Casting Emission Reduction Program
www.cerp-us.org

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Baseline: Hot Box Core Making

Technikon # 1410-126 GT

November 2005
Revised for public distribution

United States Environmental Protection Agency

CISA

AFS American Foundry Society, Inc.

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH
USCAR
DaimlerChrysler Ford Motor Company General Motors

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Baseline:
Hot Box Core Making

Technikon # 1410-126 GT

This report has been reviewed for completeness and accuracy and approved for release by the following:

Manager Measurement Technologies	*// Original Signed //* Anil Prabhu, PhD	Date
VP Measurement Technologies:	*// Original Signed //* Clifford Glowacki, CIH	Date
VP Operations:	*// Original Signed //* George Crandell	Date

The data contained in this report were developed to assess the relative emissions profile of the product or process being evaluated. You may not obtain the same results in your facility. Data were not collected to assess casting cost, or producibility.

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Executive Summary

This report contains the results of Test GT which was conducted to establish a baseline emission profile from a representative hot box core binder for the combined making and core storage processes. The test was designed to measure the VOCs and HAPs (contained in the volatile fraction of the binder used in this system) released during normal Hot Box core making.

Sand mixed with binder was loosely packed in a suitable holding chamber designed to ensure total capture of all emissions evolving from the sand, primarily from release of volatiles. The holding chamber was heated in an electrically powered AccuTherm oven to 350ºF. Emission samples were collected from the exhaust of the holder over a 60 minute period. This time period had been established to be adequate enough to complete the release of all measurable emissions. The emissions results are reported in both pounds per pound (Lb/Lb) of binder and pounds per ton (Lb/Tn) of sand.

Process and stack parameters were measured and included:

1. the weights of the sand, binder, and pan
2. ambient, exit, manifold, pan and sand temperatures
3. event timing
4. loss on ignition (LOI) values for the sand-binder mixture prior to the test
5. volumetric flow rate and moisture content.

The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the test runs.

Emission samples were collected and analyzed for specific target VOCs and HAPs. Ammonia was also monitored as a target analyte using appropriate collection media. All sampling procedures were based on US EPA Method 18. Continuous monitoring of the Total Gaseous Organic Concentration (TGOC) of the emissions was conducted according to US EPA Method 25A. A significant component of the volatile stream was expected to be formaldehyde. A TGOC analyzer using a flame ionization detector is not capable of detecting this compound. To address this issue, a photo-ionization detector, capable of detecting formaldehyde, was used in parallel

with the TGOC analyzer. This was used only to establish the time required for evolution of all measurable emissions (to include formaldehyde).

Mass emission rates for all target analytes were calculated using continuous monitoring data, laboratory analytical results, measured source data, and appropriate process data. Results are presented in summary in Section 3 of this report and in detail in Appendix B. Five emission indicators including TGOC (total gaseous organic concentration) as Propane, HC (hydrocarbons) as Hexane, Sum of Target VOCs (volatile organic compound), Sum of Target HAPS (hazardous air pollutant), and Sum of Target POMs (polycyclic organic matter), were calculated. Detailed descriptions of these indicators can be found in the Results section of this report.

Results for the emission indicators are shown in the following table reported as Lb/Tn of sand and Lb/Lb of binder.

Table 1 Summary of Test Results

	Test GT Lb/Lb Binder	Test GT Lb/Tn of Sand
TGOC as Propane	0.0260	0.8060
HC as Hexane	0.0020	0.0613
Sum of Target VOCs	0.0089	0.2400
Sum of HAPs	0.0089	0.2400
Sum of POMs	0.0071	0.1841

It must be noted that the reference and product testing performed is not suitable for use as emission factors or for purposes other than evaluating the relative emission reductions associated with the use of alternative materials, equipment, or processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests, and should not be used as the basis for estimating emissions from actual commercial foundry applications.

1.0 INTRODUCTION

1.1. Background

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Research Consortium (ERC), a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC), a laboratory of the United States Army; the American Foundry Society; and the Casting Industry Suppliers Association. The US Environmental Protection Agency (US EPA) and the California Air Resources Board (CARB) also have been participants in the CERP program and rely on CERP published report for regulatory compliance data.

1.2. Objectives

The primary objective of Technikon is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing arena has been specially designed to facilitate the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate specific VOC and HAP emissions from a representative hot box core binder for the combined core making and storage processes. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test are summarized in Section 3 of this report, with detailed data included in Appendix B of this report. Section 4 of this report contains a discussion of the results.

The raw data for this test series is maintained at the Technikon facility.

1.4. Specific Test Plan and Objectives

Table 1-1 provides a summary of the test plan. A copy of the approved test plan is included in Appendix A.

Table 1-1 Test Plan Summary

	Test Plan
Type of Process tested	Hotbox Core Making and Core Storage
Test Plan Number	1410 126 GT
Core	1.6 % (BOS) HA International 747 Hot box resin and 18 % (BOR) 89FR Hotbox catalyst.
Core Coating	None
Number of cores tested	6
Test Dates	6/13/2005 through 6/24/2005
Emissions Measured	TGOC as Propane, HC as Hexane, Ammonia, 69 Organic HAPs and VOCs
Process Parameters Measured	Total Sand and Binder Weights; % LOI; Sand, Manifold, Exit, Ambient and Pan Temperatures, Moisture Content, Sand Temperature, and Volumetric Flow Rate

2.0 TEST METHODOLOGY

2.1. Description of Process and Testing Equipment

Testing Equipment and Procedure

A special collection chamber (also known as a holding chamber) with two sections (bottom and top halves) shown in Figure 2-1 was designed and built for this test. The bottom half section consisted of a cavity that allowed for an adequate amount of sand and binder mixture to be contained within its volume. A thermocouple well was welded on to this section about midway through the depth of this cavity that allowed the insertion of a thermocouple to measure temperature of the sand (labeled as sand temperature in this report). This section also had a conical tube in the center, one end of which was open within the bottom half, the other end connected to a ½" tube that allowed for the heated sampling line to be connected to the holding chamber. The top half of the chamber meshed with the bottom half. Spacers were inserted between the top and bottom halves to provide gaps to allow air to be drawn into the collection chamber and transported via the heated sampling line to the sampling manifold. The thickness of the spacers was calculated to allow for adequate flow velocity to ensure total capture of all the emissions generated within the collection chamber.

Figure 2-1 Top and Bottom Halves of Holding Chamber

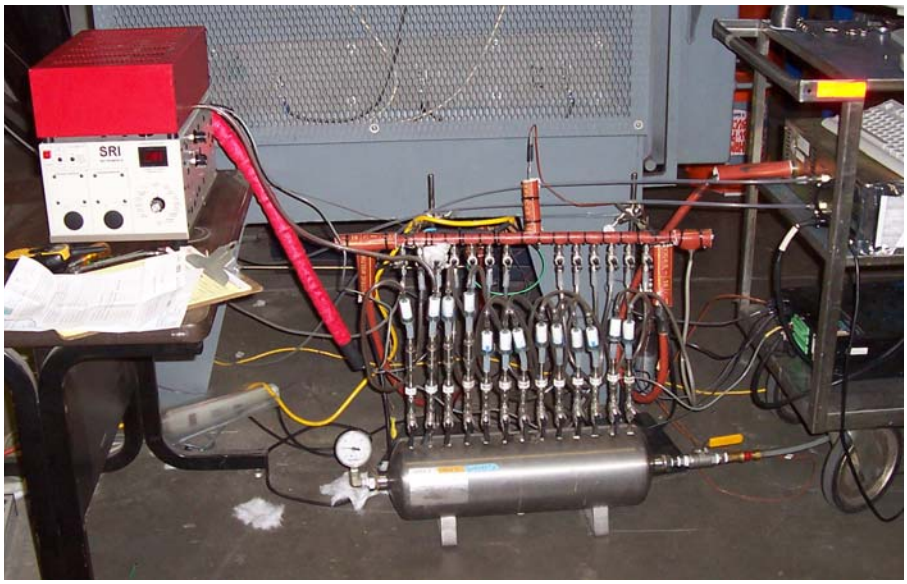
Figure 2-2 Holding Chamber placed in the AccuTherm Oven

Figure 2-2 shows the holding chamber sections placed in the oven with the lower chamber attached to the sampling line. Thermocouples were inserted at the bottom of the cavity (pan temperature) and at the inlet of the heated sampling line outside the oven (exit temperature). All the

external sampling lines were heated and maintained at 130°C. Thermocouples were also used to record manifold temperature (at the sampling manifold) and ambient temperature.

Figure 2-3 shows the sampling manifold to which was attached the hydrocarbon (TGOC) and PID analyzers, and the sampling train with the appropriate media in individual channels. A vacuum pump provided the necessary potential to draw air through the collection chamber into the sampling line. A tee on the sampling line allowed part of the flow to be diverted to the analyzers and the sampling train while the excess was vented. Though the sampling media and the analyzers required approximately 0.35 SCFM of sample, the total sample drawn from the collection chamber was approximately 5.3 SCFM. This was implemented to dilute the analyte concentrations in the emissions stream and minimize breakthroughs in the sample media due to analyte overload.

Figure 2-3 Sampling Manifold, Train, TGOC and PID Analyzer Setup



The selection of sampling media was based on the expected analytes (hydrocarbons, ammonia, etc.) that were expected to be evolved during the process and a detailed sampling plan is provided in Appendix A. The hydrocarbon analyzer (California Analytical Inc, see Appendix E for specifications) was intended to measure TGOC as propane. One specific hydrocarbon, formaldehyde, was expected to be present in the emissions stream over a longer period of time compared to other expected species. The insensitivity of the flame ionization detector to this analyte required the use of a photo ionization detector (PID) equipped analyzer (see Appendix E for details) to ensure that sampling would continue until all measurable release of volatiles was complete. The PID used an 11.6eV lamp (a standard PID uses a 10.6 eV lamp) to ionize formaldehyde (ionization potential 11.2 eV) and ensure that this species was monitored during the whole process. This analyzer served only as a qualitative tool for formaldehyde and allowed for the

determination of sampling times necessary to completely drive-off the volatiles under the influence of temperature and time. No calibration was performed to provide quantifiable values for formaldehyde. All data acquisition was performed using an IOtech DAQ 260 (www.iotech.com) box coupled to a computer. Data was recorded every second for all the measured parameters in this test.

The hydrocarbon analyzer was calibrated and calibration checks performed per EPA Method 25A. The PID was scaled to measure emissions but only to serve as a qualitative tool for formaldehyde emissions. The flow rates through the media channels was measured pre and post runs using NIST (www.nist.gov) traceable DryCal airflow calibrators (Brandt Instruments, www.brandtinst.com). The total flow through the sampling line was calculated from flow velocities measured using an ADM 870C electronic manometer (Shortridge Instruments, see Appendix E).

Figure 2-4 AccuTherm Oven

The electrically heated AccuTherm oven (Figure 2-4) was preheated to 350°F with the holding chamber placed in the oven during the pre-heat cycle. The sand was weighed and transferred to a stand mixer. An appropriate amount of HA International 747 Hot box resin was added to this to provide for a 1.6% by weight of the sand. The mixer was started and to this was added an appropriate amount of 89FR Hotbox catalyst to provide for 18% by weight of resin for the aggregate. Mixing was continued for an additional minute. The mixture holder was weighed before the sand was transferred to the holding chamber (described earlier) in the oven.

The oven door was opened, the lid of the holding chamber removed, the exhaust orifice covered to prevent sand from spilling into the sampling line, and an adequate amount of sand (established during trial runs) transferred to the

chamber as shown in Figure 2-5. The sand/binder mixture was then evenly spread in the holding chamber as shown in Figure 2-6.

The orifice cover was removed, spacers installed on the rim of the holding chamber, the chamber was closed with its lid followed by closing the oven door. Start time was established when sand was transferred to the holding chamber. The data acquisition and sample collection were started at this time.

Figure 2-5 Sand/Binder Mixture being Transferred to the Holding Chamber

Figure 2-6 Sand/Binder Mixture Evenly Spread in the Holding Chamber

Figure 2-7 shows the TGOC and PID analyzer output signals overlaid with the sand temperature reading. This was from a trial run that was conducted to establish operational parameters for the actual runs. The plot indicates that in the first 2000 seconds, evolution of all measurable emissions (using the FID for TGOC) was essentially complete. The PID output, however, indicated some residual formaldehyde in the sampling stream. To ensure total capture of all emissions, sampling was continued for an additional 1600 seconds. The selection of this additional time was based on the PID output being relatively constant (and close to zero). During the actual runs, data collection and the sample collection on the media were stopped after 60 minutes, which constituted one (1) run. Figure 2-8 shows the sand mixture after it was removed from the holding chamber. This sand was weighed after the test was complete. The data acquisition system measured the following process parameters: sand temperature, manifold temperature, pan temperature, stack temperature, ambient temperature, TGOC signal, PID signal. Five (5) additional runs were conducted to provide statistical significance to the data set.

Figure 2-7 Emissions Evolution vs. Sand Temp

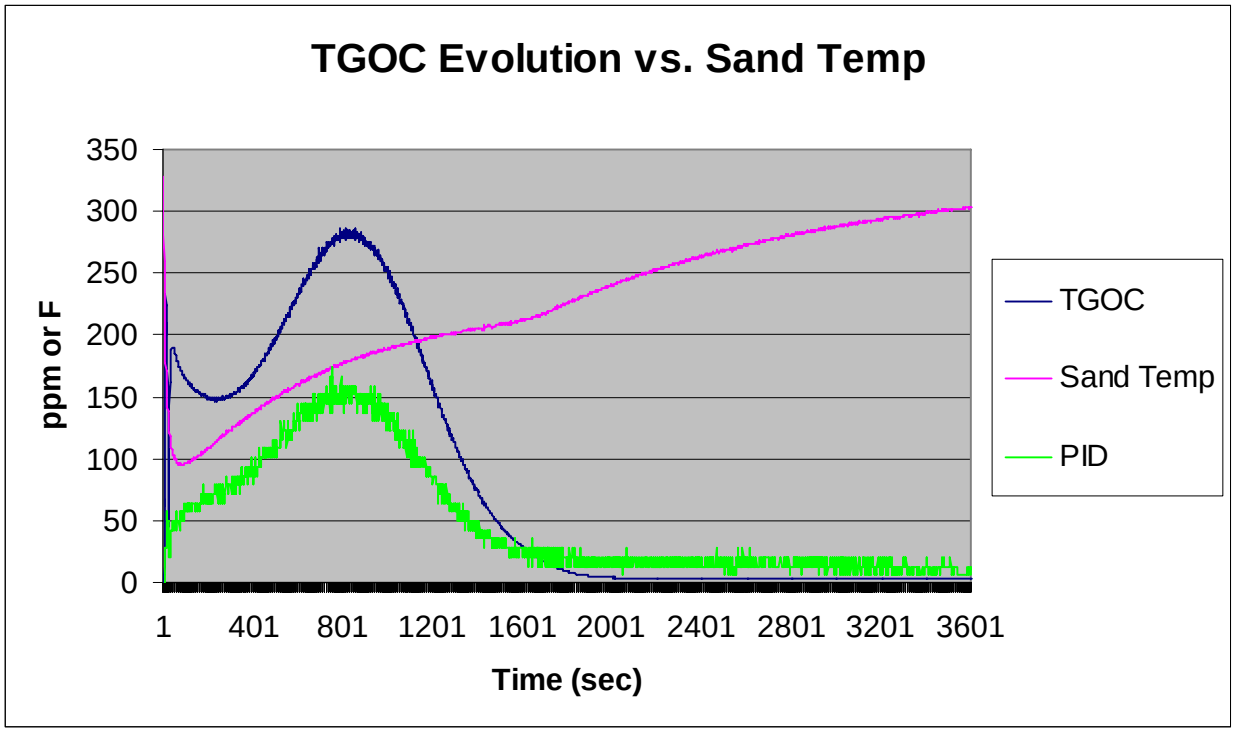


Figure 2-8 Sand/Binder Mixture after completion of test

Test Plan Review and Approval: The proposed test plan was reviewed by the Technikon staff and the CERP Emissions and Test Design Committees, and approved. Table 2-1 lists the process parameters that were monitored during each test.

The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the tests. Emissions were continuously measured according to US EPA Method 25A, Total Gaseous Organic Concentration, calibrated with propane. Methods based on US EPA Method 18 and other selected NIOSH, OSHA, and US-EPA methods were used to collect and analyze samples for specific target VOCs and HAPs.

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Binder and Sand Weight	Mettler SB12001 Digital Scale (Gravimetric)
LOI, % at Mold	Denver Instruments XE-100 (AFS procedure 5100-00-S)
Process Temperatures	J-Thermocouples

Airborne Emissions Analysis: The specific sampling and analytical methods used in the test were based on the US EPA reference methods shown in Table 2-2. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual.

Table 2-2 Sampling and Analytical Methods

Measurement Parameter	Test Method
Gas Velocity and Temperature	EPA Method 2
Gas Moisture	EPA Method 4, gravimetric
HAPs Concentration	EPA Method 18, NIOSH 1500
Target Analytes Concentration	EPA Method 18, NIOSH 1500, NIOSH 6016
TGOC as Propane	EPA Method 25A
Formaldehyde	Only monitored using a PID

Some of these methods were specifically modified to meet the testing objectives of the CERP Program.

Data Reduction, Tabulation and Preliminary Report Preparation: The analytical results of the emissions tests and average sample flow rate provided the mass emissions for Total Gaseous

Organic Concentration as propane emitted during each test run. The mass of emissions is calculated as propane and then divided by both the sand weight and the weight of the binder to provide emissions data in both pounds per ton of sand and pounds per pound of binder. The specific calculation formulas are included in the Technikon Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual. The results of each of the runs and the corresponding process data are included in Section 3 of this report.

Report Preparation and Review: The Preliminary Draft Report is reviewed by the Process Team and Emissions Team to ensure its completeness, consistency with the test plan, and adherence to the prescribed QA/QC procedures. Appropriate observations, conclusions and recommendations are added to the report to produce a Draft Report. The Draft Report is reviewed by the Vice President of Measurement Technologies, the Vice President of Operations. Comments are incorporated into a draft Final Report prior to final signature approval and distribution.

Quality Assurance and Quality Control (QA/QC) Procedures

Detailed QA/QC and data validation procedures for the process parameters, sampling line measurements, and emissions data are included in the "Technikon Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual" In order to ensure the timely review of critical quality control parameters, the following procedures are followed:

- Immediately following the individual runs performed for each test, specific process parameters are reviewed by process engineering to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, process engineering and the Vice President of Operations determine whether the individual test samples should be invalidated or flagged for further analysis.

- The source (sample) parameters and analytical results are reviewed by the Emission Measurement team to confirm the validity of the data. The Vice President of Measurement Technologies reviews and approves the recommendation, if any, that individual run data should be invalidated. Invalidated data are not used in subsequent calculations.

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3.0 TEST RESULTS

Tables 3-1 and 3-2 provide averages for the various analytes in Lb/Tn of Binder and Lb/Lb of Sand. Table 3-3 provides a summary of the process parameters. Appendix D provides overlay plots of the different parameters monitored during the study. It includes TGOC and PID analyzer outputs and the different temperatures monitored during this study. Figure 3-1 provides a graphical representation of the emissions indicators and Figure 3-2 the same for selected HAPs. POMs were essentially trace level analyte concentrations and have not been reported in a pictorial representation for this report.

Table 3-1 Average Emissions Results – Lb/Lb Binder

Analytes	Lb/Lb Binder
Emissions Indicators	
TGOC as Propane	0.0260
HC as n-Hexane	0.0020
Sum of Target VOCs	0.0089
Sum of Target HAPs	0.0089
Sum of Target POMs	0.0071
Specific Target HAPs	
Phenol	0.0071
Formaldehyde	0.0018
Other Target Analytes	
Ammonia	0.0003

Individual results constitute >95% of mass of all detected target analytes.

ND: Non Detected at the Reporting Limit of 0.0001 lb/lb binder

Table 3-2 Average Emissions Results – Lb/Tn Sand

Analytes	Lb/Tn of Sand
Emissions Indicators	
TGOC as Propane	0.8060
HC as n-Hexane	0.0613
Sum of Target VOCs	0.2400
Sum of Target HAPs	0.2400
Sum of Target POMs	0.1841
Specific Target HAPs	
Phenol	0.2198
Formaldehyde	0.0559
Acetaldehyde	0.0009
Other Target Analytes	
Ammonia	0.0090

Individual results constitute >95% of mass of all detected target analytes.

ND: Non Detected at the Reporting Limit of 0.0001 lb/tn of sand

Table 3-3 GT Summary of Process Parameters

GT Summary	
Test Date	6/16-22/2005
% Resin (BOS)	1.60
% Catalyst (BOR)	18.00
% Binder (BOS)	1.89
% Binder	1.85
Sand weight in emission chamber before test (lbs)	7.14
Binder weight, (lbs)	0.13
Sand weight in emission chamber after test (lbs)	7.08
Weight loss during test, %	0.97
Sand initial temperature, F	74.13
Sand mean temperature, F	230.5
Oven mean air temperature, F	348.4
Sand (after test) % LOI 1800 F	1.26
Total test period, minutes	60

Figure 3-1 Summary of Emission Indicators – Lb/Tn

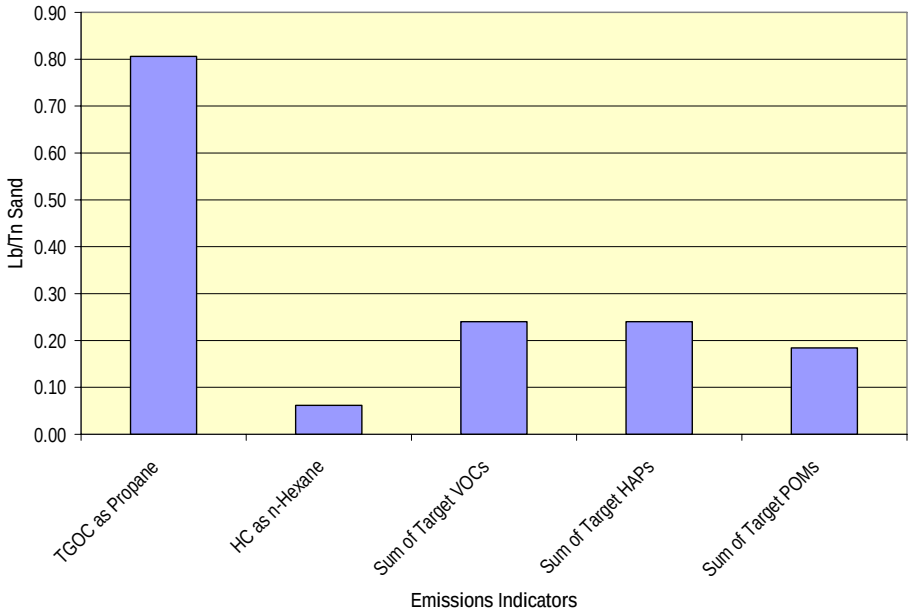
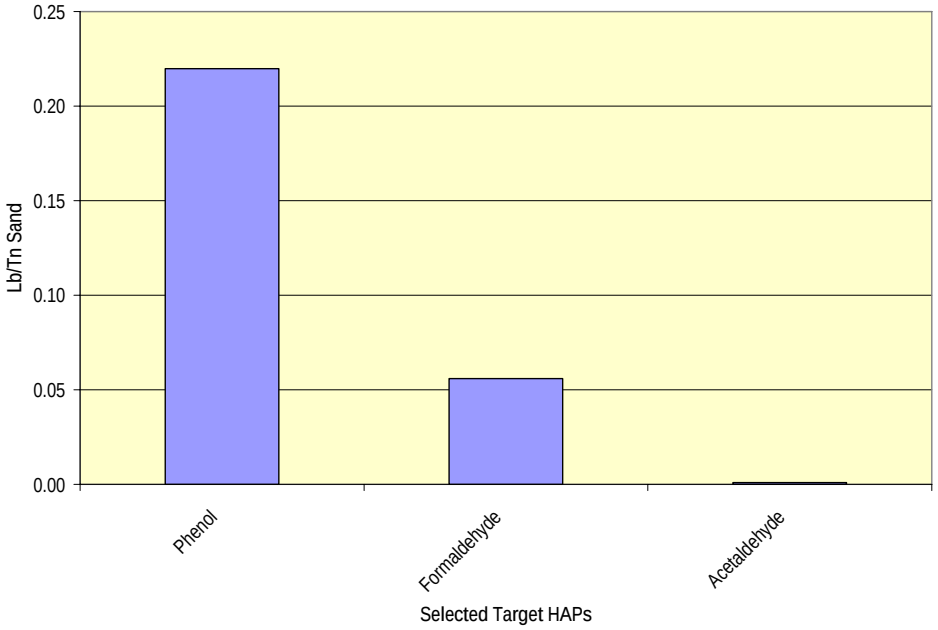


Figure 3-2 Summary of Selected HAPs - Lb/Tn



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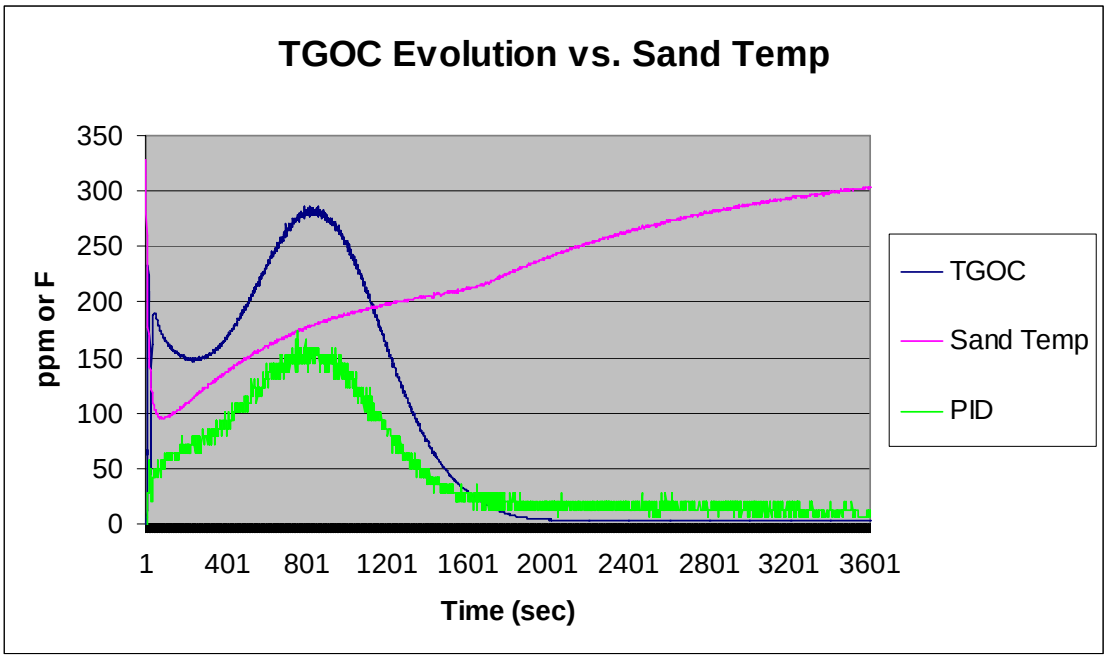
4.0 DISCUSSION OF RESULTS

This test was conducted to establish a baseline emission profile from a representative hot box core binder for the combined core making and core storage processes. This test was designed to measure the VOCs and HAPs contained in the volatile fraction of the binder used in this system that are released during normal Hot Box core making. Figure 4-1 below shows the overlay plot of the TGOC and PID analyzers and the sand temperature. It is evident that most of the measurable emissions evolved from the sand/binder system in the first 2000 seconds, at which time the average temperature of the sand mixture was 210°F. Continuation of the test for an additional 1600 seconds allowed the sand bed to be heated to 310°F, but did not lead to any increased emissions due to increased temperature. This served to validate that the temperature achieved by the bed was adequate enough for release of all measurable emissions. The use of the PID analyzer also ensured any evolved formaldehyde was sampled since adequate time was provided for all emissions to evolve from the sand binder mixture contained in the holding chamber.

Figure 4-1 Overlay Plots of TGOC and PID Analyzers and Sand Temperature



The analytical results indicate that the major analytes included phenol, formaldehyde, and ammonia with trace levels of other VOCs and HAPs (details provided in Appendix B). The ammo-

nia values show significant scatter but no cause can be assigned to this variation between runs. Target analyte quantitation limits expressed in pounds per ton of sand and pounds per pound of binder are shown in Appendix B.

APPENDIX A TEST PLANS, SAMPLING PLANS AND PROCESS INSTRUCTIONS FOR TEST GT

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TECHNIKON TEST PLAN

- CONTRACT NUMBER: **1410** TASK NUMBER**: 1.2.6** SERIES: **GT**
- SITE: **Pre-production**
- TEST TYPE: **Hotbox Core Making and Core Storage**
- METAL TYPE: **None**
- MOLD TYPE: **None**
- NUMBER OF MOLDS: **Engineering runs as required, 6 Test runs**
- CORE TYPE: **Step: 1.6 % (BOS) HA International 747 Hot box resin and 18 % (BOR) 89FR Hotbox catalyst.**
- CORE COATING: **None**
- SAMPLE EVENTS: **6**
- ANALYTE LIST: **List E + Ammonia**
- TEST DATE: START: **6/13/2005**
  FINISHED: **6/24/2005**

TEST OBJECTIVES:

Establish a comparative emission profile from a representative hot box core binder for the combined core making and core storage processes.

VARIABLES:

Seven & a quarter pounds of mixed hot box sand will be placed in an enclosed metal sample chamber within an electrically heated oven preheated and maintained at 350 oF. The Emission sampling will be continuous for a period sufficient to capture all the emission byproducts, a time yet to be determined by pre-test engineer trials.

The making portion of the test will be the first few minutes wherein, by the pre-test TGOC analysis, it is determined that the chemical reactions are occurring. The storage portion will be the remainder of the sampling period wherein the reacted components are diffusing from the core to escape from the core surface. Since only the total core processing emissions are of interest, the tube samples will represent the emissions over the entire collection period. The TGOC and other e-bench real time emission measurements can be electronically post processed to subdivide the sampling period as deemed prudent.

BRIEF OVERVIEW:

The curing in the hot box chemical system proceeds in the aqueous environment of the binder film on the sand. This chemical system will proceed at room temperature but its rate of cure is accelerated by increasing the sand, meaning the water, temperature.

In commercial practice the cores are cured in core tooling that is significantly hotter than the boiling temperature of the water, typically 400-475°F. That temperature could lead to binder deterioration, but is done to force enough heat into the sand quickly that enough of the core sand mass is sufficiently cured within the cycle time of the core machine to allow the core to be successfully ejected. The cores are then finish cured in a post cure oven at a lower temperature that will not deteriorate the core binder, typically 300-350°F. Since the type and quantity of byproducts of the hot box cure are not cure rate dependent, and our tests need not be encumbered by the necessities of production rate, and we can avoid any binder deterioration we will combine the make (cure), post –cure processes into one process at the post cure temperature for as long as is necessary to capture all the emissions.

SPECIAL CONDITIONS:

The emissions will exit the sample chamber through the bottom via a stand pipe whose open top is in the air space above curing sand. The circular lid to the sample chamber will be shimmed open on its perimeter to provide an annular aperture for heated oven makeup air to enter. The opening of the aperture will be engineered to provide a radially oriented inward air flow to assure no emission escape and a minimal pressure drop.

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/21/2005											
RUN 1											
THC	GT001	X									TOTAL
PID	GT001	X							30	1	TOTAL
M-18	GT00101								30	2	Carbopak charcoal
M-18	GT00102				1				0		Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 1500	GT00103		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GT00104				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								200	6	Excess
TO11	GT00105		1						200	7	DNPH Silica Gel (SKC 226-119)
TO11	GT00106				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								200	8	Excess
NIOSH 6016	GT00107		1						200	9	Acid Silica Gel (SKC 226-10-06)
NIOSH 6016	GT00108				1				0		Acid Silica Gel (SKC 226-10-06)
	Excess								200	10	Excess
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/21/2005											
RUN 2											
THC	GT002	X									TOTAL
PID	GT002	X							30	1	TOTAL
M-18	GT00201		1						30	2	Carbopak charcoal
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 1500	GT00202		1						200	5	100/50 mg Charcoal (SKC 226-01)
	Excess								200	6	Excess
TO11	GT00203		1						200	7	DNPH Silica Gel (SKC 226-119)
	Excess								200	8	Excess
NIOSH 6016	GT00204		1						200	9	Acid Silica Gel (SKC 226-10-06)
	Excess								200	10	Excess
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/21/2005											
RUN 3											
THC	GT003	X									TOTAL
PID	GT003	X							30	1	TOTAL
M-18	GT00301		1						30	2	Carbopak charcoal
M-18 MS	GT00302		1						30	3	Carbopak charcoal
M-18 MS	GT00303			1					30	4	Carbopak charcoal
NIOSH 1500	GT00304		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GT00305			1					200	6	100/50 mg Charcoal (SKC 226-01)
TO11	GT00306		1						200	7	DNPH Silica Gel (SKC 226-119)
TO11	GT00307			1					200	8	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	GT00308		1						200	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	GT00309			1					200	10	DNPH Silica Gel (SKC 226-119)
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/22/2005											
RUN 4											
THC	GT004	X									TOTAL
PID	GT004	X							30	1	TOTAL
M-18	GT00401								30	2	Carbopak charcoal
M-18	GT00402		1						30	3	Carbopak charcoal
	Excess								30	4	Excess
NIOSH 1500	GT00403		1						200	5	100/50 mg Charcoal (SKC 226-01)
	Excess								200	6	Excess
TO11	GT00404		1						200	7	DNPH Silica Gel (SKC 226-119)
	Excess								200	8	Excess
NIOSH 6016	GT00405		1						200	9	Acid Silica Gel (SKC 226-10-06)
	Excess								200	10	Excess
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/22/2005											
RUN 5											
THC	GT005	X									TOTAL
PID	GT005	X							30	1	TOTAL
M-18	GT00501		1						30	2	Carbopak charcoal
M-18	GT00502					1			30	2	Carbopak charcoal
M-18	GT00509		1						30	3	Carbopak charcoal
M-18	GT00510			1					30	4	Carbopak charcoal
NIOSH 1500	GT00503		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GT00504					1			200	5	100/50 mg Charcoal (SKC 226-01)
	Excess								200	6	Excess
TO11	GT00505		1						200	7	DNPH Silica Gel (SKC 226-119)
TO11	GT00506					1			200	7	DNPH Silica Gel (SKC 226-119)
	Excess								200	8	Excess
NIOSH 6016	GT00507		1						200	9	Acid Silica Gel (SKC 226-10-06)
NIOSH 6016	GT00508					1			200	9	Acid Silica Gel (SKC 226-10-06)
	Excess								200	10	Excess
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GT - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/22/2005											
RUN 6											
THC	GT006	X									TOTAL
PID	GT006	X							30	1	TOTAL
M-18	GT00601		1						30	2	Carbopak charcoal
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 1500	GT00602		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GT00603					1			200	5	100/50 mg Charcoal (SKC 226-01)
	Excess								200	6	Excess
TO11	GT00604		1						200	7	DNPH Silica Gel (SKC 226-119)
TO11	GT00605					1			200	7	DNPH Silica Gel (SKC 226-119)
	Excess								200	8	Excess
NIOSH 6016	GT00606		1						200	9	Acid Silica Gel (SKC 226-10-06)
NIOSH 6016	GT00607					1			200	9	Acid Silica Gel (SKC 226-10-06)
	Excess								200	10	Excess
	Excess								200	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

Series GT

Hot Box Core Making and Core Storage
Process Instructions

A. Experiment:
- **1.** Measure selected HAP and VOC emissions from hot box core making & curing.
- **2.** Measure selected HAP and VOC emissions from hot box core storage.

B. Materials.
- **1.** Hot box core:
  - **a.** Part I: HA International 747 hot box resin.
  - **b.** Part II: HA International 89FR hot box catalyst.
  - **c.** Wedron 530 Silica sand.

Caution
Observe all safety precautions attendant to these operations as delineated in the Pre-production operating and safety instruction manual as applicable to bldg. 238.

C. Hot box core sand mixing.
- **1.** Preheat the Accutherm oven to 350°F.
- **2.** The hot box core sand shall be 1.6% total binder (BOS) and 18% (BOR) catalyst.
- **3.** Weigh the amount of sand per the recipe and add it to the Hobart mixing bowl.
- **4.** Add the appropriate amount of catalyst per recipe and mix on speed setting '2' for 1 minute.
- **5.** Scrape the sides of the bowl.
- **6.** Restart the mixer; add the appropriate amount of resin per recipe while the Hobart mixer is mixing for three minutes.
- **7.** Scrape the sides of the bowl again.
- **8.** Mix for 1 minute more.
- **9.** Pour the contents of the bowl into a disposable grease resistant paper container, weigh it, and record the weight.
- **10.** Pour the contents into the heated emission enclosure inside the oven.
- **11.** Smooth the surface and place the three .005" shims equidistant on the rim of the emissions enclosure and replace the lid.
- **12.** Close the door and control temperature inside the oven to 350°F.
- **13.** Weigh back and record the results of the grease resistant paper container.

Caution
Observe all safety precautions attendant to these operations as the oven and its contents will be hot.

D. Measure emissions for a total of 1 hour per sample plan.

E. Core Removal
- **1.** After notification by the emissions team remove the emission enclosure, and let cool.

2. Remove the core and record weight.
3. Save core for LOI testing

Thomas Fennell
Project Engineer

APPENDIX B DETAILED EMISSIONS DATA FOR TEST GT

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Detailed Emissions – Lb/Lb Binder

HAPs	POMs	COMPOUND/RUN NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
		Emissions Indicators								
		TGOC as Propane	2.61E-02	2.66E-02	2.55E-02	2.55E-02	2.65E-02	2.58E-02	2.60E-02	4.90E-04
		HC as n-Hexane	1.05E-03	2.18E-03	2.53E-03	1.07E-03	2.31E-03	2.71E-03	1.98E-03	7.32E-04
		Sum of Target VOCs	NT	9.00E-03	8.62E-03	8.63E-03	9.15E-03	9.24E-03	8.93E-03	2.91E-04
		Sum of Target HAPs	NT	9.00E-03	8.62E-03	8.63E-03	9.15E-03	9.24E-03	8.93E-03	2.91E-04
		Sum of Target POMs	NT	7.15E-03	6.85E-03	6.98E-03	7.27E-03	7.29E-03	7.11E-03	1.89E-04
		Specific Target HAPs								
x		Phenol	NT	7.13E-03	6.83E-03	6.93E-03	7.25E-03	7.27E-03	7.08E-03	1.92E-04
x		Formaldehyde	1.74E-03	1.84E-03	1.77E-03	1.64E-03	1.88E-03	1.95E-03	1.80E-03	1.10E-04
x		Acetaldehyde	3.47E-05	2.50E-05	1.72E-05	5.12E-05	2.38E-05	2.18E-05	2.90E-05	1.23E-05
x	z	1-Methylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Benzene	NT	ND	ND	ND	ND	ND	ND	NA
x		Toluene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	Naphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Propionaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
x	z	2-Methylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Hexane	NT	ND	ND	ND	ND	ND	ND	NA
x		m,p-Cresol	NT	ND	ND	ND	ND	ND	ND	NA
x	z	1,6-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		o-Cresol	NT	ND	ND	ND	ND	ND	ND	NA
x	z	1,8-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	1,3-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	2,7-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	1,5-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	2,3-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Biphenyl	NT	ND	ND	ND	ND	ND	ND	NA
x	z	1,2-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA

I: Invalidated
NA: Not Applicable
ND: Below the Quantitation limit shown in the tables at the end of this appendix.
NT: Not Tested

Detailed Emissions – Lb/Lb Binder

HAPs	POMs	COMPOUND/RUN NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
x		m,p-Xylene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	2,3,5-Trimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Ethylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
x		Styrene	NT	ND	ND	ND	ND	ND	ND	NA
x		o-Xylene	NT	ND	ND	ND	ND	ND	ND	NA
x	z	Acenaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		2-Butanone	ND	ND	ND	ND	ND	ND	ND	NA
x	z	2,6-Dimethylnaphthalene	NT	ND	ND	ND	ND	ND	ND	NA
x		Acrolein	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		1,2,4-Trimethylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
		1,2,3-Trimethylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
		n- Propylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	NT	ND	ND	ND	ND	ND	ND	NA
		Decane	NT	ND	ND	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
		1,3-Diethylbenzene	NT	ND	ND	ND	ND	ND	ND	NA
		2,4-Dimethylphenol	NT	ND	ND	ND	ND	ND	ND	NA
		Indene	NT	ND	ND	ND	ND	ND	ND	NA
		3-Ethyltoluene	NT	ND	ND	ND	ND	ND	ND	NA
		Undecane	NT	ND	ND	ND	ND	ND	ND	NA
		Heptane	NT	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	NT	ND	ND	ND	ND	ND	ND	NA
		2-Ethyltoluene	NT	ND	ND	ND	ND	ND	ND	NA
		Butyraldehyde/Methacrolein	ND	ND	ND	ND	ND	ND	ND	NA
		Nonane	NT	ND	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	NA

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Detailed Emissions – Lb/Lb Binder

HAPs	POMs	COMPOUND/RUN NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
		Indan	NT	ND	ND	ND	ND	ND	ND	NA
		Octane	NT	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Cyclohexane	NT	ND	ND	ND	ND	ND	ND	NA
		Dodecane	NT	ND	ND	ND	ND	ND	ND	NA
		Benzaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target Analytes								
		Ammonia	1.11E-04	2.85E-04	1.40E-04	5.15E-04	3.19E-04	3.78E-04	2.91E-04	1.51E-04

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Detailed Emissions – Lb/Tn Cores

HAPs	POMs	COMPOUND/RUM NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
		Emission Indicators								
		TGOC as Propane	8.03E-01	8.29E-01	8.03E-01	7.91E-01	8.19E-01	7.92E-01	8.06E-01	1.50E-02
		HC as n-Hexane	3.24E-02	6.79E-02	7.98E-02	3.32E-02	7.14E-02	8.33E-02	6.13E-02	2.28E-02
		Sum of Target VOCs	5.45E-02	2.81E-01	2.72E-01	2.67E-01	2.82E-01	2.84E-01	2.40E-01	9.11E-02
		Sum of Target HAPs	5.45E-02	2.81E-01	2.72E-01	2.67E-01	2.82E-01	2.84E-01	2.40E-01	9.11E-02
		Sum of Target POMs	1.07E-03	2.23E-01	2.16E-01	2.16E-01	2.24E-01	2.24E-01	1.84E-01	8.97E-02
		Specific Target HAPs								
x		Phenol	I	2.22E-01	2.15E-01	2.15E-01	2.24E-01	2.23E-01	2.20E-01	4.34E-03
x		Formaldehyde	5.35E-02	5.75E-02	5.57E-02	5.10E-02	5.81E-02	5.99E-02	5.59E-02	3.27E-03
x		Acetaldehyde	1.07E-03	7.81E-04	5.41E-04	1.59E-03	7.35E-04	6.70E-04	8.97E-04	3.80E-04
x	z	1-Methylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		Benzene	I	ND	ND	ND	ND	ND	ND	NA
x		Toluene	I	ND	ND	ND	ND	ND	ND	NA
x	z	Naphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		Propionaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
x	z	2-Methylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		Hexane	I	ND	ND	ND	ND	ND	ND	NA
x		m,p-Cresol	I	ND	ND	ND	ND	ND	ND	NA
x	z	1,6-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		o-Cresol	I	ND	ND	ND	ND	ND	ND	NA
x	z	1,8-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x	z	1,3-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x	z	2,7-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x	z	1,5-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x	z	2,3-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA

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NT: Not Tested

Detailed Emissions – Lb/Tn Cores

HAPs	POMs	COMPOUND/RUM NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
x		Biphenyl	I	ND	ND	ND	ND	ND	ND	NA
x	z	1,2-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		m,p-Xylene	I	ND	ND	ND	ND	ND	ND	NA
x	z	2,3,5-Trimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		Ethylbenzene	I	ND	ND	ND	ND	ND	ND	NA
x		Styrene	I	ND	ND	ND	ND	ND	ND	NA
x		o-Xylene	I	ND	ND	ND	ND	ND	ND	NA
x	z	Acenaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		2-Butanone	ND	ND	ND	ND	ND	ND	ND	NA
x	z	2,6-Dimethylnaphthalene	I	ND	ND	ND	ND	ND	ND	NA
x		Acrolein	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		1,2,4-Trimethylbenzene	I	ND	ND	ND	ND	ND	ND	NA
		1,2,3-Trimethylbenzene	I	ND	ND	ND	ND	ND	ND	NA
		n- Propylbenzene	I	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	I	ND	ND	ND	ND	ND	ND	NA
		Decane	I	ND	ND	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	I	ND	ND	ND	ND	ND	ND	NA
		1,3-Diethylbenzene	I	ND	ND	ND	ND	ND	ND	NA
		2,4-Dimethylphenol	I	ND	ND	ND	ND	ND	ND	NA
		Indene	I	ND	ND	ND	ND	ND	ND	NA
		3-Ethyltoluene	I	ND	ND	ND	ND	ND	ND	NA
		Undecane	I	ND	ND	ND	ND	ND	ND	NA
		Heptane	I	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	I	ND	ND	ND	ND	ND	ND	NA
		2-Ethyltoluene	I	ND	ND	ND	ND	ND	ND	NA

I: Invalidated
NA: Not Applicable
ND: Below the Quantitation limit shown in the tables at the end of this appendix.
NT: Not Tested

Detailed Emissions – Lb/Tn Cores

HAPs	POMs	COMPOUND/RUM NUMBER	GT001	GT002	GT003	GT004	GT005	GT006	Average	STDEV
		Test Dates	6/21/2005	6/21/2005	6/21/2005	6/22/2005	6/22/2005	6/22/2005		
		Butyraldehyde/Methacrolein	ND	ND	ND	ND	ND	ND	ND	NA
		Nonane	I	ND	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Indan	I	ND	ND	ND	ND	ND	ND	NA
		Octane	I	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Cyclohexane	I	ND	ND	ND	ND	ND	ND	NA
		Dodecane	I	ND	ND	ND	ND	ND	ND	NA
		Benzaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target Analytes								
		Ammonia	3.41E-03	8.90E-03	4.42E-03	1.60E-02	9.84E-03	1.16E-02	9.02E-03	4.65E-03

I: Invalidated
NA: Not Applicable
ND: Below the Quantitation limit shown in the tables at the end of this appendix.
NT: Not Tested

GT Quantitation Limits – Lb/Lb Binder

Analyte	Lb/Lb Binder
1,2,3-Trimethylbenzene	7.57E-06
1,2,4-Trimethylbenzene	7.57E-06
1,2-Dimethylnaphthalene	3.78E-05
1,3,5-Trimethylbenzene	7.57E-06
1,3-Diethylbenzene	3.78E-05
1,3-Dimethylnaphthalene	7.57E-06
1,5-Dimethylnaphthalene	3.78E-05
1,6-Dimethylnaphthalene	3.78E-05
1,8-Dimethylnaphthalene	3.78E-05
1-Methylnaphthalene	7.57E-06
2,3,5-Trimethylnaphthalene	3.78E-05
2,3-Dimethylnaphthalene	3.78E-05
2,4-Dimethylphenol	3.78E-05
2,6-Dimethylnaphthalene	3.78E-05
2,6-Dimethylphenol	3.78E-05
2,7-Dimethylnaphthalene	3.78E-05
2-Butanone	1.54E-05
2-Ethyltoluene	7.57E-06
2-Methylnaphthalene	7.57E-06
3-Ethyltoluene	3.78E-05
Acenaphthalene	3.78E-05

Analyte	Lb/Lb Binder
Acetaldehyde	1.54E-05
Acrolein	1.54E-05
Ammonia	8.93E-05
Benzaldehyde	1.54E-05
Benzene	7.57E-06
Biphenyl	3.78E-05
Butyraldehyde/Methacrolein	2.57E-05
Crotonaldehyde	1.54E-05
Cyclohexane	3.78E-05
Decane	3.78E-05
Dodecane	3.78E-05
Ethylbenzene	7.57E-06
Formaldehyde	1.54E-05
Heptane	3.78E-05
Hexaldehyde	1.54E-05
Hexane	7.57E-06
Indan	3.78E-05
Indene	3.78E-05
m,p-Cresol	3.78E-05
m,p-Xylene	7.57E-06
Naphthalene	7.57E-06

Analyte	Lb/Lb Binder
Nonane	3.78E-05
o,m,p-Tolualdehyde	4.11E-05
o-Cresol	3.78E-05
Octane	3.78E-05
o-Xylene	7.57E-06
Pentanal	1.54E-05
Phenol	3.78E-05
Propionaldehyde	1.54E-05
Propylbenzene, n-	3.78E-05
Styrene	7.57E-06
Tetradecane	3.78E-05
Toluene	7.57E-06
Undecane	7.57E-06

GT Quantitation Limits – Lb/Tn Sand

Analytes	Lb/Tn Sand
1,2,3-Trimethylbenzene	2.35E-04
1,2,4-Trimethylbenzene	2.35E-04
1,2-Dimethylnaphthalene	1.17E-03
1,3,5-Trimethylbenzene	2.35E-04
1,3-Diethylbenzene	1.17E-03
1,3-Dimethylnaphthalene	2.35E-04
1,5-Dimethylnaphthalene	1.17E-03
1,6-Dimethylnaphthalene	1.17E-03
1,8-Dimethylnaphthalene	1.17E-03
1-Methylnaphthalene	2.35E-04
2,3,5-Trimethylnaphthalene	1.17E-03
2,3-Dimethylnaphthalene	1.17E-03
2,4-Dimethylphenol	1.17E-03
2,6-Dimethylnaphthalene	1.17E-03
2,6-Dimethylphenol	1.17E-03
2,7-Dimethylnaphthalene	1.17E-03
2-Butanone	4.78E-04
2-Ethyltoluene	2.35E-04
2-Methylnaphthalene	2.35E-04
3-Ethyltoluene	1.17E-03
Acenaphthalene	1.17E-03

Analytes	Lb/Tn Sand
Acetaldehyde	4.78E-04
Acrolein	4.78E-04
Ammonia	2.80E-03
Benzaldehyde	4.78E-04
Benzene	2.35E-04
Biphenyl	1.17E-03
Butyraldehyde/Methacrolein	7.97E-04
Crotonaldehyde	4.78E-04
Cyclohexane	1.17E-03
Decane	1.17E-03
Dodecane	1.17E-03
Ethylbenzene	2.35E-04
Formaldehyde	4.78E-04
Heptane	1.17E-03
Hexaldehyde	4.78E-04
Hexane	2.35E-04
Indan	1.17E-03
Indene	1.17E-03
m,p-Cresol	1.17E-03
m,p-Xylene	2.35E-04
Naphthalene	2.35E-04

Analytes	Lb/Tn Sand
Nonane	1.17E-03
o,m,p-Tolualdehyde	1.28E-03
o-Cresol	1.17E-03
Octane	1.17E-03
o-Xylene	2.35E-04
Pentanal	4.78E-04
Phenol	1.17E-03
Propionaldehyde	4.78E-04
Propylbenzene, n-	1.17E-03
Styrene	2.35E-04
Tetradecane	1.17E-03
Toluene	2.35E-04
Undecane	2.35E-04

APPENDIX C DETAILED PROCESS DATA FOR TEST GT

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Test Series GT Detailed Process Data

Test Date	06/16/05	06/17/05	06/20/05	06/21/05	06/21/05	06/21/05	06/22/05	06/22/05	06/22/05		
Emissions Sample #	GTER1	GTER2	GTER3	GT001	GT002	GT003	GT004	GT005	GT006		
Production Run Number	GT001	GT002	GT003	GT004	GT005	GT006	GT007	GT008	GT009	Average	St Dev
Raw sand weight, gm	3229.6	3229.7	3229.4	3229.4	3229.4	3229.4	3229.7	3229.5	3229.7	3229.5	0.15
747 Hot box Resin weight, gm	51.2	51.3	51.2	51.4	51.9	52.4	51.7	51.4	51.2	51.7	0.44
Hot Box Catalyst, gm	9.2	9.5	9.3	9.3	9.3	9.4	9.4	9.2	9.2	9.3	0.09
% Resin (BOS)	1.59	1.59	1.59	1.59	1.61	1.62	1.60	1.59	1.59	1.6	0.01
% Catalyst (BOR)	17.97	18.52	18.16	18.09	17.92	17.94	18.18	17.90	17.97	18.0	0.11
% Binder (BOS)	1.87	1.88	1.87	1.88	1.90	1.91	1.89	1.88	1.87	1.9	0.02
% Binder	1.84	1.85	1.84	1.84	1.86	1.88	1.86	1.84	1.84	1.9	0.02
Sand weight in emission chamber before test (gms)	3230.5	3258.5	3241.6	3253.2	3239.5	3236.3	3235.8	3241.1	3243.8	3241.6	6.42
Binder weight, (lbs)	0.1307	0.1327	0.1314	0.1323	0.1328	0.1339	0.1324	0.1316	0.1313	0.1324	0.0010
Sand weight in emission chamber after test (gms)	2191	3232	3212.3	3222.1	3207.8	3200	3209.9	3205	3217.2	3210.3	8.09
Weight loss during test, %	32.2	0.8	0.9	1.0	1.0	1.1	0.8	1.1	0.8	1.0	0.14
Sand initial temperature, F	71.2	71.1	73.8	73.9	74.5	75.4	72.1	73.6	75.3	74.1	1.23
Sand Mean Temperature, F	ND	211.7	245.2	223	225.8	221.3	241.4	237.5	233.8	230.5	8.27
Oven Mean air Temperature, F	ND	ND	346.5	341.1	348.7	343.6	364.6	346.2	346.2	348.4	8.35
Sand (after test) % LOI 1800 F	1.20	1.24	1.23	1.25	1.26	1.28	1.25	1.27	1.26	1.3	0.01
Total test period, Minutes	60	60	60	60	60	60	60	60	60	60.0	0.00

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APPENDIX D CHARTS OF EXPERIMENTAL PARAMETERS MONITORED FOR GT

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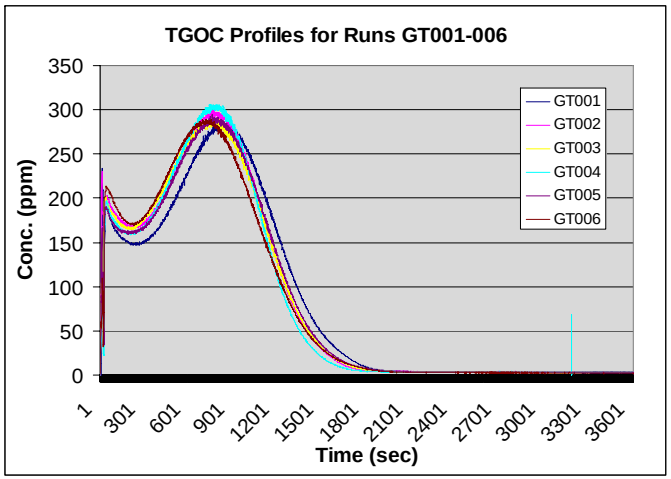
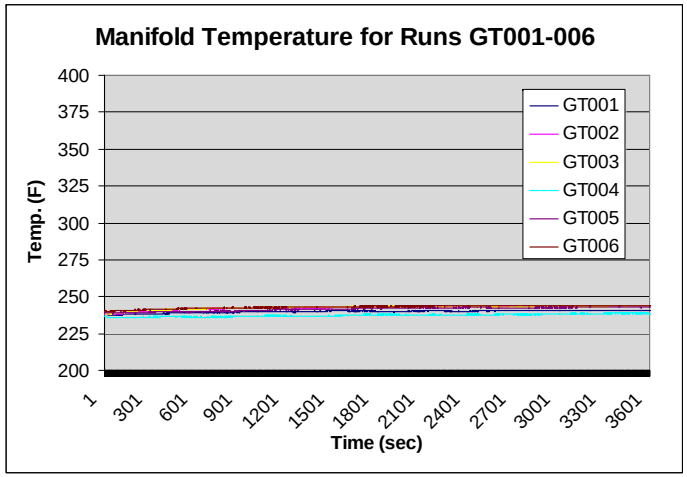
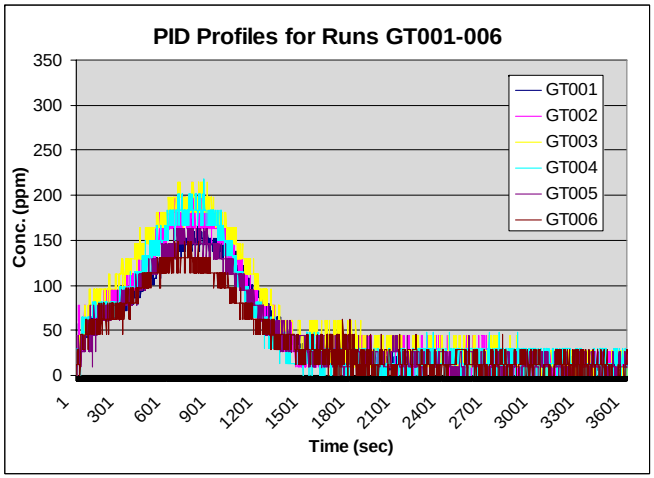
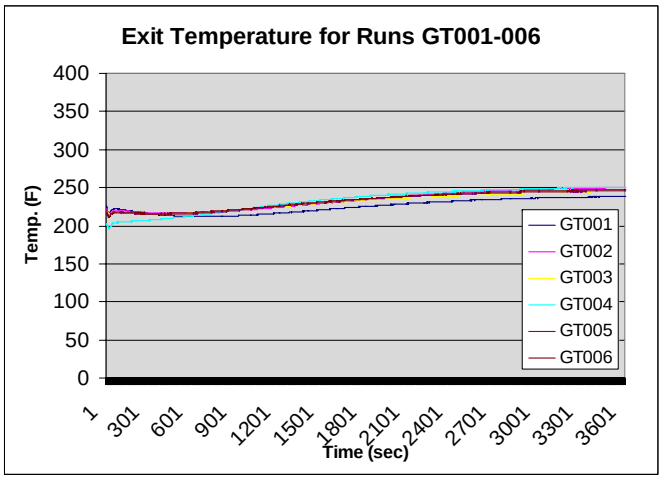
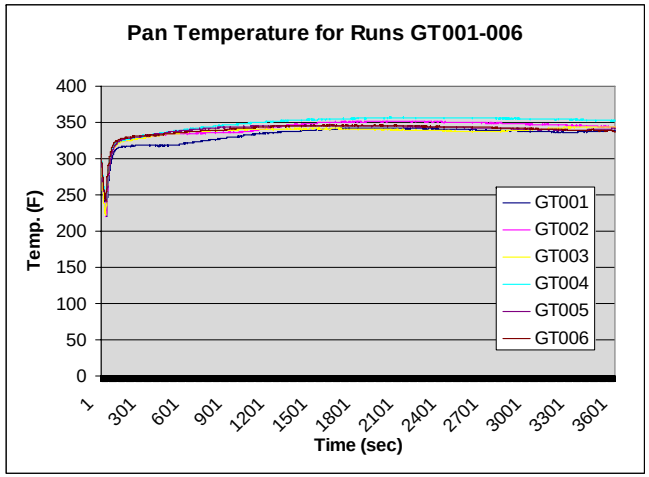
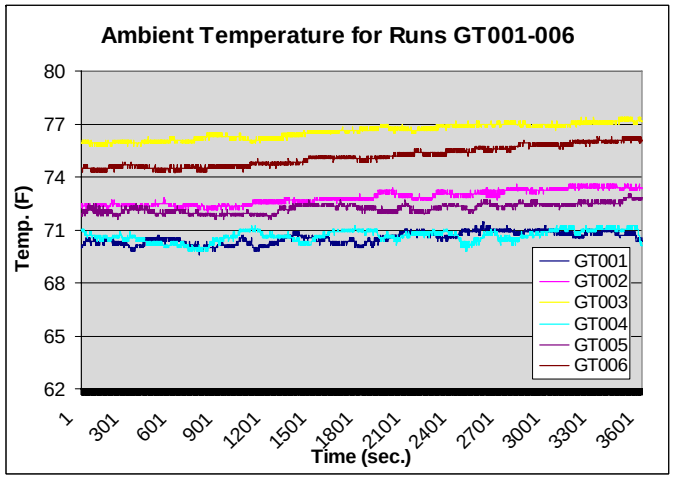

TGOC Profiles for Runs GT001-006
Conc. (ppm)
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006

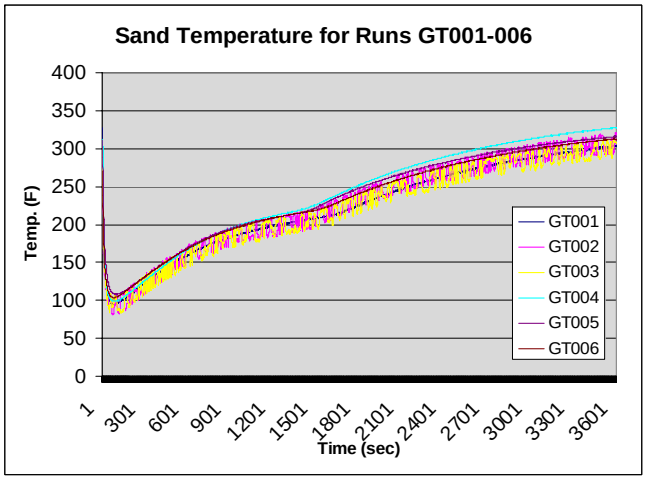

Manifold Temperature for Runs GT001-006
Temp. (F)
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006


PID Profiles for Runs GT001-006
Conc. (ppm)
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006


Exit Temperature for Runs GT001-006
Temp. (F)
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006


Pan Temperature for Runs GT001-006
Temp. (F)
400
350
300
250
200
150
100
50
0
1
301
601
901
1201
1501
1801
2101
2401
2701
3001
3301
3601
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006


Ambient Temperature for Runs GT001-006
Temp. (F)
80
77
74
71
68
65
62
1
301
601
901
1201
1501
1801
2101
2401
2701
3001
3301
3601
Time (sec.)
GT001
GT002
GT003
GT004
GT005
GT006


Sand Temperature for Runs GT001-006
Temp. (F)
400
350
300
250
200
150
100
50
0
1
301
601
901
1201
1501
1801
2101
2401
2701
3001
3301
3601
Time (sec)
GT001
GT002
GT003
GT004
GT005
GT006

APPENDIX E EQUIPMENT SPECIFICATIONS

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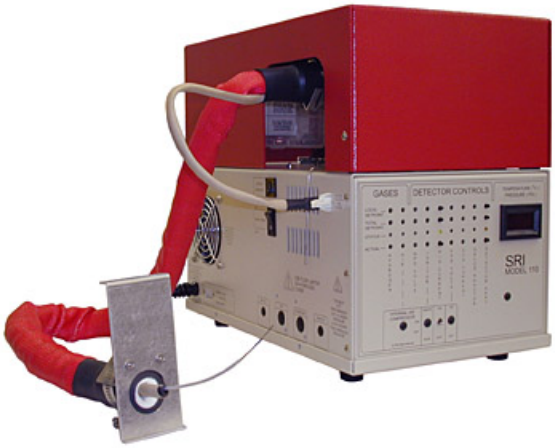
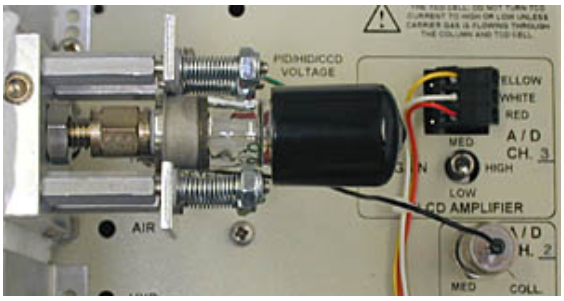
Photo Ionization Analyzer (Model 110)





from SRI Instruments

The Photo Ionization Detector (PID) responds to all molecules whose ionization potential is below 10.6eV, including aromatics and molecules with carbon double bonds. The PID is nondestructive, so the sample can be routed through the PID and on to other detectors. ID detection limits for aromatics are in the ppb range; purge and trap concentration of the sample can lower detection limits to the ppt range. The PID detector consists of a 10.6 electron volt (eV) UV lamp mounted on a thermostatted, low-volume (100µL), flow-through cell. The temperature is adjustable from ambient to 250°C. Three detector gain levels (LOW, MEDIUM and HIGH) are provided for a wide range of sample concentrations. The PID lamp is held in place by a spring-loaded plate, so that the lamp may be quickly removed for cleaning and replaced without any special tools. The PID can run on air carrier for gasless operation, or for stream monitoring applications where the entire stream of sample is directed through the detector (no column is used).

Theory of Operation

The SRI PID design uses a 10.6eV lamp with a high voltage power supply. Sample laden carrier gas flows from the analytical column into the PID sample inlet, where it is streamed through a 100µL flow-through cell. When sample molecules flow into the cell, they are bombarded by the UV light beam. Molecules with an ionization potential lower than 10.6eV release an ion when struck by the ultraviolet photons. These ions are attracted to a collector electrode, and then sent to the amplifier to produce an analog signal, which is acquired by the data acquisition system. Unlike other PID designs that heat the entire lamp, only the lamp window of the SRI PID is heated. This results in a longer lamp life for SRI PID detectors.

General Operating Procedure

The capillary column enters the PID cell from inside the column oven through the bulkhead fitting in the insulated oven wall. The column may be installed with the lamp in place. Insert the capillary column into the PID detector inlet until the column stops at the lamp window inside the PID cell, then pull it back about 1mm from the lamp window. Tighten the 1/8" nut with the graphite ferrule at the PID inlet to secure the column in place. The collector electrode is positioned at the factory and should not touch the column under normal circumstances.

Always ensure that the black plastic hood is in place on the lamp prior to operating the PID detector. The hood contains the high voltage band which is maintained at a high potential; never attempt to adjust the PID high voltage band unless the main GC power is turned off.

Turn ON the GC. Turn ON the PID lamp current. The violet light is visible here when the lamp is on with the flip switch on the GC's front control panel. Set the PID current to 70 (= 0.70ma) with the trim pot set point on the top edge of the GC's front control panel. Use the flat blade screwdriver provided with your GC to adjust the trim pot. The lamp should emit a violet-colored light visible down the center of the tube. Confirm that the lamp is operating at or near 0.70ma by pressing the PID detector ACTUAL display button on the front control panel. The sensitivity of the lamp increases proportionally to the current applied, but operation at higher currents reduces lamp life. The PID operating current range is 70-125. A setting of 70 should provide the user with sufficient sensitivity and lamp durability. Most PID applications can be performed using LOW gain. Set the PID temperature to 150°C. Once the detector has reached temperature and the signal appears stable, sample may be introduced.

Shortridge Micro Manometer

Model ADM-870C

The ADM-870C AirDate Multimeter is designed specifically for flow measurement applications.

It provides for air velocity and flow readings to be displayed as either standard mass flow equivalent, or as local density air velocity or volumetric flow, as compensated for variations in barometric pressure and temperature.

Specifications:

AIR VELOCITY:
±3% of reading ±7 fpm 50 to 8,000 fpm pitot tube (30,000 fpm FS); 50 to 5,000 fpm Airfoil; 50 to 2500 fpm VelGrid.

DIFFERENTIAL PRESSURE:
±2% of reading ±0.001 in WC from 0.0500 to 50.00 in WC, (0.0001 to 60 in FS). 20 psid safe pressure.

TEMPERATURE:
±0.5°F accuracy from 32°F to 158°F.

AIR FLOW:
Accuracy is ±3% of reading ±7 cfm from 100 to 2000 cfm; range is 25 to 2500 cfm supply, 25 to 1500 cfm exhaust with the **8400 Flow Hood.**

ABSOLUTE PRESSURE:
±2% of reading ±0.1 in Hg from 14 to 40 in Hg referenced to vacuum. 60 psia maximum safe pressure.

AMBIENT RANGE:
Full range compensation from 40°F to 140°F.

AIR DENSITY CORRECTION:
Local air density correction range is 14 to 40 in Hg and -67°F to 250°F.

POSITION SENSITIVITY:
Unaffected by position or motion.

MEMORY:
100 readings, sequence labeled, sum, average, minimum and maximum.

CALIBRATION:
Calibration certified NIST traceable.

READOUT:
10 digit, 0.4", high contrast, liquid crystal display.

METER HOUSING:
High impact, molded, "T" grade ABS.

METER WEIGHT:
36 ounces (1.02kg), including batteries

SIZE:
6.0" x 6.4" x 2.7" (15.2 x 16.3 x 6.9 cm)

CONNECTIONS:
1/4" OD slip-on for 3/16" ID soft tubing.

BATTERY LIFE:
3000 readings per charge, 500 recharge cycles.

California Analytical
Model 300 HFID
Hydrocarbon Analyzer

DESCRIPTION

The CAI Heated Total Hydrocarbon Analyzer Model 300 HFID is designed to continuously measure the total concentration of hydrocarbons within a gaseous sample. All components in contact with the sample are maintained at the oven set temperature preventing condensation.

METHOD OF OPERATION

The Model 300 HFID uses the Flame Ionization Detection (FID) method to determine the total hydrocarbon concentration within a gaseous sample. The analyzer has an adjustable heated oven (60 TO 200°C) which contains a heated pump and a burner in which a small flame is elevated and sustained by regulated flows of air and pure hydrogen. The burner jet is used as an electrode and is connected to the negative side of a precision power supply. An additional electrode, known as the "collector," is connected to a high impedance, low noise electronic amplifier. The two electrodes establish an electrostatic field. When a gaseous sample is introduced to the burner, it is ionized in the flame and the electrostatic field causes the charged particles (ions) to migrate to their respective electrodes. The migration creates a small current between the electrodes. This current is measured by the precision electrometer amplifier and is directly proportional to the hydrocarbon concentration of the sample.

SPECIFICATIONS

ANALYSIS METHOD:
Flame Ionization Detector

MULTIPLE RANGE CAPABILITY:
Eight operation ranges - 10, 30, 100, 300, 1000, 3000, 10,000, 30,000 ppm carbon

RESOLUTION:
0.01 ppm Carbon (lowest range)

REPEATABILITY:
Better than ± 0.5% of full scale

LINEARITY:
Better than 1% of full scale

O2 EFFECT:
Less than 2% of full scale

CH4 EFFECT:
Less than 1.3 times Propane

RESPONSE TIME:
90% of full scale in 1.5 seconds

SAMPLE FLOW RATE:
With pump: 3.0 liter/min. ±1.5 liter/min.

INTERNAL SAMPLE FILTER:
0.1 micron replaceable filter provided

NOISE:
Less than ± 0.5% of full scale

ZERO & SPAN DRIFT:
Less than 1% of full scale per 24 hours

FLOW CONTROL:
Electronic Proportional Pressure Controller

FUEL REQUIREMENTS:
40% H2/60% He (100cc/min.) or 100% H2 (30cc/min.) (specify at time of order) Fuel inlet pressure 25 psig

READOUT:
As ppm CH4 or C3H8 (specify at time of order)

AIR REQUIREMENTS:
Less than 1 ppm Carbon - Purified or synthetic air (200cc/min.) Air Inlet Pressure 25psig

DISPLAY:
3-1/2 Digit Panel Meter

DIAGNOSTICS:
31/2 Digit Panel Meter with 8 Position Switch

COLLECTOR VOLTAGE:
15 VDC

ANALOG OUTPUT:
0-10 VDC & 4-20 mA DC/0-20 mA DC

FUEL/AIR CONTROL:
Forward Pressure Regulator

IGNITION:
Momentary push-button with Flame-On Indicator (manual or remote control)

AMBIENT TEMPERATURE:
5-45°C

WARM-UP TIME:
1 hour

FITTINGS:
1/4" tube

POWER REQUIREMENTS:
115/230 (±10%)VAC@50/60Hz, 750watt

DIMENSIONS:
5-1/4"H x 19"W x 23"D (133mm x 483mm x 508mm)

RELATIVE HUMIDITY:
Less than 90%

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APPENDIX F ACRONYMS AND ABBREVIATIONS

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Acronyms and Abbreviations

BO( )	Based on ( ).
BOA	Based on Aggregate
BOR	Based on Resin
BOS	Based on Sand.
FPM	Feet Per Minute
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC as Hexane	Calculated by the summation of all area between elution of Hexane through the elution of Hexadecane. The quantification of HC is performed against a five-point calibration curve of Hexane by dividing the total area count from C6 through C16 to the area of Hexane from the initial calibration curve and multi-plying by the hexane mass per unit area derived from the calibration cure.
I	Invalid, Data rejected based on data validation considerations
NA	Not Applicable, Not Available
ND	Non-Detect
NT	Not Tested, Lab testing was not done
PID	Photo Ionization Detector
POM	Polycyclic Organic Matter (POM) including Naphthalene and other compounds that contain more than one benzene ring and have a boiling point greater than or equal to 100 degrees Celsius.
PPMV (PPM)	Parts Per Million by Volume
SCFM	Standard Cubic Feet per Minute
TGOC	Total Gaseous Organic Concentration
TGOC as Propane	Weighted to the detection of more volatile hydrocarbon species, beginning at C1 (methane), with results calibrated against a three-carbon alkane (propane).
VOC	Volatile Organic Compound