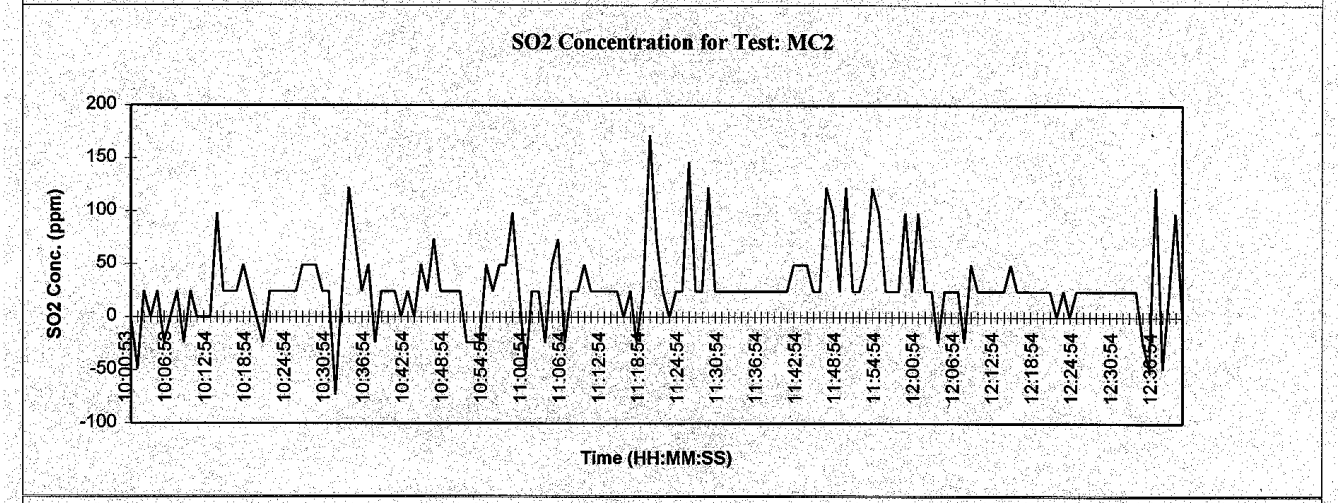

CO HI Stack Conc. for Test: MC6
CO HI (%)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10:13:34
10:19:34
10:25:34
10:31:34
10:37:34
10:43:34
10:49:34
10:55:34
11:01:34
11:07:34
11:13:34
11:19:34
11:25:34
11:31:34
11:37:34
11:43:34
11:49:34
11:55:34
12:01:34
12:07:34
12:13:34
12:19:34
12:25:34
Time

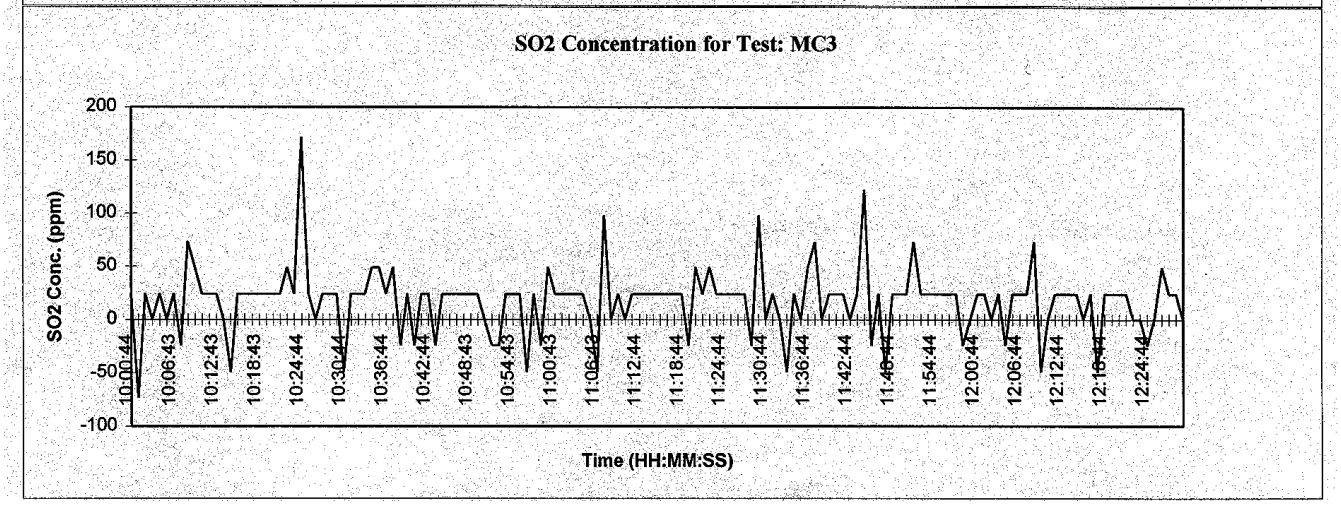

CO HI Stack Conc. for Test: MC7
CO HI (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
10:25:30
10:32:31
10:39:31
10:46:30
10:53:30
11:00:30
11:07:31
11:14:31
11:21:31
11:28:31
11:35:31
11:42:31
11:49:31
11:56:31
12:03:31
12:10:31
12:17:31
12:24:31
12:31:31
12:38:31
12:45:31
12:52:31
12:59:31
Time

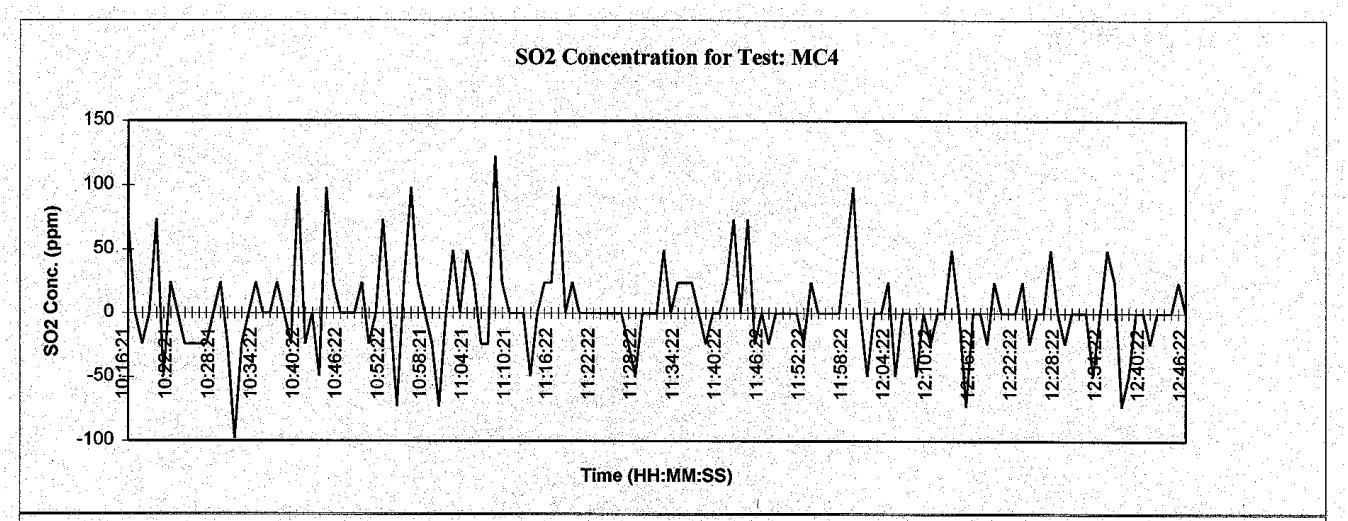

CO HI Stack Conc. for Test: MC8
CO HI (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
10:31:40
10:36:39
10:41:40
10:46:39
10:51:40
10:56:39
11:01:39
11:06:40
11:11:39
11:16:40
11:21:39
11:26:40
11:31:40
11:36:40
11:41:40
11:46:40
11:51:40
11:56:40
12:01:40
12:06:40
12:11:40
12:16:40
Time

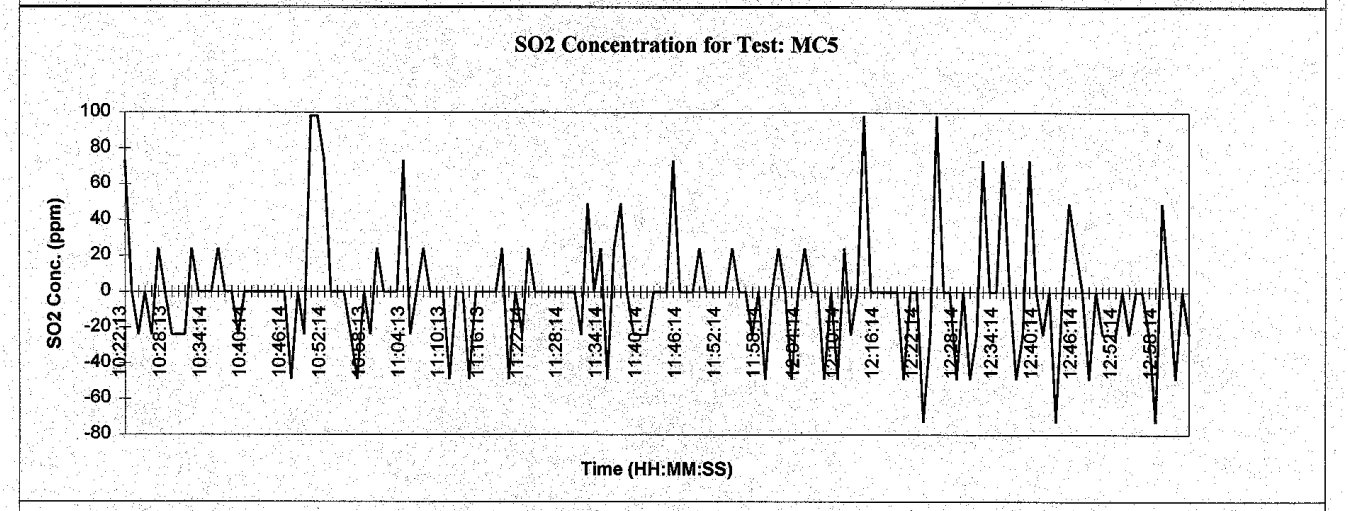

CO HI Stack Conc. for Test: MC9
CO HI (%)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10:43:17
10:49:17
10:55:17
11:01:17
11:07:17
11:13:17
11:19:17
11:25:17
11:31:17
11:37:17
11:43:17
11:49:17
11:55:17
12:01:17
12:07:17
12:13:17
12:19:17
12:25:17
12:31:17
12:37:17
12:43:17
12:49:17
Time

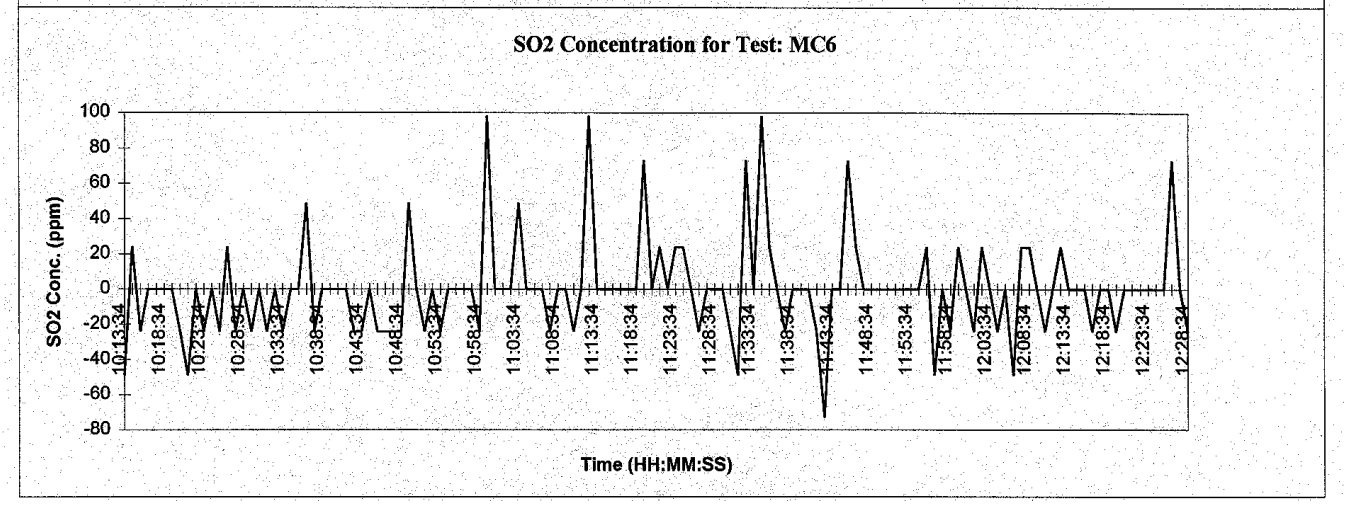

SO2 Concentration for Test: MC1
SO2 Conc. (ppm)
300
250
200
150
100
50
0
-50
-100
-150
10:32:54
10:39:54
10:46:54
10:53:54
11:00:54
11:07:54
11:14:54
11:21:54
11:28:54
11:35:54
11:42:54
11:49:54
11:56:54
12:03:54
12:10:54
12:17:54
12:24:54
12:31:54
12:38:54
12:45:54
12:52:54
12:59:54
13:06:54
13:13:54
13:20:54
13:27:54
13:34:54
13:41:54
13:48:54
Time (HH:MM:SS)

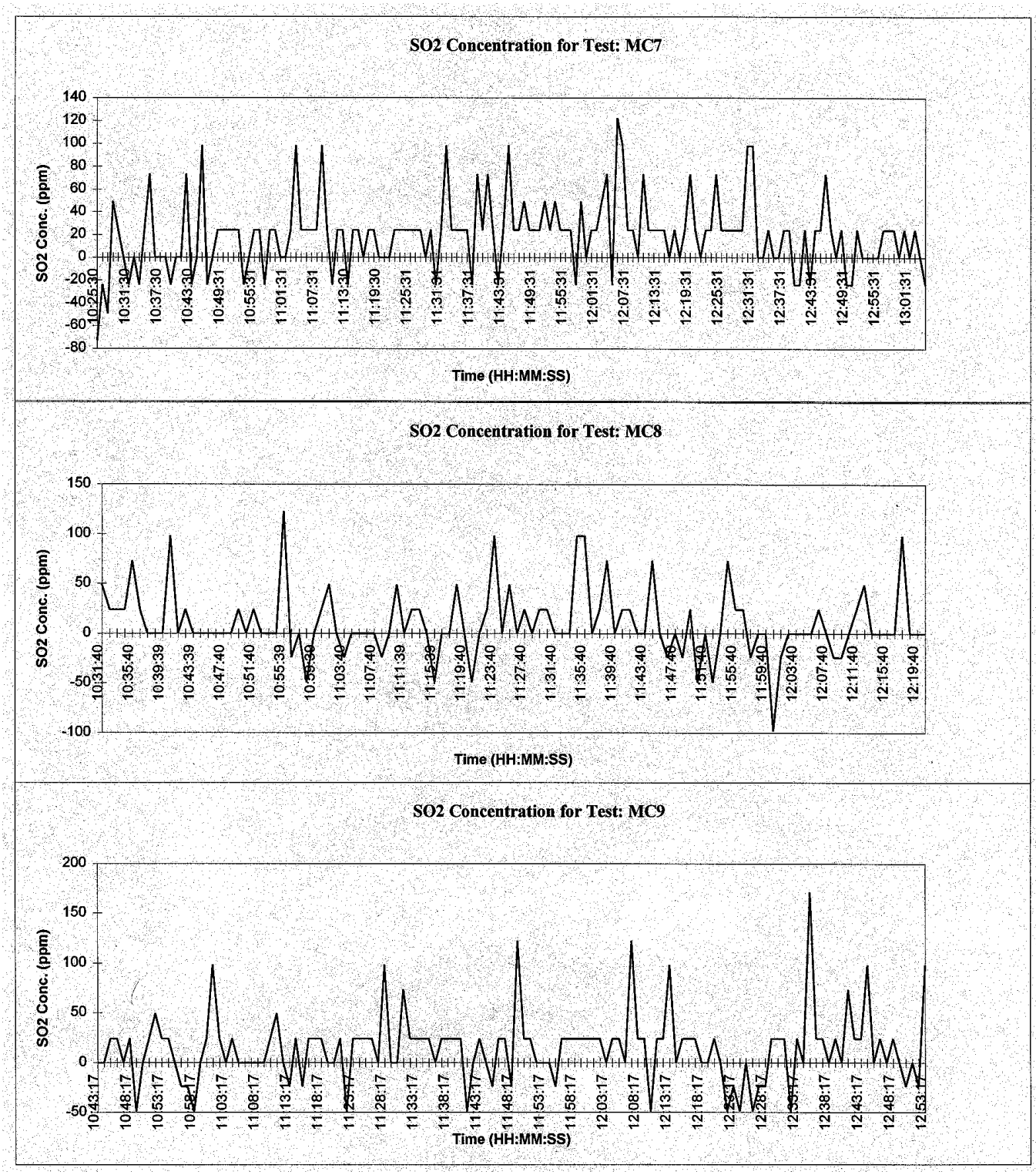

SO2 Concentration for Test: MC2
SO2 Conc. (ppm)
200
150
100
50
0
-50
-100
10:00:53
10:06:54
10:12:54
10:18:54
10:24:54
10:30:54
10:36:54
10:42:54
10:48:54
10:54:54
11:00:54
11:06:54
11:12:54
11:18:54
11:24:54
11:30:54
11:36:54
11:42:54
11:48:54
11:54:54
12:00:54
12:06:54
12:12:54
12:18:54
12:24:54
12:30:54
12:36:54
Time (HH:MM:SS)

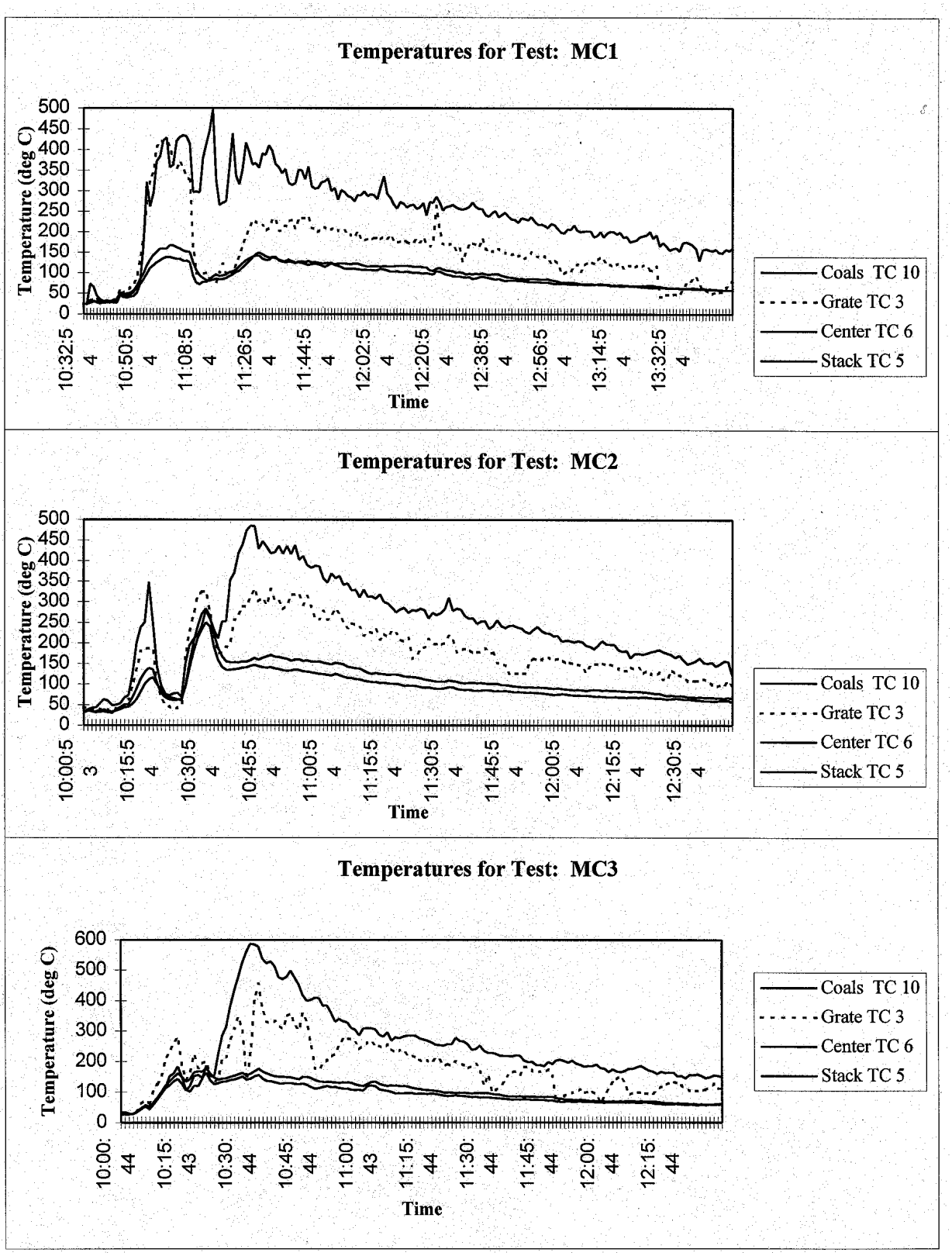

SO2 Concentration for Test: MC3
SO2 Conc. (ppm)
200
150
100
50
0
-50
-100
10:00:44
10:06:43
10:12:43
10:18:43
10:24:44
10:30:44
10:36:44
10:42:44
10:48:43
10:54:43
11:00:43
11:06:43
11:12:44
11:18:44
11:24:44
11:30:44
11:36:44
11:42:44
11:48:44
11:54:44
12:00:44
12:06:44
12:12:44
12:18:44
12:24:44
Time (HH:MM:SS)

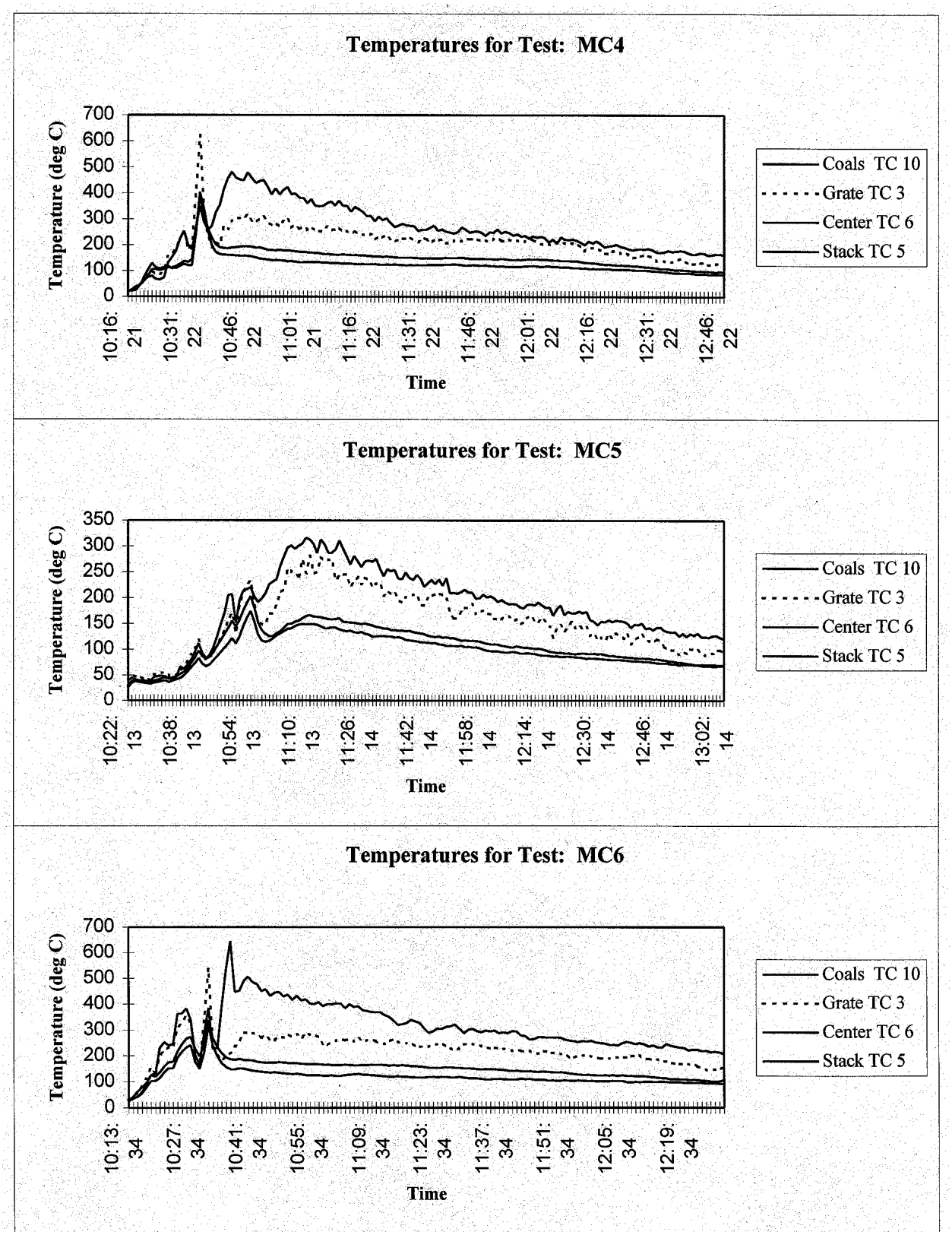

SO2 Concentration for Test: MC4
SO2 Conc. (ppm)
150
100
50
0
-50
-100
10:16:21
10:22:21
10:28:21
10:34:22
10:40:22
10:46:22
10:52:22
10:58:21
11:04:21
11:10:21
11:16:22
11:22:22
11:28:22
11:34:22
11:40:22
11:46:22
11:52:22
11:58:22
12:04:22
12:10:22
12:16:22
12:22:22
12:28:22
12:34:22
12:40:22
12:46:22
Time (HH:MM:SS)

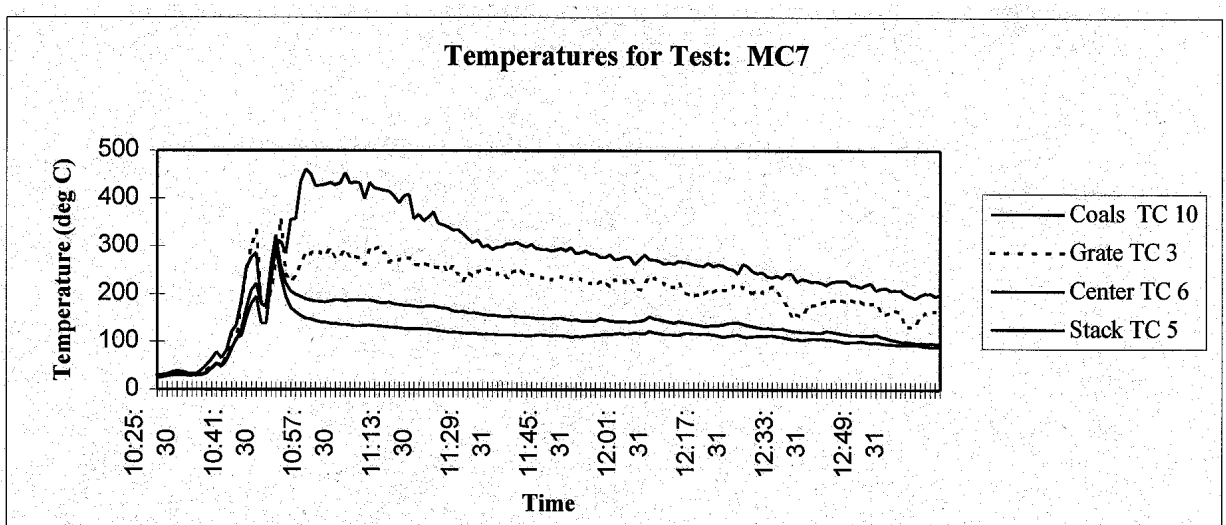

SO2 Concentration for Test: MC5
SO2 Conc. (ppm)
100
80
60
40
20
0
-20
-40
-60
-80
10:22:13
10:28:13
10:34:14
10:40:14
10:46:14
10:52:14
10:58:13
11:04:13
11:10:13
11:16:13
11:22:13
11:28:14
11:34:14
11:40:14
11:46:14
11:52:14
11:58:14
12:04:14
12:10:14
12:16:14
12:22:14
12:28:14
12:34:14
12:40:14
12:46:14
12:52:14
12:58:14
Time (HH:MM:SS)

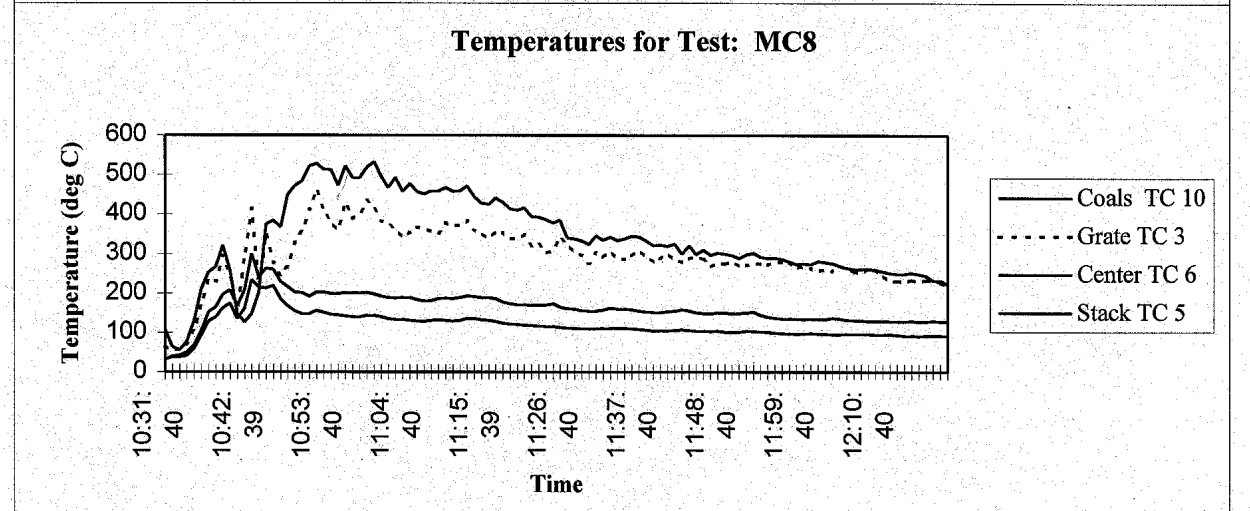

SO2 Concentration for Test: MC6
SO2 Conc. (ppm)
100
80
60
40
20
0
-20
-40
-60
-80
10:13:34
10:18:34
10:23:34
10:28:34
10:33:34
10:38:34
10:43:34
10:48:34
10:53:34
10:58:34
11:03:34
11:08:34
11:13:34
11:18:34
11:23:34
11:28:34
11:33:34
11:38:34
11:43:34
11:48:34
11:53:34
11:58:34
12:03:34
12:08:34
12:13:34
12:18:34
12:23:34
12:28:34
Time (HH:MM:SS)

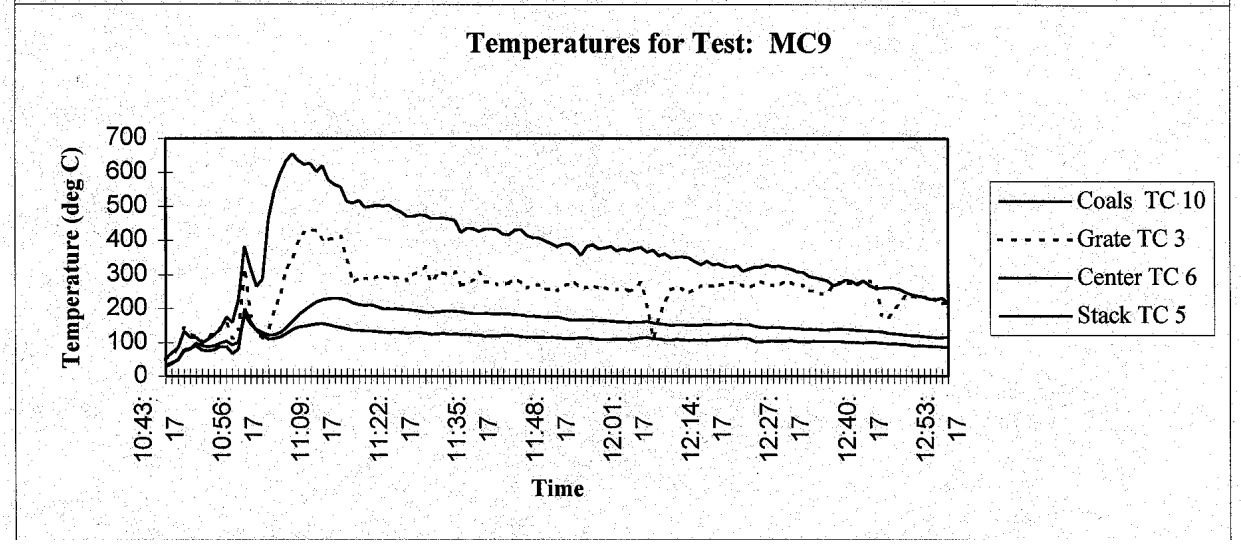

SO2 Concentration for Test: MC7
SO2 Conc. (ppm)
Time (HH:MM:SS)
SO2 Concentration for Test: MC8
SO2 Conc. (ppm)
Time (HH:MM:SS)
SO2 Concentration for Test: MC9
SO2 Conc. (ppm)
Time (HH:MM:SS)

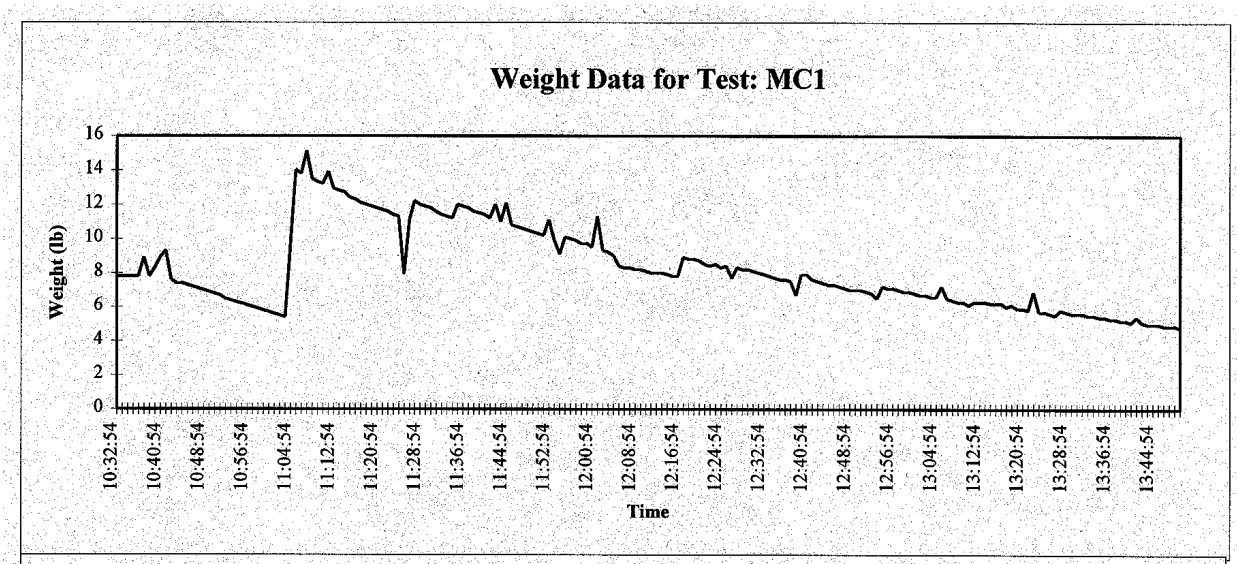

Temperatures for Test: MC1
Temperature (deg C)
500
450
400
350
300
250
200
150
100
50
0
10:32:54
10:50:54
11:08:54
11:26:54
11:44:54
12:02:54
12:20:54
12:38:54
12:56:54
13:14:54
13:32:54
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5
Temperatures for Test: MC2
Temperature (deg C)
500
450
400
350
300
250
200
150
100
50
0
10:00:53
10:15:54
10:30:54
10:45:54
11:00:54
11:15:54
11:30:54
11:45:54
12:00:54
12:15:54
12:30:54
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5
Temperatures for Test: MC3
Temperature (deg C)
600
500
400
300
200
100
0
10:00:44
10:15:43
10:30:44
10:45:44
11:00:43
11:15:44
11:30:44
11:45:44
12:00:44
12:15:44
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5

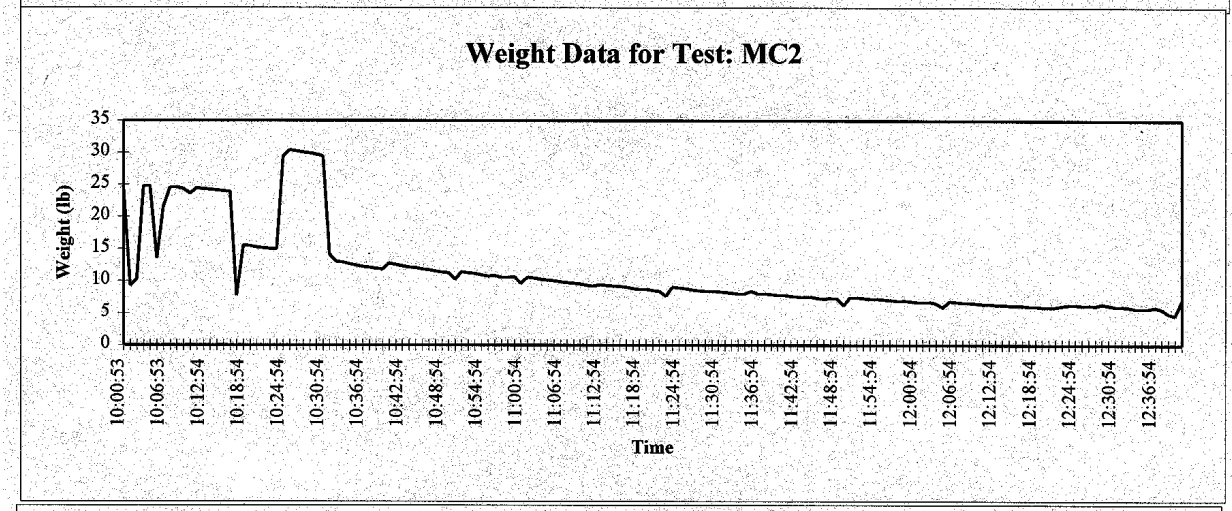

Temperatures for Test: MC4
Temperature (deg C)
700
600
500
400
300
200
100
0
10:16: 21
10:31: 22
10:46: 22
11:01: 21
11:16: 22
11:31: 22
11:46: 22
12:01: 22
12:16: 22
12:31: 22
12:46: 22
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5
Temperatures for Test: MC5
Temperature (deg C)
350
300
250
200
150
100
50
0
10:22: 13
10:38: 13
10:54: 13
11:10: 13
11:26: 14
11:42: 14
11:58: 14
12:14: 14
12:30: 14
12:46: 14
13:02: 14
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5
Temperatures for Test: MC6
Temperature (deg C)
700
600
500
400
300
200
100
0
10:13: 34
10:27: 34
10:41: 34
10:55: 34
11:09: 34
11:23: 34
11:37: 34
11:51: 34
12:05: 34
12:19: 34
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5

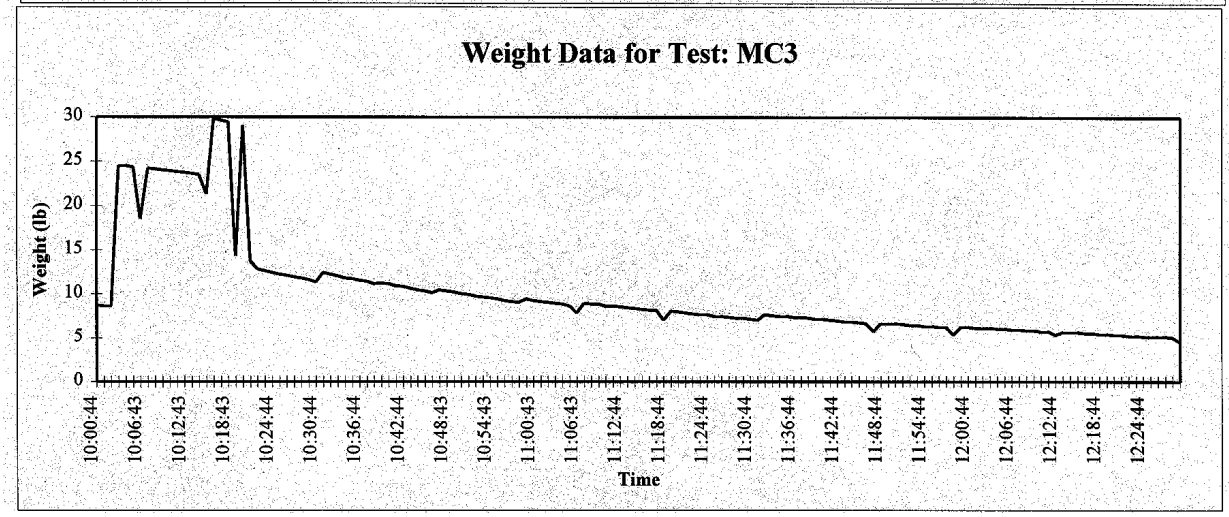

Temperatures for Test: MC7
Temperature (deg C)
500
400
300
200
100
0
10:25: 30
10:41: 30
10:57: 30
11:13: 30
11:29: 31
11:45: 31
12:01: 31
12:17: 31
12:33: 31
12:49: 31
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5

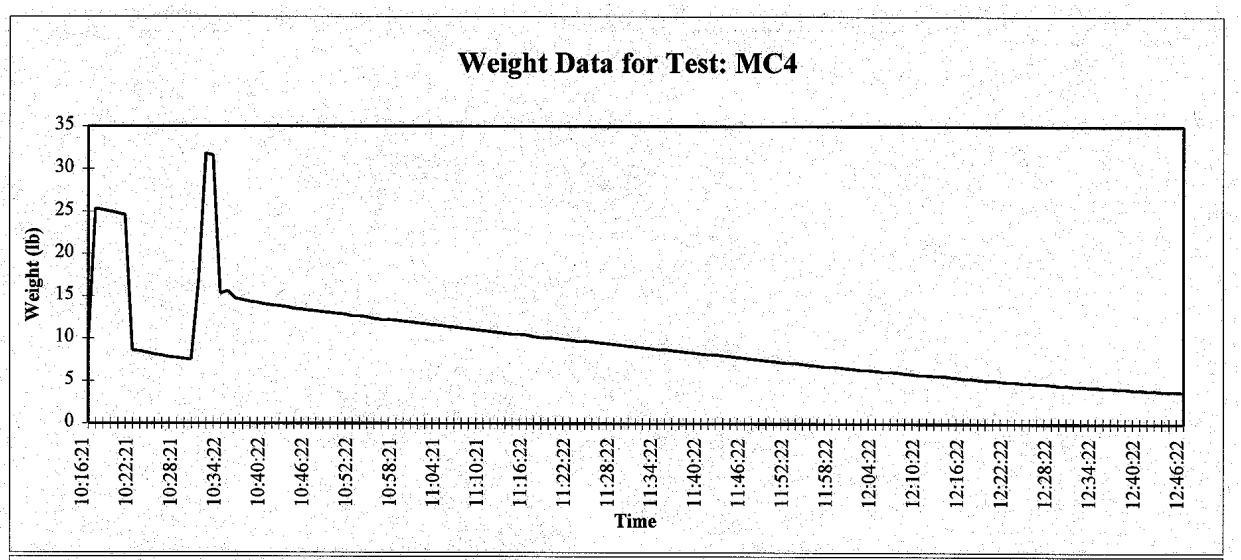

Temperatures for Test: MC8
Temperature (deg C)
600
500
400
300
200
100
0
10:31: 40
10:42: 39
10:53: 40
11:04: 40
11:15: 39
11:26: 40
11:37: 40
11:48: 40
11:59: 40
12:10: 40
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5

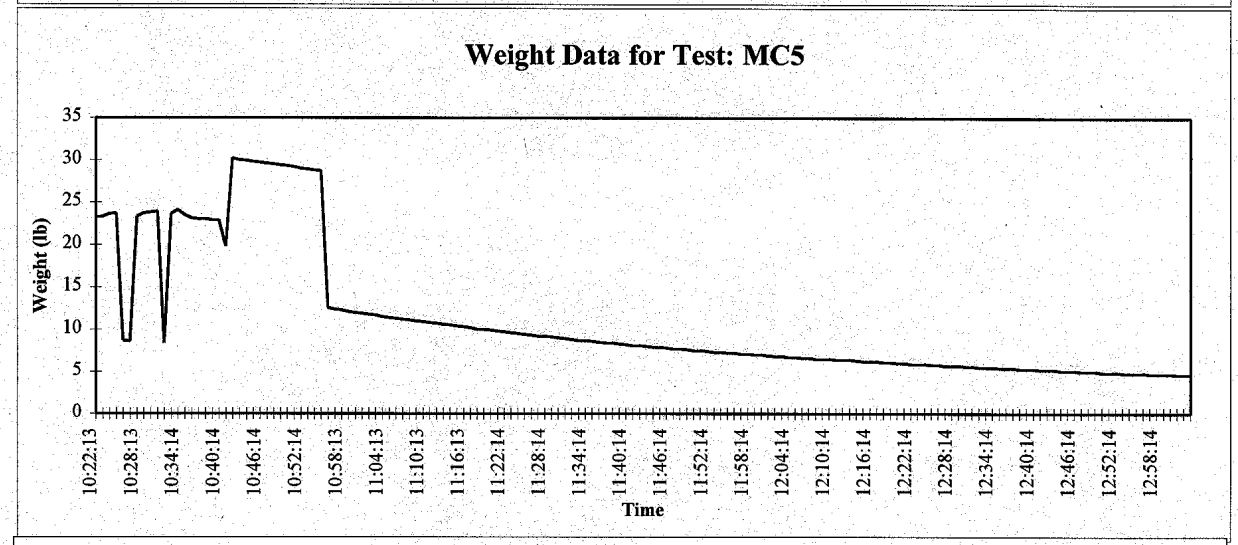

Temperatures for Test: MC9
Temperature (deg C)
700
600
500
400
300
200
100
0
10:43: 17
10:56: 17
11:09: 17
11:22: 17
11:35: 17
11:48: 17
12:01: 17
12:14: 17
12:27: 17
12:40: 17
12:53: 17
Time
Coals TC 10
Grate TC 3
Center TC 6
Stack TC 5

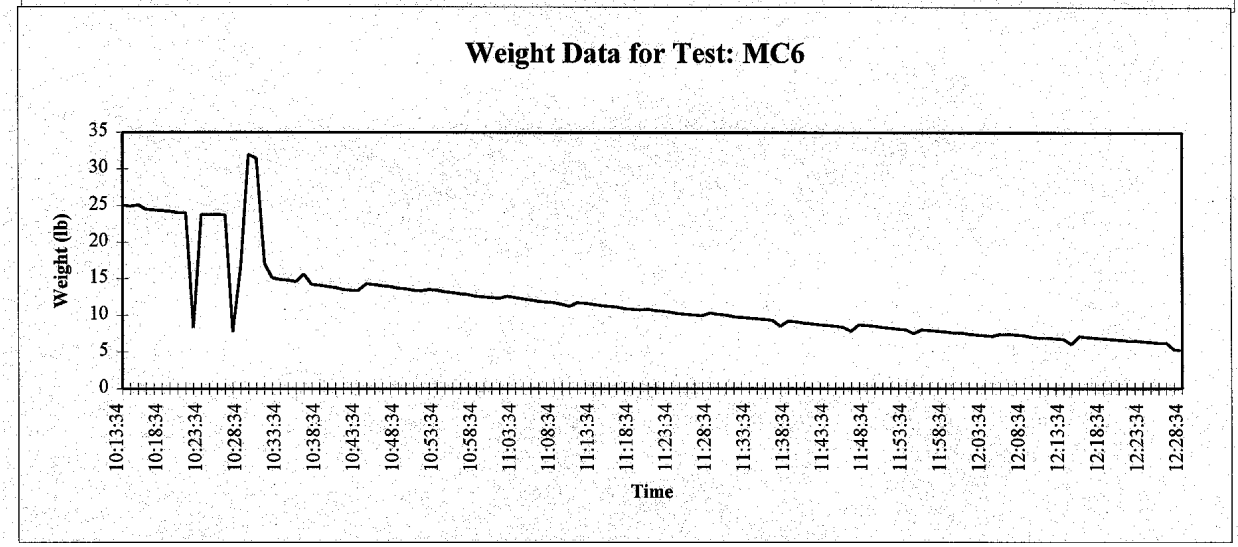

Weight Data for Test: MC1
Weight (lb)
16
14
12
10
8
6
4
2
0
10:32:54
10:40:54
10:48:54
10:56:54
11:04:54
11:12:54
11:20:54
11:28:54
11:36:54
11:44:54
11:52:54
12:00:54
12:08:54
12:16:54
12:24:54
12:32:54
12:40:54
12:48:54
12:56:54
13:04:54
13:12:54
13:20:54
13:28:54
13:36:54
13:44:54
Time

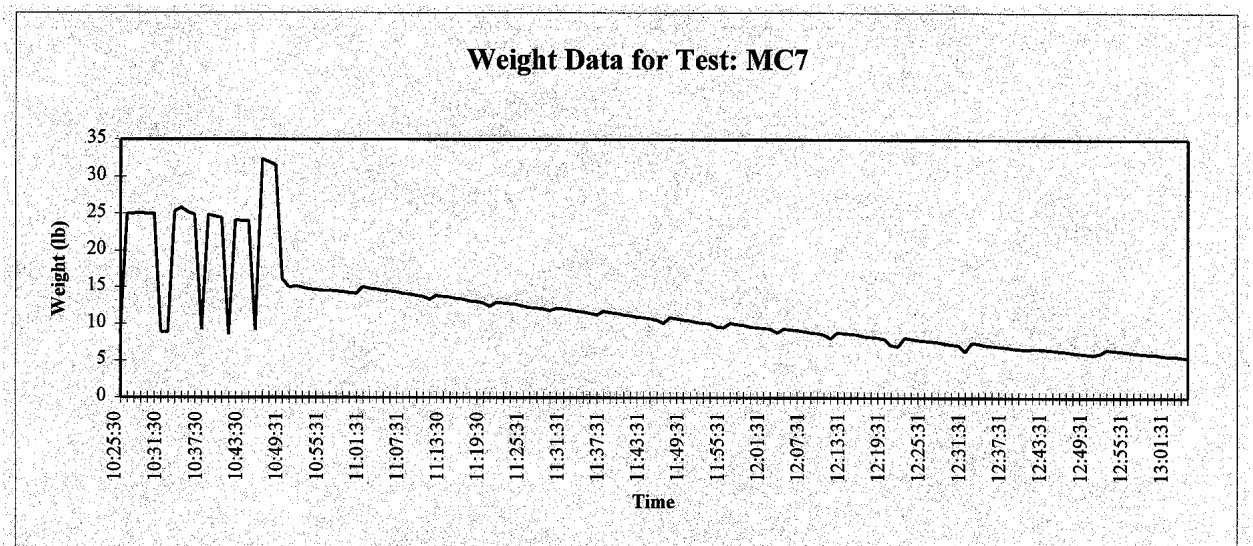

Weight Data for Test: MC2
Weight (lb)
35
30
25
20
15
10
5
0
10:00:53
10:06:53
10:12:54
10:18:54
10:24:54
10:30:54
10:36:54
10:42:54
10:48:54
10:54:54
11:00:54
11:06:54
11:12:54
11:18:54
11:24:54
11:30:54
11:36:54
11:42:54
11:48:54
11:54:54
12:00:54
12:06:54
12:12:54
12:18:54
12:24:54
12:30:54
12:36:54
Time

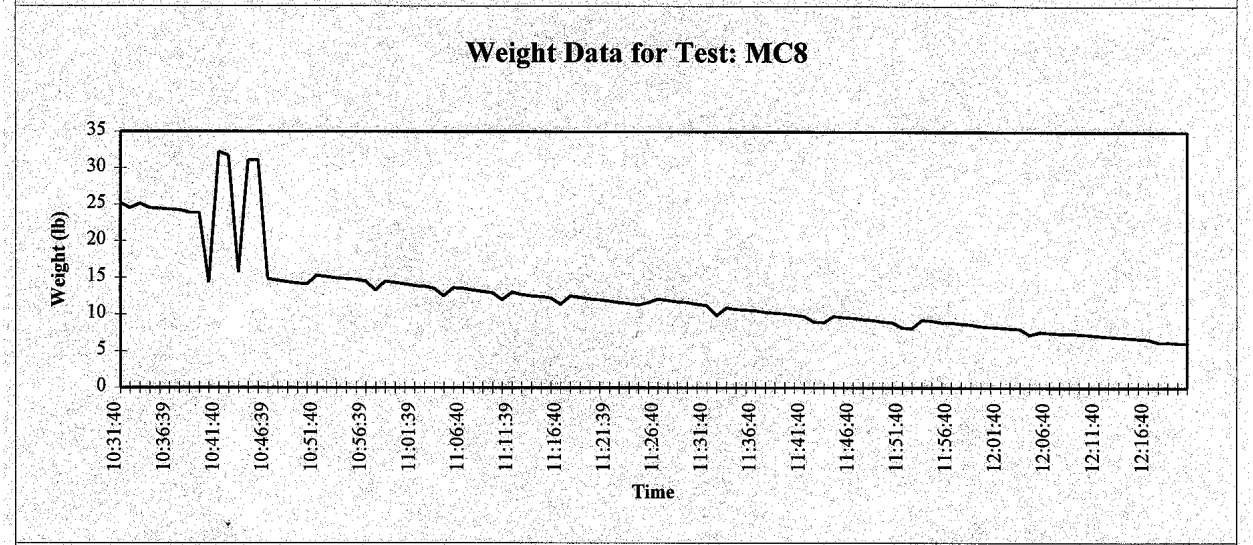

Weight Data for Test: MC3
Weight (lb)
30
25
20
15
10
5
0
10:00:44
10:06:43
10:12:43
10:18:43
10:24:44
10:30:44
10:36:44
10:42:44
10:48:43
10:54:43
11:00:43
11:06:43
11:12:44
11:18:44
11:24:44
11:30:44
11:36:44
11:42:44
11:48:44
11:54:44
12:00:44
12:06:44
12:12:44
12:18:44
12:24:44
Time

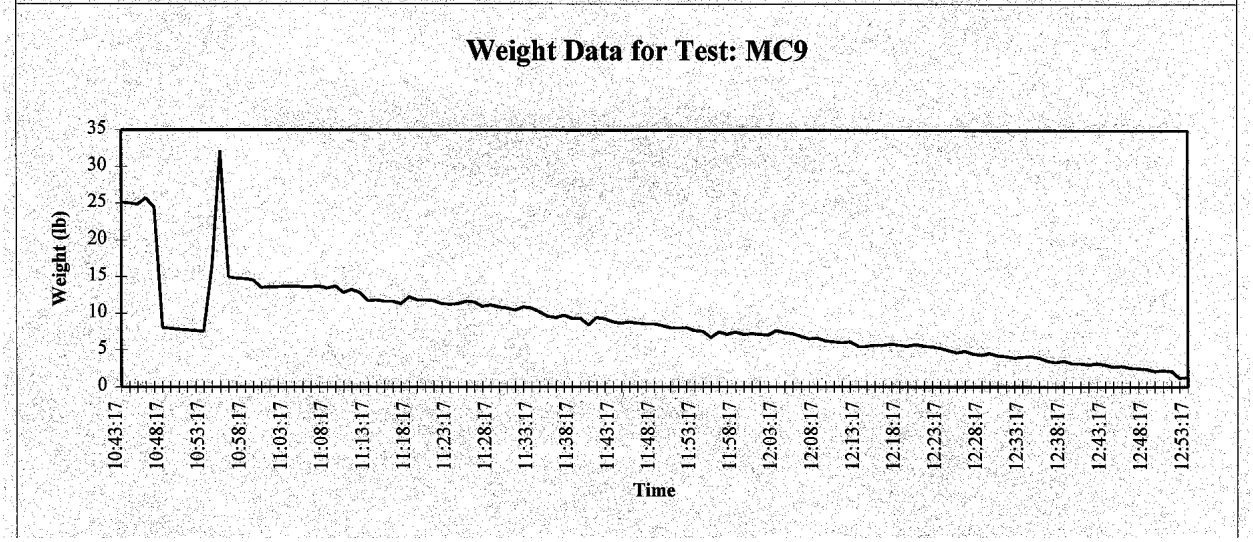

Weight Data for Test: MC4
Weight (lb)
0
5
10
15
20
25
30
35
10:16:21
10:22:21
10:28:21
10:34:22
10:40:22
10:46:22
10:52:22
10:58:21
11:04:21
11:10:21
11:16:22
11:22:22
11:28:22
11:34:22
11:40:22
11:46:22
11:52:22
11:58:22
12:04:22
12:10:22
12:16:22
12:22:22
12:28:22
12:34:22
12:40:22
12:46:22
Time


Weight Data for Test: MC5
Weight (lb)
0
5
10
15
20
25
30
35
10:22:13
10:28:13
10:34:14
10:40:14
10:46:14
10:52:14
10:58:13
11:04:13
11:10:13
11:16:13
11:22:14
11:28:14
11:34:14
11:40:14
11:46:14
11:52:14
11:58:14
12:04:14
12:10:14
12:16:14
12:22:14
12:28:14
12:34:14
12:40:14
12:46:14
12:52:14
12:58:14
Time


Weight Data for Test: MC6
Weight (lb)
0
5
10
15
20
25
30
35
10:13:34
10:18:34
10:23:34
10:28:34
10:33:34
10:38:34
10:43:34
10:48:34
10:53:34
10:58:34
11:03:34
11:08:34
11:13:34
11:18:34
11:23:34
11:28:34
11:33:34
11:38:34
11:43:34
11:48:34
11:53:34
11:58:34
12:03:34
12:08:34
12:13:34
12:18:34
12:23:34
12:28:34
Time


Weight Data for Test: MC7
Weight (lb)
0
5
10
15
20
25
30
35
10:25:30
10:31:30
10:37:30
10:43:30
10:49:31
10:55:31
11:01:31
11:07:31
11:13:30
11:19:30
11:25:31
11:31:31
11:37:31
11:43:31
11:49:31
11:55:31
12:01:31
12:07:31
12:13:31
12:19:31
12:25:31
12:31:31
12:37:31
12:43:31
12:49:31
12:55:31
13:01:31
Time


Weight Data for Test: MC8
Weight (lb)
0
5
10
15
20
25
30
35
10:31:40
10:36:39
10:41:40
10:46:39
10:51:40
10:56:39
11:01:39
11:06:40
11:11:39
11:16:40
11:21:39
11:26:40
11:31:40
11:36:40
11:41:40
11:46:40
11:51:40
11:56:40
12:01:40
12:06:40
12:11:40
12:16:40
Time


Weight Data for Test: MC9
Weight (lb)
0
5
10
15
20
25
30
35
10:43:17
10:48:17
10:53:17
10:58:17
11:03:17
11:08:17
11:13:17
11:18:17
11:23:17
11:28:17
11:33:17
11:38:17
11:43:17
11:48:17
11:53:17
11:58:17
12:03:17
12:08:17
12:13:17
12:18:17
12:23:17
12:28:17
12:33:17
12:38:17
12:43:17
12:48:17
12:53:17
Time

APPENDIX H

VOC Emission Data

VOC EMISSION DATA

	Concentration, micogram per cubic meter								
Target Compound	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
dichloromethane	30	ND	ND	29	44	ND	57	59	74
1,2-dichloroethane	49	45	78	ND	11	56	70	48	99
benzene	1632	1675	1429	232	406	1979	2419	1812	757
toluene	575	733	605	25	117	758	865	647	258
ethyl benzene	109	134	93	ND	12	167	193	124	65
m,p-xylene	88	108	97	19	34	89	101	83	125
o-xylene	74	100	81	ND	13	146	163	110	197
styrene	682	436	558	48	33	897	1162	689	39
Tetatively Identified Compound	Concentration, micogram per cubic meter								
ethanol	124	2539	2359	1205	1411	1036	3675	1883	2581
1-butene	106	1652	1667	ND	53	1305	1934	1687	707
1,3-butadiene	155	1097	2109	ND	ND	1799	3113	2506	1065
1,2-dimethyl cyclopropane	80	1255	1302	ND	ND	1005	1451	1207	507
2-methyl-1,3-butadiene	33	594	599	ND	ND	ND	ND	ND	ND
cyclopentene	42	2056	2441	ND	ND	509	828	668	952
1-hexene	142	583	602	ND	ND	1871	2625	2250	826
1-heptene	126	1888	2309	ND	ND	1851	2681	1905	259
n-heptane	39	736	860	ND	ND	560	776	ND	ND
1-decene	39	408	740	ND	ND	646	779	ND	ND
2-propanone	ND	ND	ND	72	47	ND	ND	ND	ND
carbon disulfide	ND	ND	ND	52	53	ND	ND	ND	ND
methyl furan	ND	ND	ND	205	48	ND	ND	ND	ND
3-buten-2-one	ND	ND	ND	66	ND	ND	ND	ND	ND
isoprene	ND	ND	ND	ND	ND	ND	773	ND	232

APPENDIX I

SVOC Emission Data

SVOC EMISSION DATA

SVOC RESULTS (FILTER)

	micograms								
Target Compound	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzyl alcohol	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
acetophenone	ND	ND	ND	ND	ND	ND	ND	ND	ND
methyl phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	12	16	8	ND	ND	16	24	9	ND
fluoranthene	6	8	6	ND	ND	5	8	ND	ND
pyrene	7	6	6	ND	ND	ND	5	ND	ND
diethyl phthalate	ND	52	35	ND	ND	ND	ND	ND	ND
di-n-butyl phthalate	ND	6	ND	ND	ND	ND	ND	ND	ND
benzene butyl phthalate	ND	6	ND	ND	ND	ND	ND	ND	ND
Tetatively Identified Compound	micrograms								
hexanoic acid	62	97	ND	ND	ND	50	63	ND	ND
2-heptadecanone	160	150	ND	ND	ND	ND	ND	ND	ND
hexadecanoic acid	370	400	200	ND	ND	ND	ND	540	ND
2-heptadecanone	90	ND	ND	ND	ND	ND	ND	51	ND
9-octadecanone	300	ND	ND	ND	ND	ND	ND	ND	ND
octadecanoic acid	120	ND	67	ND	ND	250	180	150	48
5-hydroxydecanoic	59	ND	ND	ND	ND	250	ND	ND	ND
n-tetradecanoic acid	63	ND	53	ND	ND	75	ND	81	ND
1-methyl phenol	70	ND	ND	ND	ND	75	ND	ND	ND
9-octadecenamide	97	120	60	ND	ND	120	ND	71	ND
bi-hexanedioic acid	88	120	ND	ND	ND	120	ND	ND	ND
9,12-octadecadienoic	57	ND	ND	ND	ND	120	ND	ND	ND
6,9-heptadecad	ND	79	ND	ND	ND	ND	ND	ND	ND
9-hexadecenoic acid	ND	87	ND	ND	ND	71	250	57	ND
4-ethyl-4-methyl-1-h	ND	49	ND	ND	ND	ND	ND	ND	ND
stearic acid	ND	99	ND	ND	ND	ND	ND	ND	ND
nonanamide	ND	73	ND	ND	ND	66	ND	ND	20
4,4-phenol	ND	56	51	22	ND	ND	ND	ND	ND
oleic acid	ND	72	ND	ND	ND	ND	ND	ND	ND
1-heptadecene	ND	ND	60	ND	ND	ND	ND	ND	ND
2-pentadecanone	ND	ND	140	ND	ND	ND	ND	ND	ND
2-nonadecanone	ND	ND	90	ND	ND	ND	ND	ND	ND
9-octadecanoic acid	ND	ND	160	ND	ND	71	1400	ND	ND
1,4-octadecenoic acid	ND	ND	54	ND	ND	ND	ND	ND	ND
2,4-dimethyl heptane	ND	ND	ND	ND	49	ND	ND	ND	ND
4-hydro 2-pentanone	ND	ND	ND	ND	40	ND	ND	ND	ND
2,4,6-trimet octane	ND	ND	ND	ND	40	ND	ND	ND	ND
heptadecanone	ND	ND	ND	ND	44	ND	ND	ND	ND
2,6-bis phenol	ND	ND	ND	ND	120	ND	ND	ND	ND
acrylic acid hexadec	ND	ND	ND	ND	27	ND	ND	ND	ND
2-dodecanone	ND	ND	ND	ND	ND	73	ND	ND	ND
hexadecanoic acid	ND	ND	ND	ND	ND	720	970	36	180
octadecanal	ND	ND	ND	ND	ND	53	ND	ND	ND
9-octadecenoic acid	ND	ND	ND	ND	ND	810	120	ND	89
decanoic acid	ND	ND	ND	ND	ND	ND	71	ND	ND
1-pentadecene	ND	ND	ND	ND	ND	ND	56	ND	ND
5-do-2(3h)-furanone	ND	ND	ND	ND	ND	ND	63	ND	ND
n-tetradecanoic acid	ND	ND	ND	ND	ND	ND	93	ND	33
9-octadecen-1-ol	ND	ND	ND	ND	ND	ND	69	ND	ND
pentanamide	ND	ND	ND	ND	ND	ND	ND	40	ND
dodecanamide	ND	ND	ND	ND	ND	ND	ND	36	ND
indeno[1,2,3-cd]pyre	ND	ND	ND	ND	ND	ND	ND	130	ND
dibenz[a,h]anthracene	ND	ND	ND	ND	ND	ND	ND	72	ND
pentanoic acid	ND	ND	ND	ND	ND	ND	ND	ND	30
2-tridecanone	ND	ND	ND	ND	ND	ND	ND	ND	37
heptadecene-(8)-carb	ND	ND	ND	ND	ND	ND	ND	ND	120
1,2-benzenedicarboxy	ND	ND	ND	ND	ND	ND	ND	ND	34

SVOC RESULTS (XAD)

	micograms								
Target Compound	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9
phenol	230	240	150	65	79	190	270	170	710
benzyl alcohol	ND	ND	6	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	9	ND	ND	ND	ND
2-methyl phenol	15	16	10	ND	ND	11	23	8	ND
acetophenone	42	34	26	10	ND	13	17	9	5
4-methy phenol	26	44	18	ND	8	18	30	17	5
naphthalene	260	220	190	17	54	260	310	240	91
2-methylnaphthalene	58	57	43	ND	7	39	54	25	9
acenaphthylene	16	16	11	ND	ND	13	20	12	ND
dibenzofuran	32	27	23	9	16	20	24	12	8
fluorene	6	6	ND	ND	ND	8	14	ND	ND
phenanthrene	20	17	17	ND	11	17	26	8	7
2-nitrophenol	40	74	37	7	13	8	ND	ND	ND
4-nitrophenol	ND	62	ND	ND	7	ND	ND	ND	ND
diethyl phthalate	ND	74	ND	ND	ND	ND	ND	92	ND
di-n-butyl phthalate	ND	12	6	ND	ND	ND	ND	15	ND
n-nitrosodi-n-butylamine	ND	ND	9	ND	ND	ND	ND	ND	ND
2-naphthylamine	ND	ND	10	ND	ND	ND	ND	ND	ND
diethyl phthalate	ND	ND	50	ND	ND	ND	ND	ND	ND
methyl methanesulfonate	ND	ND	ND	ND	ND	16	ND	ND	ND
4-chloroaniline	ND	ND	ND	ND	ND	ND	ND	ND	41
Tetatively Identified Compound					**micrograms**				
ethyl benzene	250	260	170	ND	ND	210	320	130	ND
cis-2-nonene	440	ND	370	ND	ND	ND	ND	ND	ND
nonane	250	170	210	ND	ND	180	190	140	ND
styrene	270	250	ND	ND	ND	ND	ND	220	80
1,2-dimethyl benzene	330	270	230	ND	ND	ND	ND	110	ND
benzaldehyde	260	170	170	25	ND	240	250	230	110
1-decene	410	250	360	ND	ND	360	310	450	170
1,2,4-trimethylbenzene	190	ND	ND	ND	ND	140	170	ND	ND
butyl benzene	260	220	170	ND	ND	150	370	230	160
1-undecene	430	280	ND	ND	ND	ND	ND	ND	ND
n-undecene	170	ND	160	ND	ND	ND	ND	ND	ND
2-dodecene	330	ND	ND	ND	ND	ND	ND	ND	ND
n-dodecene	230	ND	200	ND	ND	ND	ND	ND	ND
1-tetradecene	370	250	380	ND	ND	170	ND	360	ND
tridecane	210	150	220	ND	ND	170	ND	120	50
1-pentadecene	400	260	400	ND	ND	170	ND	290	120
pentadecene	200	ND	200	ND	ND	220	250	ND	87
1-nonene	ND	310	ND	ND	ND	ND	400	430	ND
5-undecene	ND	130	ND	ND	ND	ND	ND	ND	ND
pentyl benzene	ND	150	ND	ND	ND	ND	ND	ND	ND
1-dodecene	ND	220	330	ND	ND	ND	230	320	110
2,4-dodecene	ND	140	ND	ND	ND	ND	ND	ND	ND
2-decenal	ND	140	ND	ND	ND	190	250	140	64
1-tridecene	ND	210	360	ND	ND	250	250	290	100
1,3,5,7-cyclooctatetra silane	ND	ND	170	ND	ND	220	310	ND	ND
cyclopropane	ND	ND	370	ND	ND	ND	ND	ND	ND
tetradecane	ND	ND	140	ND	ND	ND	ND	ND	ND
1-hexadecene	ND	ND	230	ND	ND	ND	ND	ND	ND
benzonitrile	ND	ND	ND	27	61	ND	ND	ND	ND
1-methyl cyclopropane	ND	ND	ND	ND	ND	420	200	ND	160
heptanal	ND	ND	ND	ND	ND	380	440	300	130
octyl cyclopropane	ND	ND	ND	ND	ND	370	340	ND	ND
nonanoic acid	ND	ND	ND	ND	ND	140	ND	ND	56
3-dodecen-1-al	ND	ND	ND	ND	ND	160	210	ND	ND
1-tridecanol	ND	ND	ND	ND	ND	310	ND	ND	ND
3-methyl 2-norcaranone	ND	ND	ND	ND	ND	ND	190	ND	ND
2-nonenal	ND	ND	ND	ND	ND	ND	210	130	ND
e-2-octenal	ND	ND	ND	ND	ND	ND	ND	120	ND
1-hepta cyclopropane	ND	ND	ND	ND	ND	ND	ND	410	170
pentadecane	ND	ND	ND	ND	ND	ND	ND	190	ND
4,5-di 1h-imidazole	ND	ND	ND	ND	ND	ND	ND	ND	62
2-octanone and trime	ND	ND	ND	ND	ND	ND	ND	ND	48
octanoic acid	ND	ND	ND	ND	ND	ND	ND	ND	79
2-undecenal	ND	ND	ND	ND	ND	ND	ND	ND	ND
5-octadecene	ND	ND	ND	ND	ND	ND	ND	ND	140

TECHNICAL REPORT DATA
Please read Instructions on the reverse before completing)

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16. ABSTRACT

The report discusses a joint U.S./Mexican program to establish a reliable emissions inventory for street vendor cooking devices (charcoal grilling), a significant source of air pollutants in the Mexicali-Imperial Valley area of Mexico. Emissions from these devices, prevalent in the streets of Mexicali, Mexico, were investigated experimentally by measuring levels of particulate matter, particle size distributions, volatile and semivolatile organic compounds, aldehydes, and oxides of nitrogen and sulfur, emitted when meat is cooked on a grill over a charcoal fire. The test grill simulated the street vendor cooking devices in Mexicali. To investigate the emission rate, both beef and chicken were tested. Furthermore, both meats were marinated with a mixture similar to that used by the street vendors. Difficulties in obtaining enough Mexicali charcoal necessitated using local charcoal for some of the tests. Both types of charcoal were compared to ensure similar physical and chemical properties. Some tests were conducted with non-marinated beef for comparison. Two blank runs were performed sampling charcoal fires without meat. Finally, a simple control device, normally used in an exhaust fan to trap grease over a kitchen stove, was evaluated for its effectiveness in reducing emissions. All, except sulfur dioxide, emissions measured during the runs appeared to be reasonable.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Emission	Pollution Control	13B 14G
Cooking Devices	Particles	Stationary Sources	06H
Charcoal	Organic Compounds	Grilling	21D 07C
Combustion	Nitrogen Oxides	Particulate	21B 07B
Chickens	Sulfur Oxides	Marinades	06C, 02E
Beef		Grease Traps	

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