Casting Emission Reduction Program

Prepared by:

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Baseline Test: Pouring, Cooling, Shakeout of Coated Phenolic Urethane Core (Greensand with Seacoal, Iron)

Technikon #1411-121 GB

November 2004

Revised for public distribution

United States Environmental Protection Agency

CISA

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

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Baseline Test: Pouring, Cooling, Shakeout of Coated Phenolic Urethane Core (Greensand Seacoal, Iron)

1411-121 GB

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

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The data contained in this report were developed to provide a relative emissions baseline profile for future product or process evaluation. You may not obtain the same results in your facility. Data was not collected to assess cost or producibility.

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Executive Summary

This report contains the results of emission testing to evaluate the pouring, cooling, and shakeout emissions from Test GB, a coated phenolic urethane core in greensand with seacoal baseline. Test GB will be used as a core baseline against which other core products and processes are to be compared. All testing was conducted by Technikon, LLC in its research foundry. The emissions results are reported in both pounds of analyte per pound of binder and pounds of analyte per ton of metal poured.

The testing performed involved the collection of continuous air samples over a seventy-five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and include: the weights of the casting, mold, and binder; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack temperature, pressure, volumetric flow rate, and moisture content were also collected. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the tests runs. Samples were collected and analyzed for sixty-eight (68) target compounds using procedures 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. Carbon monoxide and carbon dioxide were also monitored according to US EPA Methods 10 and 3A, respectively.

The mass emission rate of each parameter or target compound was calculated using the continuous monitoring data or the laboratory analytical results, the measured source data and the weight of each core's binder or casting. Results for structural isomers have been grouped and reported as a single entity. For example, ortho-, meta-, and para-xylene are the three (3) structural isomers of dimethyl benzene. The individual isomer results are available in Appendix B of this report. Other "emissions indicators," in addition to the TGOC as Propane, were also calculated. The HC as Hexane results represent the sum of all organic compounds detected and expressed as Hexane. All of the following sums are sub-groups of this measure. The "Sum of Target Analytes" is based on the sum of the individual target analytes measured and includes the selected HAPs and selected Polycyclic Organic Material (POMs) listed in the Clean Air Act Amendments of 1990. The "Sum of HAPs" is the sum of the individual target HAPs measured and includes the selected POMs. Finally, the "Sum of POMs" is the sum of all of the polycyclic organic material measured.

Results for the emission indicators are shown in the following table reported in both lbs/lb of binder and lbs/tn of metal.

Test Plan GB Emissions Indicators

	TGOC as Propane	HC as Hexane	Sum of Target Analytes	Sum of HAPs	Sum of POMs
Test GB Lb/Tn Metal	2.454	0.8289	0.6581	0.5484	0.0565
Test GB Lb/Lb Binder	0.3179	0.1073	0.0845	0.0703	0.0073

Results of this test represent a new combination coated core in greensand baseline that is different from the previous CERP combination core in greensand baseline. The major differences are:

- A core coating was applied to the phenolic urethane cores and the cores dried in a 275^{o}F core drying oven.
- The resin level was reduced to 1.4% compared to the previous standard of 1.75%.
- A new pattern was used with 4 cavities versus the previous 8-on pattern.

A pictorial casting record was made of all of the cavities from each mold. Only cavity 3 is included in this report as it will be used for reference for future castings made with vendor products. The pictures are shown in rank-order in Appendix C.

It must be noted that the baseline 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). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes. Other technical partners directly supporting the project include: the American Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US EPA); and the California Air Resources Board (CARB).

1.2 TECHNIKON 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, especially for the 1990 Clean Air Act Amendment. The facility has two principal testing arenas: a Pre-Production Foundry designed to measure airborne emissions from individually poured molds, and a Production Foundry designed to measure air emissions in a continuous full scale production process. Each of these testing arenas has been specially designed to facilitate the collection and evaluation of airborne emissions and associated process data.

The Production Foundry provides simultaneous detailed individual emission measurements using methods based on US EPA protocols for the melting, pouring, sand preparation, mold making, and core making processes.

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

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 target analyte emissions from a cored greensand system. 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 the appendices of this report. Section 4 of this report contains a discussion of the results.

The raw data for this test series are included in a data binder that is maintained at the Technikon facility.

1.4 SPECIFIC TEST PLAN AND OBJECTIVES

Table 1-1 provides a summary of the test plan. The details of the approved test plan are included in Appendix A.

Table 1-1 Test Plan Summary

	Test Plan
Type of Process tested	Coated Core, Greensand with Seacoal, Iron PCS Baseline
Test Plan Number	1411 121 GB
Greensand System	Wexford W450, 7% Western and Southern Bentonite, 5% Hill & Griffith Seacoal
Metal Poured	Iron
Casting Type	4-on Step Core
Core Binder	1.4% Ashland ISOCURE® 305/904
Core Coating	Ashland Velvaplast® CGW 9022SL
Anti-Veining Material	NA
Parting Spray	Black Diamond®
Number of molds poured	3 Conditioning + 9 Sampling
Test Dates	7/14/04 > 7/16/04
Emissions Measured	TGOC as Propane, Carbon Monoxide, Carbon Dioxide, HC as Hexane, 68 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate

2.0 Test Methodology

2.1 DESCRIPTION OF PROCESS AND TESTING EQUIPMENT

Figure 2-1 is a diagram of the Research Foundry process equipment.

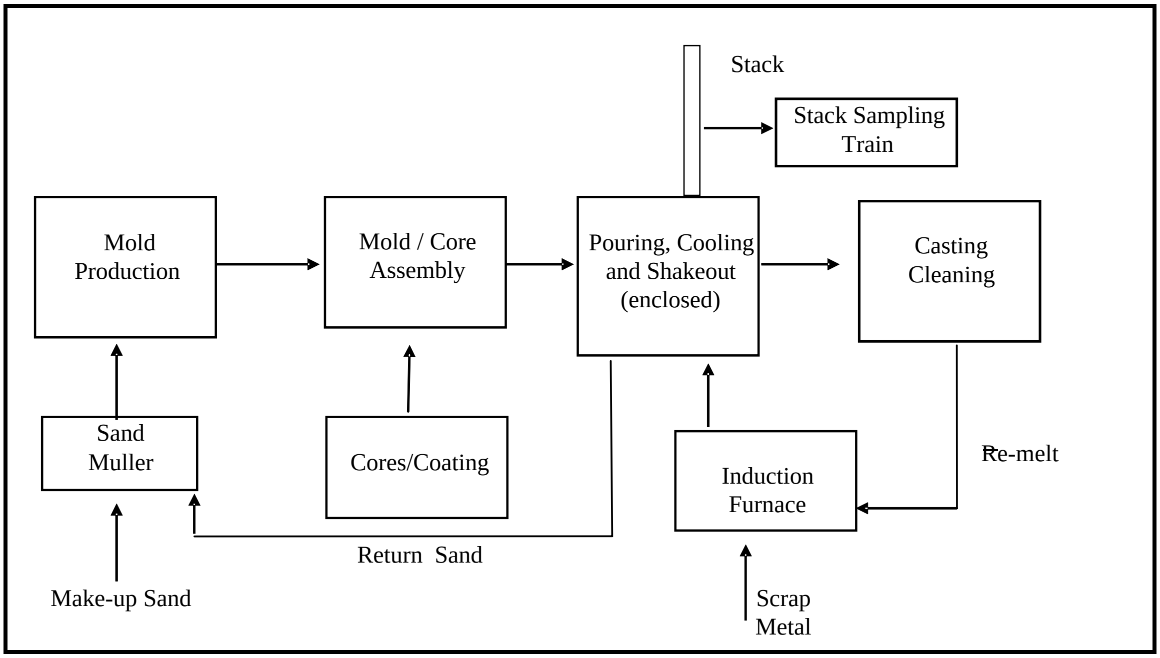


Figure 2-1 Research Foundry Layout Diagram

2.2 DESCRIPTION OF TESTING PROGRAM

The specific steps used in this sampling program are summarized below:

1. **Test Plan Review and Approval:** The proposed test plan was reviewed and approved by the Technikon staff.

Coated Step Cores

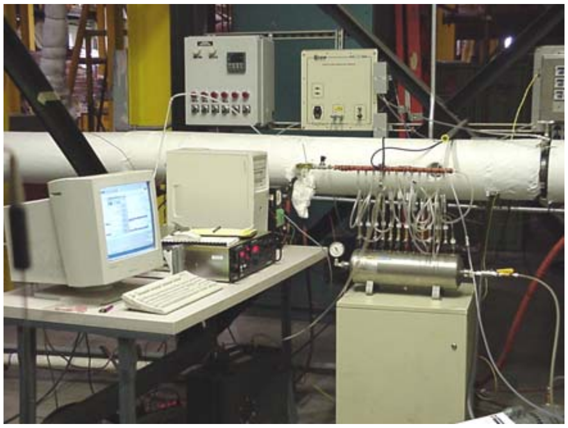
2. **<u>Mold, Core and Metal Preparation:</u>** The molds and cores were prepared to a standard composition by the Technikon production team. The cores were blown in a Redford/Carver core blower and then coated with the vendor supplied core coating. Relevant process data was collected and recorded. Iron was melted in a 1000 lb. Ajax induction furnace. The amount of metal melted was determined from the poured weight of the casting and the number of molds to be poured. The metal composition was Class-30 Gray Iron as prescribed by a metal composition worksheet. The weight of metal poured into each mold was recorded on the process data summary sheet.

3. **<u>Individual Sampling Events:</u>** Replicate tests were performed on nine (9) mold packages. The mold packages were placed into an enclosed test stand heated to approximately 85°F. Iron was poured through an opening in the top of the emission enclosure, after which the opening was closed.

   Continuous air samples were collected during the forty-five minute pouring and cooling process, during the fifteen minute shakeout of the mold, and for an additional fifteen minute period following shakeout. The total sampling time was seventy-five minutes.

Mold and Step Cores

Total Enclosure Test Stand



Method 25A (TGOC) and Method 18 Sampling Train

4. **Process Parameter Measurements:** Table 2-1 lists the process parameters that are monitored during each test. The analytical equipment and methods used are also listed.

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Cardinal 748E platform scale (Gravimetric)
Casting Weight	Cardinal 748E platform scale (Gravimetric)
Muller water weight	Cardinal 748E platform scale (Gravimetric)
Binder Weight	Mettler SB12001 Digital Scale (Gravimetric)
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold and Shakeout	Denver Instruments XE-100 Analytical Scale (AFS procedure 5100-00-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C Immersion Pyrometer)
Carbon/Silicon Fusion Temperature	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale
Mold Compactability	Dietert 319A Sand Squeezer (AFS Procedure 2221-00-S)
Carbon/Silicon	Electro-Nite DataCast 2000 (thermal arrest)

5. **Air Emissions Analysis:** The specific sampling and analytical methods used in the Pre-Production Foundry tests are 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 Standard Operating Procedures.

Table 2-2 Sampling and Analytical Methods

Measurement Parameter	Test Method
Port Location	EPA Method 1
Number of Traverse Points	EPA Method 1
Gas Velocity and Temperature	EPA Method 2
Gas Density and Molecular Weight	EPA Method 3A
Gas Moisture	EPA Method 4, gravimetric
HAPs Concentration	EPA Method 18, TO11, NIOSH 1500, 2002
VOC Concentration	EPA Method 18, 25A, TO11, NIOSH 1500, 2002
Carbon Monoxide	EPA Method 10
Carbon Dioxide	EPA Method 3A

*These methods were specifically modified to meet the testing objectives of the CERP Program.

6. **<u>Data Reduction, Tabulation and Preliminary Report Preparation</u>:** The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter, and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the casting poured to provide emissions data in both pounds of analyte per pound of binder and pounds of analyte per ton of metal.

   The results of each of the sampling events are included in the appendices of this report. The emissions results are also averaged and are shown in Tables 3-1 and 3-3.

7. **<u>Report Preparation and Review</u>:** 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-Measurement Technologies, the Vice President-Operations, the Manager-Process Engineering, and the Technikon President. Comments are incorporated into a draft Final Report prior to final signature approval and distribution.

2.3 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC) PROCEDURES

Detailed QA/QC and data validation procedures for the process parameters, stack measurements, and laboratory analytical procedures are included in the <u>Technikon Emissions Testing and Analytical Testing Standard Operating Procedures.</u> In order to ensure the timely review of critical quality control parameters, the following procedures are followed:

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

- The source (stack) and sampling parameters, analytical results and corresponding laboratory QA/QC data are reviewed by the Emissions Measurement Team to confirm the validity of the data. The VP-Measurement Technologies reviews and approves the recommendation, if any, that individual sample data should be invalidated. Invalidated data are not used in subsequent calculations.

3.0 Test Results

The average emission results in pounds per pound of binder and pounds per ton of metal are presented in Tables 3-1 and 3-2 respectively. The tables include the individual target compounds that comprise at least 95% of the total target analytes measured, along with the corresponding Sum of Target Analytes, Sum of HAPs, and Sum of POMs. The tables also include the carbon monoxide, carbon dioxide, TGOC as propane, and HC as hexane.

Figures 3-1 to 3-3 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-1 in graphical form based on binder weight.

Figures 3-4 to 3-6 present the five emissions indicators and selected HAP and VOC emissions data from Table 3-2 in graphical form based on metal weight.

Appendix B contains the detailed emissions data including the results for all analytes measured. Table 3-3 includes the averages of the key process parameters. Detailed process data are presented in Appendix C.

Method 25A charts for the test is included in Appendix D of this report. The charts are presented to show the VOC profile of emissions for each pour.

All Cavity 3 castings are shown in Appendix C.

Table 3-1 Summary of Test Plan GB Average Results – Lb/Lb Binder

Analytes	Test GB Average Lb/Lb Binder	STDEV
TGOC as Propane	0.3179	0.0316
HC as Hexane	0.1073	0.0073
Sum of Target Analytes	0.0845	0.0048
Sum of HAPs	0.0703	0.0041
Sum of POMs	0.0073	0.0012
Individual Organic HAPs		
Benzene	0.0236	0.0026
Toluene	0.0101	0.0006
Phenol	0.0100	0.0013
o,m,p-Xylene	0.0072	0.0004
o,m,p-Cresol	0.0049	0.0007
Methylnaphthalenes	0.0033	0.0006
Dimethylnaphthalenes	0.0033	0.0006
Aniline	0.0028	0.0006
Naphthalene	0.0026	0.0003
Hexane	0.0021	0.0003
Ethylbenzene	0.0012	0.0001
Acetaldehyde	0.0010	0.0001
Other VOCs		
Trimethylbenzenes	0.0026	0.0002
Octane	0.0025	0.0002
Heptane	0.0015	0.0002
Ethyltoluenes	0.0014	0.0000
Undecane	0.0013	0.0001
Nonane	0.0010	0.0001
Decane	0.0009	0.0001
Dodecane	0.0007	0.0001
Other Analytes		
Carbon Dioxide	1.296	0.2569
Carbon Monoxide	0.5481	0.0908

Individual results constitute >95% of mass of all detected Target Analytes.

All "Other Analytes" are not included in the sum of HAPs or Target Analytes.

Table 3-2 Summary of Test Plan GB Average Results – Lb/Tn Metal

Analytes	Test GB Average Lb/Tn	STDEV
TGOC as Propane	2.454	0.2498
HC as Hexane	0.8289	0.0572
Sum of Target Analytes	0.6581	0.0311
Sum of HAPs	0.5484	0.0244
Sum of POMs	0.0563	0.0065
Individual Organic HAPs		
Benzene	0.1821	0.0210
Toluene	0.0773	0.0054
Phenol	0.0773	0.0100
o,m,p-Xylene	0.0555	0.0035
o,m,p-Cresol	0.0377	0.0057
Methylnaphthalenes	0.0256	0.0044
Aniline	0.0213	0.0048
Naphthalene	0.0203	0.0025
Hexane	0.0167	0.0015
Dimethylnaphthalenes	0.0105	0.0027
Ethylbenzene	0.0096	0.0006
Acetaldehyde	0.0080	0.0006
Other VOCs		
Trimethylbenzenes	0.0204	0.0014
Octane	0.0190	0.0018
Heptane	0.0117	0.0015
Ethyltoluenes	0.0111	0.0004
Undecane	0.0100	0.0005
Nonane	0.0079	0.0009
Decane	0.0070	0.0007
Dodecane	0.0053	0.0005
Other Analytes		
Carbon Dioxide	9.996	1.960
Carbon Monoxide	4.231	0.711

Individual results constitute >95% of mass of all detected Target Analytes.

All "Other Analytes" are not included in the sum of HAPs or Target Analytes.

Table 3-3 Summary of Test Plan GB Average Process Parameters

Greensand PCS		
		Test GB
Test Dates		7/15-16/04
Cast Weight (all metal inside mold), Lbs.		106.45
Pouring Time, sec.		24
Pouring Temp ,°F		2633
Pour Hood Process Air Temp at Start of Pour, °F		86
Core Mixer Auto Dispensed Batch Weight, Lbs		49.08
Calibrated Auto Dispensed Core Binder Weight, Lbs		0.690
Core Binder Calibrated Weight, %BOS		1.41
Core Binder Calibrated Weight, %		1.39
Total Uncoated Core Weight in Mold, Lbs.		29.61
Total Binder Weight in Mold, Lbs.		0.411
Core LOI, % Note 2		1.19
Total Dried Core Coating Weight in Mold, Lbs.		0.36
Dogbone Tensile Test (Thwing-Albert psi)		236
Core Age, hrs.		75
Muller Batch Weight, Lbs.		944
GS Mold Sand Weight, Lbs.		615
Mold Compactability, %		55
Mold Temperature, °F		83
Average Green Compression , psi		21.43
GS Compactability, %		49
GS Moisture Content, %		2.51
GS MB Clay Content, %		7.49
MB Clay Reagent, ml		28.9
1800°F LOI - Mold Sand, %		5.30
900°F Volatiles , %		0.51
Appearance ranking Cav 3: 1 = best, 9 = worst	Greensand Surface Emission Run Number	Core Surface Emission Run Number
Rank1	1	2
Rank2	8	3
Rank3	3	5
Rank4	5	6
Rank5	2	1
Rank6	9	7
Rank7	4	8
Rank8	7	4
Rank9	6	9

Figure 3-1 Emission Indicators from Test Series GB – Lb/Lb Binder

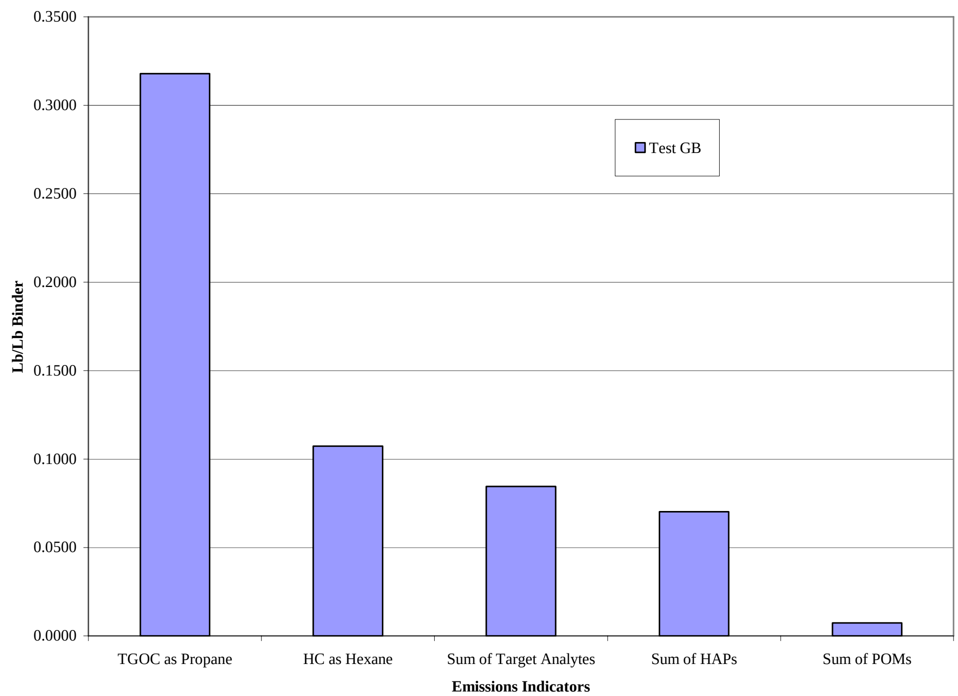


Figure 3-2 Selected HAP Emissions from Test Series GB – Lb/Lb Binder

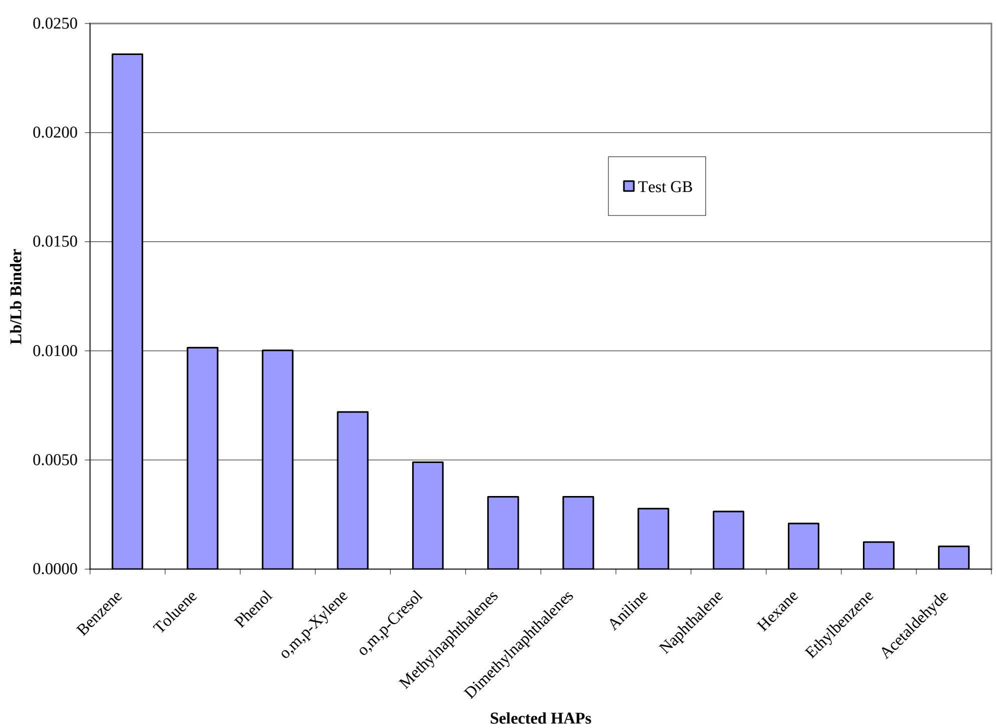


Figure 3-3 Selected VOC Emissions from Test Series GB – Lb/Lb Binder

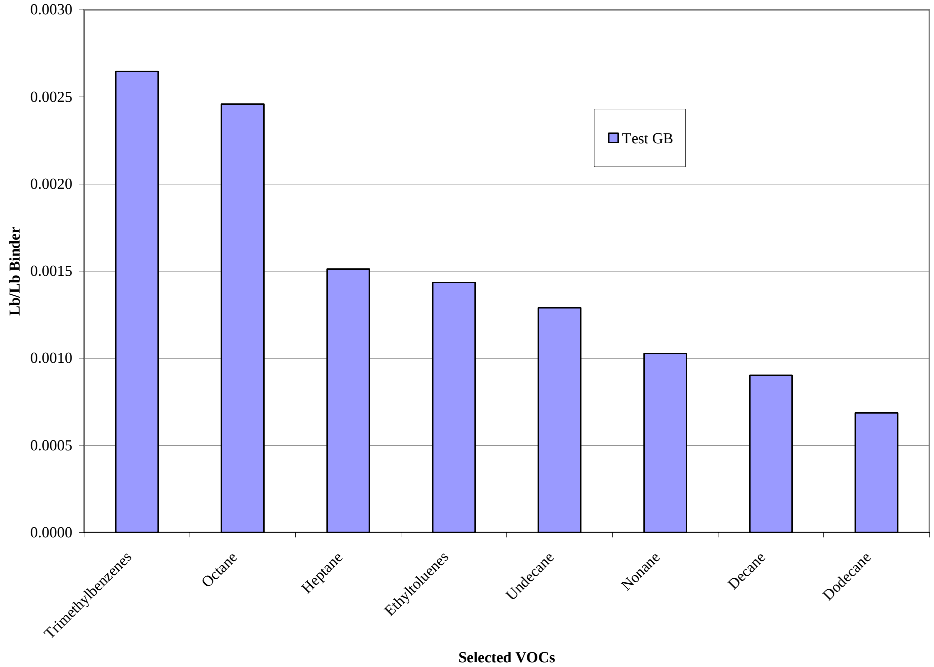


Figure 3-4 Emissions Indicators from Test Series GB – Lb/Tn Metal

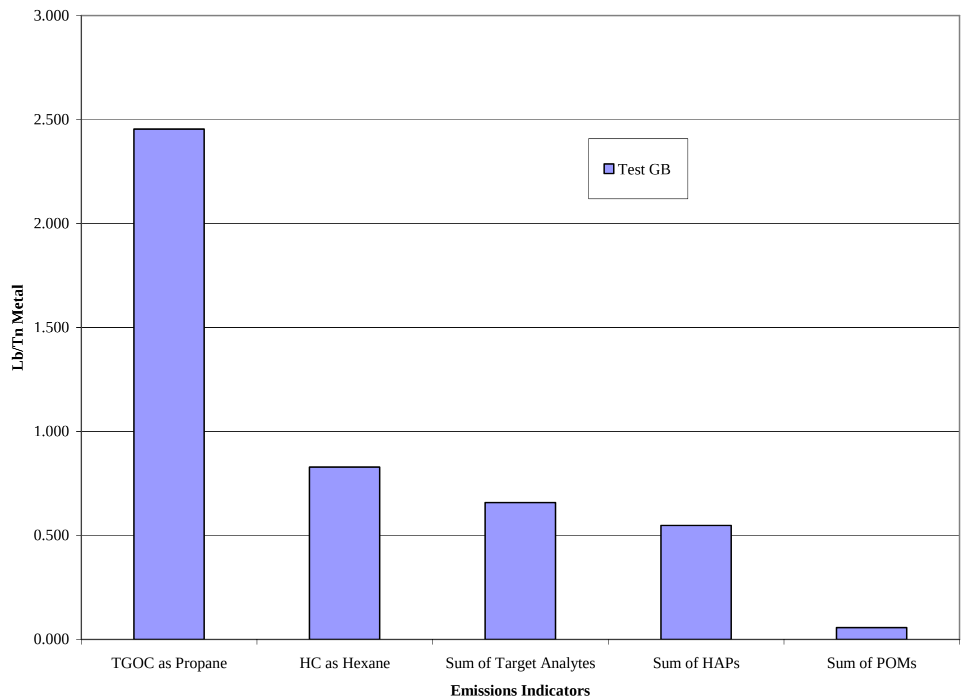


Figure 3-5 Selected HAP Emissions from Test Series GB – Lb/Tn Metal

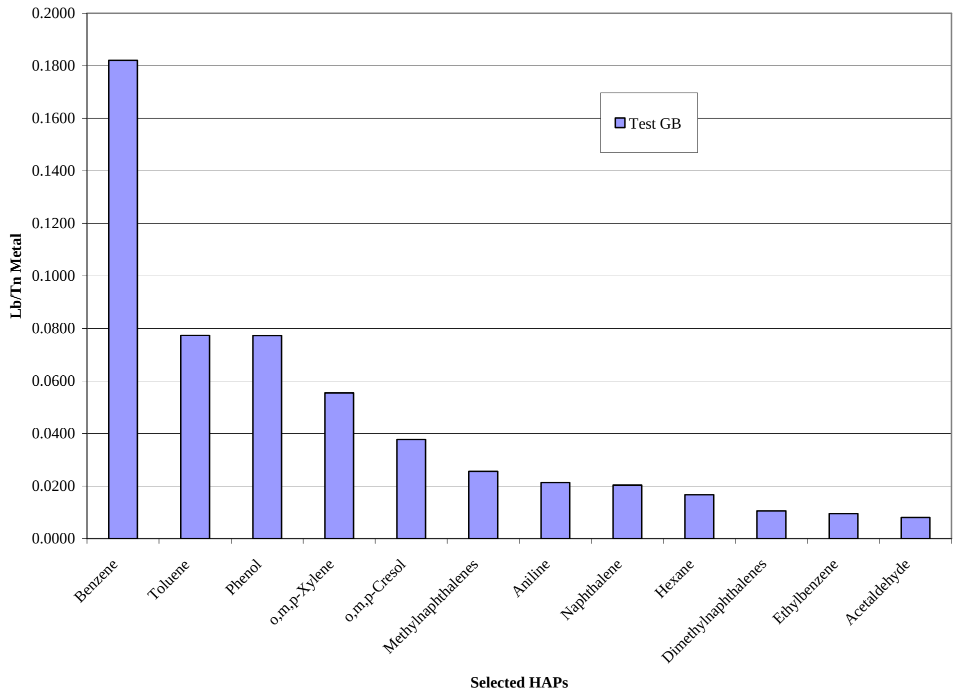
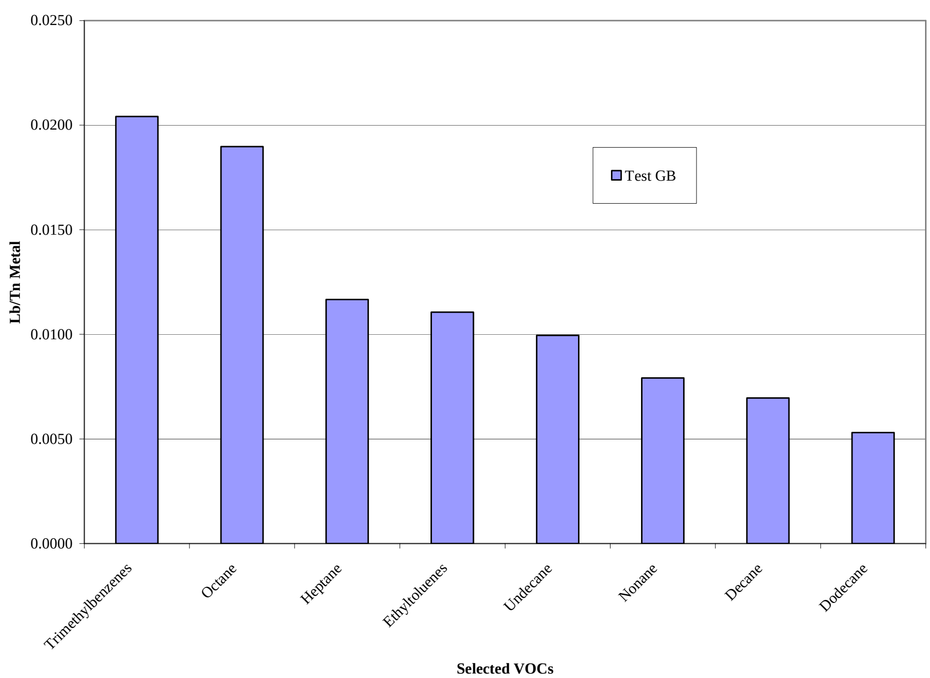


Figure 3-6 Selected VOC Emissions from Test Series GB – Lb/Tn Metal



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4.0 Discussion of Results

Twenty (20) of the measured compounds comprised greater than 95% of the mass of all Target Analytes detected from the Coated Core in Greensand with Seacoal baseline test series. Benzene comprised approximately 33% of the total HAPs followed by toluene, phenol, and o,m,p-xylene at 14%, 14%, 10% respectively when expressed in pounds per ton of metal. The remaining HAPs listed in the table individually contributed 1-7% of the total HAPs. See Table 3-3.

Two methods were employed to measure undifferentiated hydrocarbon emissions, TGOC as propane, performed in accordance with EPA Method 25A, and HC as hexane. EPA Method 25A, TGOC (as propane), is weighted to the detection of more volatile hydrocarbon species, beginning at C1 (methane), with results calibrated against a three-carbon alkane (propane). HC as hexane is weighted to the detection of relatively less volatile compounds. This method detects hydrocarbon compounds in the alkane range between C6 and C16, with results calibrated against a six-carbon alkane (hexane).

Target analyte reporting limits expressed in both pounds per pound of binder and pounds per ton of metal are shown in Appendix B.

Observation of measured process parameters indicates that the tests were run within an acceptable range.

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APPENDIX A APPROVED TEST PLAN AND SAMPLE PLAN FOR TEST SERIES GB

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TECHNIKON TEST PLAN

> **CONTRACT NUMBER:** 1411 **TASK NUMBER:** 1.2.1 **Series:** GB

> **SITE:** Pre-production

> **TEST TYPE:** Combination Baseline Test: Pouring, cooling, & shakeout of seacoal containing greensand with coated phenolic urethane step cores.

> **METAL TYPE:** Class 30 gray iron

> **MOLD TYPE:** Virgin greensand with 7% western and southern bentonite in 5:2 ratio and seacoal to generate a 5% LOI. Molds will be recycled.

> **NUMBER OF MOLDS:** Three engineering & conditioning runs + 9 sampling runs. Twelve (12) molds total**.**

> **CORE TYPE: Step:** 1.4% Ashland ISOCURE ® Phenolic Urethane LF305 part I (55%), 904GR Part II (45%), amine cured, 50-120 hrs old.

> **CORE COATING:** Test cores shall be coated with Ashland Velvaplast® CWG9022SL core coating and dried at 275^{o}F**.**

> **SAMPLE EVENTS:** Nine (9)

> **TEST DATE:** **START:** 12 Jul 2004
> **FINISHED**: 23 Jul 2004

TEST OBJECTIVES:

Measure the airborne pouring, cooling, & shakeout emissions from coated organic step cores in a mechanically-produced clay, water, coal containing greensand mold.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford W450 Lakesand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB Clay, seacoal to produce 5% LOI, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 80-90^{o}F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10^{o}F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes. Cores will be made with Wedron 530 silica sand heated to 85-90^{o}F and made in an 80-90^{o}F heated enclosed core machine. No emission sampling will be done during core manufacture. The cores will be dip coated in Ashland Velvaplast® core coating and dried at 275^{o}F.

BRIEF OVERVIEW:

This is the third of the 4-on greensand baseline tests. This test differs from previous 4-on greensand tests in that both seacoal and organic binder are sources for emissions.

The greensand molds will be produced on the mechanically assisted Osborne 716 molding machines.

The emission results will be used to compare future product tests using a seacoal replacement in the presence of organic core or a different core binder in the presence of a seacoal containing greensand. In addition to a suite of selected emission analytes TGOC, CO & CO_2 content of the runs will be monitored using instruments specific to those gasses.

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially for each subtest a 1,300 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. The cores shall be maintained at 80-90^{o}F awaiting insertion in the mold. The cores shall be stabilized for 50-120 hours when tested.

Series GB

PCS Core Baseline Test in Greensand with Ashland 305/904 Core Binder, & Mechanized Molding
Process Instructions

A. Experiment:

1) Measure pouring, cooling, & shakeout emissions from coated organic cores in a green-sand mold made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5% MB Clay, & seacoal. The molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand. Emissions will be compared to those from the same mold configuration containing cores with no anti-veining compound

B. Materials:

1) Mold sand: Virgin mix of **Wexford W450** lake sand, western and southern bentonites in the ratio of 5:2, and potable water per recipe.
2) Core: Step cores made with virgin Wedron 530 sand and 1.4% Ashland ISOCURE® **LF305/52-904GR** regular phenolic urethane binder in a 55/45 ratio, TEA catalyzed.
3) Ashland Velvaplast® CWG9022SL core coating.
4) Metal: Class 30-gray cast iron poured at 2630 +/- 10^{o}F.
5) Pattern Spray**: Black Diamond**, hand wiped.

C. Briefing:

1) The Process Engineer, Emissions Engineer, and the area Supervisor will brief the operating personnel on the requirements of the test at least one (1) day prior to the test.

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

D. ISOCURE® regular Step Cores:

1) Klein vibratory core sand mixer.
- **a)** Attach the day tanks with the intended part I and part II binder components via respective binder shut-off valves so that they gravity feed to the respective pumps. The binder components should be 80-85^{o}F.
- **b)** On the main control panel turn the AUTO/MAN switch to MANUAL, turn on main disconnects and MASTER START push button.
- **c)** Fill the Part I and Part II pumps and de-air the lines.
- **d)** Calibrate the Klein mixer.
  - **i)** Remove the mixing bowl skirt to gain access to the binder injection tubes and the bottom side of the batch hopper outlet gate.

2) Calibrate sand. Recalibrate for each sand mixture used.
   a) Turn the AUTO/MAN switch to MANUAL on main control panel.
   b) Place one bucket of preheated sand, raw, or containing one of the iron oxides, of at least fifty-two (52) pounds net weight, into the sand hopper and manually fill batch hopper using max. and min. proximity switches.
   c) Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.
   d) Repeat 3 times to determine the weight variation. The sand should be 80-85 ^{o}F.

3) Calibrate the binder pumps.
   a) Adjust the part I dispensing rate by adjusting the part I pump stroke to be 55% of 1.4 % (0.77% BOS) of the average sand batch weight dispensed in D.2.e.2).
   b) Adjust the machine's inlet air pressure to dispense the binder in about the same time as the sand is dispensed, about 10-15 seconds.
   c) Record the pressure and dispensing time, and net weight.
   d) Repeat 3 times to determine the variation in dispensing rate.
   e) Adjust the part II dispensing rate by adjusting the part II pump stroke to be 45% of 1.4% (.63% BOS) of the average sand rate dispensed in D.2.e.2).
   f) Repeat D.2.d.3).c), & d) for Part II pump.

4) Turn off the mixer and replace the mixing bowl skirt.
   a) Turn on the mixer and turn the AUTO/MAN switch to AUTO.
   b) Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. Make three (3) batches to start the Redford Carver core machine.
   c) Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.

5) Clean the mixer after each material.

Caution: Do not make more sand than sand magazine will hold plus one (1) batch. If too much sand is made the sand will be exposed to captured TEA and significantly shorten the sand bench life

E. Redford/Carver core machine.
   1) Mount the Step-Core core box on the Carver/Redford core machine.
   2) Start the core machine auxiliary equipment per the <u>Production Foundry OSI</u> for that equipment.
   3) Set up the core machine in the cold box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
   4) Core process setup
      a) Set the TEA to a nominal 5 grams per blow (gas time 0.75 sec (R/C), flow .019 lbs/sec (Luber).
      b) Set the blow pressure to 30+/-2 psi for 3 seconds (R/C).
      c) Set the max purge pressure to 45 psi on the Luber gas generator.

  - **d)** Purge for 20 seconds(R/C) with a 10 second rise time (Luber).
  - **e)** Total cycle time approximately 1 minute.

5) Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. Make five (5) additional 50 pound sand batches and run the sand out making core. A minimum of 35 cores are required.

6) One half hour to 1 hour after manufacture randomly perform a scratch hardness test on the outer edge of the blow surface on 10 % of the cores and record the results on the Core Production Log. Values less than 25 shall be marked with a HOLD TAG until they can be 100 % scratch hardness tested to re-qualify. Contact the Process Engineer for disposition on all cores with values less than 15 after 1 hour. Weigh each core and log the results.

7) The sand lab will sample, at the time of manufacture, one (1) core from each row of each shelf (1 of 11) on each core rack. Those cores will be tested for LOI using the standard 1800^{o}F core LOI test method and reported out associated with the core rack shelf it represents. Qualified cores receiving the green **Quality Checked** tag must have **LOI** values between 1.25-1.50%. Individual rows that qualify may have the **Quality Checked** tag affixed. Only cores with the green Quality Tag bearing the current test series and dates and signature of the lab technician and core rack/shelf/position on shelf may be taken to the mold assembly area.

Note: The core rack position from the Quality Checked tag shall be transferred to the mold assembly check list with the core weights.

8) The sand lab will sample one (1) core from the core rack for each mold produced just prior to the emission test to represent the four (4) cores placed in that mold. Those cores will be tested for LOI using the standard 1800^{o}F core LOI test method and reported out associated with the test mold it is to represent.

F. Core coating.

1) Ashland Velvaplast® CGW 9022 SL core coating material will be used to dip-coat the cores.
2) Weigh the uncoated core and log the weight.
3) Coat the entire core up to the ½ inch from the invest side.
4) Normalize the core coating temperature to 70 -80^{o}F.
5) Dip the core into the core wash and hold for a count of two (2).
6) Shake the core vertically until the coating ceases to drip.
7) Place the core invest side down on the OSI ovenlear (chain belt).
8) Dry the core at 275^{o}F for 1 hour in the OSI core drying oven.
9) Weigh the dried and cooled coated core and log the weight.

G. Sand preparation

1) Start up batch: make 1, GBCD1
  - **a)** Thoroughly clean the pre-production muller, elevator, and molding hoppers.

- **b)** Weigh and add 1225 +/-10 pounds of new Wexford W450 Lakesand, per the recipe, to the running pre-production muller to make a 1300 batch.
- **c)** Add 5 pounds of potable to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
- **d)** Add the clays slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.
- **e)** Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
- **f)** Temper the sand-clay mixture slowly, with potable water, to allow for distribution.
- **g)** After about 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
- **h)** Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 40-45%.
- **i)** Discharge the sand into the mold station elevator.
- **j)** Grab sufficient sample after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
- **k)** Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge.
- **l)** The sand will be characterized for Methylene Blue Clay, Moisture content, Compactability, Green Compression strength, 1800^{o}F loss on ignition (LOI), and 900^{o}F volatiles. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.
- **m)** Empty the extra greensand from the mold hopper into a clean empty dump hopper whose tare weight is known. Set this sand aside to be used to maintain the recycled batch at 900+/-10 pounds

2) Re-mulling: GBCD2, GBCD3, & GB4-12

- **a)** Add to the sand recovered from poured mold **GBCD1** sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.
- **b)** Return the sand to the muller and dry blend for about one minute.
- **c)** Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.
- **d)** Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
- **e)** Follow the above procedure beginning at E.1.f.

H. Molding: Step core pattern.

1) Pattern preparation:

- **a)** Inspect and tighten all loose pattern and gating pieces.
- **b)** Repair any damaged pattern or gating parts.

2) Making the green sand mold.

- **a)** Mount the drag pattern on one Osborne Whisper Ram molding machine and mount the cope pattern on the other Osborne machine.

b) Lightly rub parting oil from a damp oil rag on the pattern particularly in the corners and recesses.

Caution: Do not pour gross amounts of parting oil on the pattern to be blown of with air. This practice will leave sufficient oil at the parting line to be adsorbed by the sand weakening it and the burning oil will be detected by the emission samplers.

3) Use the overhead crane to place the pre-weighed drag/cope flask on the mold machine table, parting line surface down.
4) Locate a 24 x 24 x4 inch deep wood upset on top of the flask.
5) Make the green sand mold cope or drag on the Osborn Whisper Ram Jolt-Squeeze mold machine.

WARNING: Only properly trained personnel may operate this machine.
Proper personal protective equipment must be worn at all times while operating this equipment, including safety glasses with side shields and a properly fitting hard hat.
Industrial type boots are highly recommended.

WARNING: Stand clear of the mold machine table and swinging head during the following operation or serious injury or death could result.

a) Open the air supply to the mold machine.

WARNING: The squeeze head may suddenly swing to the outboard side or forward. Do not stand in the outer corners of the molding enclosure.

b) On the operator's panel turn the POWER switch to ON.
c) Turn the RAM-JOLT-SQUEEZE switch to ON.
d) Turn the DRAW UP switch to AUTO
e) Set the PRE-JOLT timer to 4-5 seconds.
f) Set the squeeze timer to 8 seconds.
g) Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
h) Manually riddle a half to one inch or so of sand on the pattern using a ¼ inch mesh riddle. Source the sand from the overhead mold sand hopper by actuating the CHATTER GATE valve located under the operators panel.
i) Fill the center potion of the flask.
j) Manually move sand from the center portion to the outboard areas and hand tuck the sand.
k) Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
l) Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.
m) Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.
n) Remove the upset and set it aside.

WARNING: Failure to stand clear of the molding table and flasks in the following operations could result in serious injury as this equipment is about to move up and down with great force.

WARNING: Stand clear of the entire mold machine during the following operations. Several of the machine parts will be moving. Failure to stand clear could result in severe injury even death.

o) Using both hands initiate the automatic machine sequence by simultaneously pressing, holding for 2-3 seconds, and releasing the green push buttons on either side of the operators panel. The machine will squeeze and jolt the sand in the flask and then move the squeeze head to the side.

WARNING: Do not re-approach the machine until the squeeze head has stopped at the side of the machine.

p) Screed the bottom of the drag mold flat to the bottom of the flask if required.
q) Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
r) Use the overhead crane to lift the mold half and remove it from the machine. If the mold half is a drag, roll it parting line side up, set it on the floor, blow it out.
s) Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.

6) Set four (4) step cores that have been weighed and logged into the drag. Verify that the cores are fully set and flush with the parting line.
7) Close the cope over the drag being careful not to crush anything.
8) Clamp the flask halves together.
9) Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the coated cores, and the sand weight by difference.
10) Measure and record the sand temperature.
11) Deliver the mold to the previously cleaned shakeout to be poured.
12) Cover the mold with the emission hood.

I. Pig molds
1) Each day make a 900 pound capacity pig mold for the following day's use.

J. Emission hood:
1) Loading.
a) Hoist the mold onto the shakeout deck within the emission hood.
b) Close, seal, and lock the emission hood
c) Adjust the ambient air heater control so that the measured temperature of the blended air within the hood is 85-90^{o}F at the start of the test run.

2) Shakeout.

- **a)** After the 45 minute cooling time prescribed in the emission sample plan has elapsed turn on the shakeout unit and run for it the 15 minutes prescribed in the emission sample plan or until the sand has all fallen through the grating.
- **b)** Turn off the shakeout.
- **c)** Sample the emissions for 30 minutes after the start of shakeout, a total of 75 minutes.

3) When the emission sampling is completed remove the flask with casting, and recover the sand from the hopper and surrounding floor.

- **a)** Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.
- **b)** Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

K. Melting:

1) Initial iron charge:

- **a)** Charge the furnace according to the heat recipe.
- **b)** Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
- **c)** Place a pig on top of the steel.
- **d)** Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
- **e)** Add the balance of the metallics under full power until all is melted and the temperature has reached 2600 to 2700^{o}F.
- **f)** Slag the furnace and add the balance of the alloys.
- **g)** Raise the temperature of the melt to 2700 ^{o}F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350^{o}F.
- **h)** Hold the furnace at 2500-2550^{o}F until near ready to tap.
- **i)** When ready to tap raise the temperature to 2700^{o}F and slag the furnace.
- **j)** Record all metallic and alloy additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with an associated time.

2) Back charging.

- **a)** Back charge the furnace according to the heat recipe,
- **b)** Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.
- **c)** Follow the above steps beginning with I.1.e

3) Emptying the furnace.

- **a)** Pig the extra metal only after the last emission measurement is complete to avoid contaminating the air sample.
- **b)** Cover the empty furnace with ceramic blanket to cool.

L. Pouring:

1) Preheat the ladle.

- **a)** Tap 400 pounds more or less of 2700^{o}F iron into the cold ladle.

- **b)** Carefully pour the metal back to the furnace.
- **c)** Cover the ladle.
- **d)** Reheat the metal to 2780 +/- 20^{o}F.
- **e)** Tap 450 pounds of iron into the ladle while pouring inoculating alloys onto the metal stream near its base.
- **f)** Cover the ladle to conserve heat.
- **g)** Move the ladle to the pour position and wait until the metal temperature reaches 2630 +/- 10^{o}F.
- **h)** Commence pouring keeping the sprue full.
- **i)** Upon completion return the extra metal to the furnace, and cover the ladle.
- **j)** Record the pour temperature and pour time on the heat log

M. Rank order evaluation.

- **1)** The supervisor shall select a group of five persons to make a collective subjective judgment of the casting relative surface appearance.
- **2)** Review the general appearance of the castings and select specific casting features to compare.
- **3)** For cavity 3 only:
  - **a)** Place each casting initially in sequential mold number order.
  - **b)** Beginning with casting from mold GB001, compare it to castings from mold GB002.
  - **c)** Place the better appearing casting in the first position and the lesser appearing casting in the second position.
  - **d)** Repeat this procedure with GB001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than GB001 and the next casting farther down the line is inferior.
  - **e)** Repeat this comparison to next neighbors for each casting number.
  - **f)** When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
  - **g)** Repeat this comparison until all concur with the ranking order.

- **4)** Record mold number by rank-order series for this cavity.

Steven M. Knight
Mgr. Process Engineering

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/13/2004											**GB CONDITIONING - RUN 1**
GB CR-1											
THC		x									
CO, CO2		X									TOTAL

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/13/2004											**GB CONDITIONING - RUN 2**
GB CR-2											
THC		x									
CO, CO2		X									TOTAL

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/13/2004											**GB CONDITIONING - RUN 3**
GB CR-3											
THC		x									
CO, CO2		X									TOTAL

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/14/2004											
RUN 1											
THC	GB001	X									TOTAL
CO, CO2	GB001	X									TOTAL
M-18	GB00101		1						60	1	Carbopak charcoal
M-18	GB00102				1				0		Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00103		1						500	5	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	GB00104				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00105		1						500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GB00106				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00107		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	GB00108				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/14/2004											
RUN 2											
THC	GB002	X									TOTAL
CO, CO2	GB002	X									TOTAL
M-18	GB00201		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00202		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00203		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00204		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/14/2004											
RUN 3											
THC	GB003	X									TOTAL
CO, CO2	GB003	X									TOTAL
M-18	GB00301		1						60	1	Carbopak charcoal
M-18	GB00302			1					60	2	Carbopak charcoal
M-18 MS	GB00303			1					60	3	lost
	Excess								60	4	Excess
NIOSH 2002	GB00304		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00305		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00306		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/15/2004											
RUN 4											
THC	GB004	X									TOTAL
CO, CO2	GB004	X									TOTAL
M-18	GB00401		1						60	1	Carbopak charcoal
M-18 MS	GB00402		1						60	2	Carbopak charcoal
M-18 MS	GB00403			1					60	3	Carbopak charcoal
	Excess								60	4	Excess
NIOSH 2002	GB00404		1						500	5	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	GB00405			1					500	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 1500	GB00406		1						500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GB00407			1					500	8	100/50 mg Charcoal (SKC 226-01)
TO11	GB00408		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	GB00409			1					850	10	DNPH Silica Gel (SKC 226-119)
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/15/2004											
RUN 5											
THC	GB005	X									TOTAL
CO, CO2	GB005	X									TOTAL
M-18	GB00501		1						60	1	Carbopak charcoal
M-18	GB00502					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								40	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00503		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00504		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00505		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/15/2004											
RUN 6											
THC	GB006	X									TOTAL
CO, CO2	GB006	X									TOTAL
M-18	GB00601		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00602		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00603		1						500	7	lost
	Excess								500	8	Excess
TO11	GB00604		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/16/2004											
RUN 7											
THC	GB007	X									TOTAL
CO, CO2	GB007	X									TOTAL
M-18	GB00701		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00702		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00703		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00704		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/16/2004											
RUN 8											
THC	GB008	X									TOTAL
CO, CO2	GB008	X									TOTAL
M-18	GB00801		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00802		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00803		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00804		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GB - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/16/2004											
RUN 9											
THC	GB009	X									TOTAL
CO, CO2	GB009	X									TOTAL
M-18	GB00901		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 2002	GB00902		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	GB00903		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	GB00904		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

APPENDIX B TEST SERIES GB DETAILED EMISSION RESULTS

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Test Plan GB Individual Emission Test Results – Lb/Lb Binder

HAPs	POMs	COMPOUND/SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	**7/14/04**	**7/14/04**	**7/14/04**	**7/15/04**	**7/15/04**	**7/15/04**	**7/16/04**	**7/16/04**	**7/16/04**		
		TGOC as Propane	3.26E-01	3.65E-01	3.02E-01	3.05E-01	3.60E-01	2.84E-01	3.42E-01	2.95E-01	2.82E-01	3.18E-01	3.16E-02
		HC as Hexane	1.01E-01	1.11E-01	1.04E-01	1.08E-01	1.20E-01	I	1.06E-01	1.11E-01	9.65E-02	1.07E-01	7.33E-03
		Sum of Target Analytes	8.66E-02	8.62E-02	8.29E-02	7.86E-02	9.17E-02	8.46E-02	8.89E-02	8.51E-02	7.62E-02	8.45E-02	4.81E-03
		Sum of HAPs	7.33E-02	7.16E-02	6.87E-02	6.68E-02	7.63E-02	6.99E-02	7.31E-02	7.04E-02	6.23E-02	7.03E-02	4.08E-03
		Sum of POMs	8.18E-03	6.51E-03	6.82E-03	5.20E-03	7.16E-03	8.35E-03	7.68E-03	6.74E-03	9.25E-03	7.32E-03	1.19E-03
			Individual Organic HAPs										
x		**Benzene**	2.30E-02	2.56E-02	2.41E-02	2.50E-02	2.77E-02	1.88E-02	2.41E-02	2.36E-02	2.05E-02	2.36E-02	2.65E-03
x		**Toluene**	1.05E-02	1.05E-02	9.82E-03	1.01E-02	1.09E-02	8.84E-03	1.03E-02	1.03E-02	I	1.01E-02	6.16E-04
x		**Phenol**	1.01E-02	8.93E-03	9.20E-03	8.16E-03	1.03E-02	1.23E-02	9.71E-03	9.71E-03	1.17E-02	1.00E-02	1.31E-03
x		**m,p-Xylene**	5.19E-03	4.93E-03	4.66E-03	4.71E-03	5.05E-03	4.45E-03	4.78E-03	4.92E-03	4.31E-03	4.78E-03	2.82E-04
x		**o-Cresol**	3.83E-03	3.19E-03	3.47E-03	3.07E-03	3.69E-03	4.67E-03	3.93E-03	3.53E-03	4.63E-03	3.78E-03	5.63E-04
x		**Aniline**	2.89E-03	2.59E-03	2.07E-03	1.89E-03	2.40E-03	3.84E-03	3.37E-03	2.63E-03	3.22E-03	2.77E-03	6.28E-04
x	z	**Naphthalene**	2.72E-03	2.30E-03	2.53E-03	2.08E-03	2.67E-03	2.93E-03	2.58E-03	2.72E-03	3.20E-03	2.64E-03	3.25E-04
x		**o-Xylene**	2.65E-03	2.56E-03	2.32E-03	2.33E-03	2.60E-03	2.25E-03	2.47E-03	2.41E-03	2.18E-03	2.42E-03	1.61E-04
x		**Hexane**	2.26E-03	2.49E-03	2.12E-03	2.03E-03	2.03E-03	1.49E-03	2.33E-03	2.17E-03	1.88E-03	2.09E-03	2.88E-04
x	z	**2-Methylnaphthalene**	2.45E-03	1.91E-03	1.92E-03	1.44E-03	2.03E-03	2.27E-03	2.23E-03	1.88E-03	2.60E-03	2.08E-03	3.48E-04
x		**Ethylbenzene**	1.36E-03	1.30E-03	1.20E-03	1.21E-03	1.32E-03	1.15E-03	1.26E-03	1.25E-03	1.11E-03	1.24E-03	8.02E-05
x	z	**1-Methylnaphthalene**	1.39E-03	1.09E-03	1.13E-03	8.60E-04	1.20E-03	1.40E-03	1.32E-03	1.14E-03	1.62E-03	1.24E-03	2.20E-04
x		**m,p-Cresol**	1.11E-03	9.34E-04	1.10E-03	8.98E-04	1.04E-03	1.36E-03	1.22E-03	9.49E-04	1.39E-03	1.11E-03	1.80E-04
x		**Acetaldehyde**	1.12E-03	1.09E-03	9.92E-04	1.08E-03	1.03E-03	1.15E-03	9.83E-04	9.97E-04	9.05E-04	1.04E-03	7.71E-05
x	z	**1,3-Dimethylnaphthalene**	6.28E-04	4.69E-04	4.81E-04	3.73E-04	4.95E-04	6.24E-04	6.10E-04	4.70E-04	7.31E-04	5.42E-04	1.11E-04
x		**Styrene**	5.10E-04	4.86E-04	4.62E-04	4.67E-04	4.90E-04	4.65E-04	4.59E-04	4.98E-04	4.34E-04	4.75E-04	2.32E-05
x	z	**1,6-Dimethylnaphthalene**	2.96E-04	2.23E-04	2.31E-04	1.77E-04	2.34E-04	2.88E-04	2.84E-04	2.20E-04	3.39E-04	2.55E-04	5.01E-05
x		**Formaldehyde**	2.46E-04	1.63E-04	2.88E-04	3.30E-04	2.12E-04	2.83E-04	1.55E-04	3.11E-04	3.00E-04	2.54E-04	6.44E-05
x		**2-Butanone**	2.41E-04	2.37E-04	I	2.57E-04	2.64E-04	2.79E-04	2.32E-04	2.87E-04	2.58E-04	2.57E-04	1.96E-05
x	z	**2,6-Dimethylnaphthalene**	2.30E-04	1.71E-04	1.75E-04	1.30E-04	1.78E-04	2.15E-04	2.16E-04	1.59E-04	2.53E-04	1.92E-04	3.88E-05
x	z	**2,7-Dimethylnaphthalene**	2.30E-04	1.71E-04	1.75E-04	1.30E-04	1.78E-04	2.15E-04	2.16E-04	1.59E-04	2.53E-04	1.92E-04	3.88E-05
x	z	**2,3-Dimethylnaphthalene**	2.35E-04	1.77E-04	1.82E-04	ND	1.85E-04	2.28E-04	2.26E-04	ND	2.66E-04	1.67E-04	9.89E-05
x		**Propionaldehyde**	1.27E-04	1.22E-04	1.14E-04	1.23E-04	1.13E-04	1.25E-04	1.05E-04	1.11E-04	9.96E-05	1.16E-04	9.42E-06
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	1.75E-04	ND	ND	I	2.19E-05	6.19E-05
x		**Biphenyl**	ND	ND	ND	ND	ND	ND	ND	ND	1.81E-04	2.02E-05	6.05E-05
x	z	**Acenaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GB Individual Emission Test Results – Lb/Lb Binder

HAPs	POM	COMPOUND/SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	**7/14/04**	**7/14/04**	**7/14/04**	**7/15/04**	**7/15/04**	**7/15/04**	**7/16/04**	**7/16/04**	**7/16/04**		
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Dimethylaniline**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
			Other VOCs										
		Octane	2.25E-03	2.44E-03	2.37E-03	2.52E-03	2.86E-03	2.15E-03	2.57E-03	2.74E-03	2.25E-03	2.46E-03	2.36E-04
		1,2,4-Trimethylbenzene	1.93E-03	1.69E-03	1.71E-03	1.65E-03	1.82E-03	1.78E-03	1.72E-03	1.88E-03	1.66E-03	1.76E-03	9.89E-05
		Heptane	1.63E-03	1.77E-03	1.39E-03	1.35E-03	1.69E-03	1.34E-03	1.75E-03	1.41E-03	1.28E-03	1.51E-03	1.94E-04
		Undecane	1.38E-03	1.19E-03	1.23E-03	I	1.33E-03	1.28E-03	1.33E-03	1.23E-03	1.34E-03	1.29E-03	6.57E-05
		Nonane	1.10E-03	1.17E-03	9.62E-04	9.43E-04	1.17E-03	9.05E-04	1.12E-03	9.47E-04	9.19E-04	1.03E-03	1.11E-04
		Decane	9.87E-04	1.00E-03	8.64E-04	8.11E-04	1.00E-03	8.15E-04	9.50E-04	8.52E-04	8.37E-04	9.02E-04	8.18E-05
		3-Ethyltoluene	I	8.86E-04	8.56E-04	8.39E-04	9.21E-04	8.69E-04	8.76E-04	9.06E-04	8.12E-04	8.70E-04	3.52E-05
		1,2,3-Trimethylbenzene	8.58E-04	7.63E-04	7.51E-04	7.14E-04	8.15E-04	8.12E-04	7.94E-04	8.26E-04	7.74E-04	7.90E-04	4.40E-05
		Dodecane	7.21E-04	6.54E-04	7.79E-04	5.68E-04	7.20E-04	6.39E-04	6.94E-04	7.16E-04	I	6.86E-04	6.46E-05
		Indene	7.03E-04	5.94E-04	6.44E-04	6.25E-04	6.65E-04	7.42E-04	6.49E-04	7.09E-04	7.11E-04	6.71E-04	4.79E-05
		2-Ethyltoluene	I	5.70E-04	5.52E-04	5.37E-04	5.82E-04	5.62E-04	5.59E-04	5.90E-04	5.57E-04	5.64E-04	1.70E-05
		Cyclohexane	4.09E-04	6.84E-04	5.60E-04	I	6.53E-04	4.75E-04	5.83E-04	4.67E-04	4.28E-04	5.32E-04	1.03E-04
		Tetradecane	2.91E-04	2.51E-04	2.83E-04	2.40E-04	2.93E-04	3.37E-04	2.99E-04	3.17E-04	4.29E-04	3.04E-04	5.56E-05
		2,4-Dimethylphenol	ND	ND	3.04E-04	ND	ND	7.40E-04	7.77E-04	ND	8.24E-04	2.94E-04	3.78E-04
		Propylbenzene	3.06E-04	2.85E-04	2.71E-04	2.67E-04	3.03E-04	3.05E-04	3.06E-04	2.91E-04	2.85E-04	2.91E-04	1.52E-05
		Benzaldehyde	2.39E-04	2.28E-04	2.32E-04	2.49E-04	2.36E-04	2.59E-04	2.15E-04	2.65E-04	2.20E-04	2.38E-04	1.68E-05
		Crotonaldehyde	1.48E-04	1.38E-04	1.49E-04	9.08E-05	1.50E-04	2.13E-04	1.83E-04	2.30E-04	1.59E-04	1.62E-04	4.16E-05
		Butyraldehyde/Methacrolein	1.19E-04	1.20E-04	1.31E-04	1.27E-04	1.22E-04	I	1.18E-04	1.27E-04	1.11E-04	1.22E-04	6.28E-06
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	3.20E-04	2.99E-04	ND	2.50E-04	9.66E-05	1.46E-04
		o,m,p-Tolualdehyde	9.95E-05	1.00E-04	1.21E-04	1.02E-04	I	1.24E-04	ND	1.01E-04	ND	8.09E-05	5.09E-05
		Pentanal	6.94E-05	5.56E-05	I	5.68E-05	4.84E-05	6.28E-05	4.95E-05	5.65E-05	4.70E-05	5.57E-05	7.63E-06
		Hexaldehyde	3.75E-05	3.75E-05	3.34E-05	1.79E-05	ND	3.93E-05	ND	3.93E-05	ND	2.28E-05	1.83E-05
		1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GB Individual Emission Test Results – Lb/Lb Binder

HAPs	POM	COMPOUND/SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	7/14/04	7/14/04	7/14/04	7/15/04	7/15/04	7/15/04	7/16/04	7/16/04	7/16/04		
			Other Analytes										
		Acetone	1.12E-03	1.10E-03	1.04E-03	1.12E-03	1.16E-03	1.17E-03	1.03E-03	1.14E-03	I	1.11E-03	5.23E-05
		Carbon Dioxide	1.42E+00	9.20E-01	1.37E+00	1.58E+00	9.72E-01	1.53E+00	1.00E+00	1.44E+00	1.42E+00	1.30E+00	2.57E-01
		Carbon Monoxide	5.13E-01	6.72E-01	5.00E-01	5.24E-01	6.80E-01	4.28E-01	6.36E-01	4.86E-01	4.93E-01	5.48E-01	9.08E-02

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable; All "Other Analytes" are not included in the Sum of VOCS.

Test Plan GB Individual Emission Test Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	**7/14/04**	**7/14/04**	**7/14/04**	**7/15/04**	**7/15/04**	**7/15/04**	**7/16/04**	**7/16/04**	**7/16/04**		
		TGOC as Propane	2.52E+00	2.79E+00	2.37E+00	2.34E+00	2.80E+00	2.17E+00	2.65E+00	2.25E+00	2.17E+00	2.45E+00	2.50E-01
		HC as Hexane	7.78E-01	8.53E-01	8.17E-01	8.35E-01	9.37E-01	I	8.23E-01	8.48E-01	7.42E-01	8.29E-01	5.72E-02
		Sum of Target Analytes	6.69E-01	6.60E-01	6.51E-01	6.04E-01	7.14E-01	6.37E-01	6.90E-01	6.48E-01	6.51E-01	6.58E-01	3.11E-02
		Sum of HAPs	5.67E-01	5.48E-01	5.39E-01	5.14E-01	5.94E-01	5.24E-01	5.67E-01	5.36E-01	5.48E-01	5.48E-01	2.44E-02
		Sum of POMs	6.32E-02	4.98E-02	5.35E-02	4.00E-02	5.58E-02	6.40E-02	5.96E-02	5.13E-02	7.11E-02	5.65E-02	9.21E-03
			Individual Organic HAPs										
x		**Benzene**	1.78E-01	1.96E-01	1.89E-01	1.92E-01	2.16E-01	1.44E-01	1.87E-01	1.80E-01	1.57E-01	1.82E-01	2.10E-02
x		**Toluene**	8.11E-02	8.00E-02	7.71E-02	7.75E-02	8.49E-02	6.77E-02	7.95E-02	7.82E-02	6.99E-02	7.73E-02	5.39E-03
x		**Phenol**	7.84E-02	6.83E-02	7.22E-02	6.27E-02	8.02E-02	9.45E-02	7.53E-02	7.39E-02	8.99E-02	7.73E-02	9.99E-03
x		**m,p-Xylene**	4.01E-02	3.77E-02	3.66E-02	3.62E-02	3.93E-02	3.41E-02	3.71E-02	3.75E-02	3.31E-02	3.69E-02	2.23E-03
x		**o-Cresol**	2.97E-02	2.44E-02	2.72E-02	2.36E-02	2.87E-02	3.58E-02	3.05E-02	2.69E-02	3.56E-02	2.92E-02	4.32E-03
x		**Aniline**	2.23E-02	1.98E-02	1.63E-02	1.46E-02	1.87E-02	2.94E-02	2.61E-02	2.00E-02	2.48E-02	2.13E-02	4.79E-03
x	z	**Naphthalene**	2.10E-02	1.76E-02	1.98E-02	1.60E-02	2.07E-02	2.25E-02	2.00E-02	2.07E-02	2.46E-02	2.03E-02	2.49E-03
x		**o-Xylene**	2.05E-02	1.96E-02	1.83E-02	1.79E-02	2.02E-02	1.73E-02	1.91E-02	1.83E-02	1.68E-02	1.87E-02	1.28E-03
x		**Hexane**	1.75E-02	1.91E-02	1.67E-02	1.56E-02	1.58E-02	I	1.81E-02	1.65E-02	1.45E-02	1.67E-02	1.47E-03
x	z	**2-Methylnaphthalene**	1.90E-02	1.46E-02	1.51E-02	1.11E-02	1.58E-02	1.74E-02	1.73E-02	1.43E-02	2.00E-02	1.60E-02	2.69E-03
x		**Ethylbenzene**	1.05E-02	9.96E-03	9.45E-03	9.29E-03	1.03E-02	8.78E-03	9.75E-03	9.51E-03	8.57E-03	9.56E-03	6.37E-04
x	z	**1-Methylnaphthalene**	1.07E-02	8.37E-03	8.88E-03	6.61E-03	9.35E-03	1.07E-02	1.02E-02	8.65E-03	1.24E-02	9.55E-03	1.69E-03
x		**m,p-Cresol**	8.56E-03	7.15E-03	8.64E-03	6.90E-03	8.08E-03	1.04E-02	9.48E-03	7.22E-03	1.07E-02	8.57E-03	1.39E-03
x		**Acetaldehyde**	8.63E-03	8.34E-03	7.79E-03	8.27E-03	8.04E-03	8.83E-03	7.63E-03	7.59E-03	6.96E-03	8.01E-03	5.80E-04
x	z	**1,3-Dimethylnaphthalene**	4.86E-03	3.59E-03	3.78E-03	2.87E-03	3.85E-03	4.78E-03	4.73E-03	3.58E-03	5.62E-03	4.18E-03	8.58E-04
x		**Styrene**	3.94E-03	3.72E-03	3.63E-03	3.59E-03	3.81E-03	3.57E-03	3.56E-03	3.79E-03	3.34E-03	3.66E-03	1.77E-04
x		**2-Butanone**	1.86E-03	1.82E-03	I	1.97E-03	2.05E-03	2.14E-03	1.80E-03	2.18E-03	1.99E-03	1.98E-03	1.44E-04
x	z	**1,6-Dimethylnaphthalene**	2.29E-03	1.71E-03	1.82E-03	1.36E-03	1.82E-03	2.21E-03	2.20E-03	1.68E-03	2.61E-03	1.97E-03	3.86E-04
x		**Formaldehyde**	1.90E-03	1.25E-03	2.26E-03	2.53E-03	1.65E-03	2.17E-03	1.20E-03	2.37E-03	2.31E-03	1.96E-03	4.93E-04
x	z	**2,6-Dimethylnaphthalene**	1.78E-03	1.31E-03	1.37E-03	1.00E-03	1.39E-03	1.65E-03	1.68E-03	1.21E-03	1.94E-03	1.48E-03	3.00E-04
x	z	**2,7-Dimethylnaphthalene**	1.78E-03	1.31E-03	1.37E-03	1.00E-03	1.39E-03	1.65E-03	1.68E-03	1.21E-03	1.94E-03	1.48E-03	3.00E-04
x	z	**2,3-Dimethylnaphthalene**	1.82E-03	1.35E-03	1.43E-03	0.00E+00	1.44E-03	1.75E-03	1.75E-03	ND	2.05E-03	1.29E-03	7.63E-04
x		**Propionaldehyde**	9.82E-04	9.31E-04	8.97E-04	9.46E-04	8.81E-04	9.61E-04	8.17E-04	8.44E-04	7.65E-04	8.91E-04	7.18E-05
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	1.34E-03	ND	ND	I	1.68E-04	4.75E-04
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GB Individual Emission Test Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	7/14/04	7/14/04	7/14/04	7/15/04	7/15/04	7/15/04	7/16/04	7/16/04	7/16/04		
x	z	**Acenaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Biphenyl**	ND	ND	ND	ND	ND	ND	ND	ND	I	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
			Other VOCs										
		Octane	1.74E-02	1.87E-02	1.86E-02	1.93E-02	2.22E-02	1.65E-02	1.99E-02	2.08E-02	1.73E-02	1.90E-02	1.84E-03
		1,2,4-Trimethylbenzene	1.49E-02	1.30E-02	1.34E-02	1.27E-02	1.41E-02	1.37E-02	1.33E-02	1.43E-02	1.28E-02	1.36E-02	7.60E-04
		Heptane	1.26E-02	1.35E-02	1.09E-02	1.04E-02	1.31E-02	1.03E-02	1.36E-02	1.07E-02	9.88E-03	1.17E-02	1.52E-03
		Undecane	1.06E-02	9.09E-03	9.68E-03	I	1.04E-02	9.83E-03	1.03E-02	9.38E-03	1.03E-02	9.95E-03	5.41E-04
		Nonane	8.50E-03	8.94E-03	7.56E-03	7.25E-03	9.11E-03	6.94E-03	8.69E-03	7.21E-03	7.06E-03	7.92E-03	8.78E-04
		Decane	7.63E-03	7.65E-03	6.78E-03	6.23E-03	7.81E-03	6.25E-03	7.37E-03	6.49E-03	6.44E-03	6.96E-03	6.51E-04
		3-Ethyltoluene	I	6.78E-03	6.72E-03	6.45E-03	7.17E-03	6.66E-03	6.79E-03	6.89E-03	6.24E-03	6.71E-03	2.79E-04
		1,2,3-Trimethylbenzene	6.63E-03	5.84E-03	5.90E-03	5.48E-03	6.35E-03	6.22E-03	6.16E-03	6.29E-03	5.95E-03	6.09E-03	3.38E-04
		Dodecane	5.57E-03	5.01E-03	6.12E-03	4.36E-03	5.60E-03	4.90E-03	5.38E-03	5.45E-03	I	5.30E-03	5.33E-04
		Indene	5.44E-03	4.55E-03	5.05E-03	4.80E-03	5.17E-03	5.69E-03	5.04E-03	5.40E-03	5.46E-03	5.18E-03	3.59E-04
		2-Ethyltoluene	I	4.36E-03	4.33E-03	4.12E-03	4.53E-03	4.31E-03	4.34E-03	4.50E-03	4.29E-03	4.35E-03	1.25E-04
		Cyclohexane	3.16E-03	5.23E-03	4.40E-03	I	5.08E-03	3.64E-03	4.52E-03	3.55E-03	3.29E-03	4.11E-03	8.07E-04
		2,4-Dimethylphenol	ND	ND	2.39E-03	ND	ND	5.68E-03	6.03E-03	ND	6.33E-03	2.27E-03	2.92E-03
		n-Propylbenzene	2.37E-03	2.18E-03	2.12E-03	2.06E-03	2.36E-03	2.34E-03	2.37E-03	2.21E-03	2.19E-03	2.24E-03	1.18E-04
		Tetradecane	2.25E-03	1.92E-03	2.22E-03	1.84E-03	2.28E-03	2.58E-03	2.32E-03	2.41E-03	I	2.23E-03	2.44E-04
		Benzaldehyde	1.85E-03	1.75E-03	1.82E-03	1.91E-03	1.84E-03	1.98E-03	1.66E-03	2.02E-03	1.69E-03	1.84E-03	1.21E-04
		Crotonaldehyde	1.15E-03	1.05E-03	1.17E-03	1.11E-03	1.17E-03	1.64E-03	1.42E-03	1.75E-03	1.22E-03	1.30E-03	2.48E-04
		Butyraldehyde/Methacrolein	9.18E-04	9.22E-04	1.03E-03	9.73E-04	9.50E-04	I	9.13E-04	9.68E-04	8.54E-04	9.41E-04	5.15E-05
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	2.45E-03	2.32E-03	ND	1.92E-03	7.44E-04	1.12E-03
		o,m,p-Tolualdehyde	7.69E-04	7.69E-04	9.49E-04	7.80E-04	I	9.52E-04	ND	7.67E-04	ND	6.23E-04	3.93E-04
		Pentanal	5.36E-04	4.25E-04	I	4.36E-04	3.76E-04	4.81E-04	3.84E-04	4.30E-04	3.61E-04	4.29E-04	5.82E-05
		Hexaldehyde	2.90E-04	2.87E-04	2.62E-04	1.38E-04	ND	3.01E-04	ND	2.99E-04	ND	1.75E-04	1.41E-04
		1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GB Individual Emission Test Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	GB001	GB002	GB003	GB004	GB005	GB006	GB007	GB008	GB009	Average	STDEV
		Test Dates	**7/14/04**	**7/14/04**	**7/14/04**	**7/15/04**	**7/15/04**	**7/15/04**	**7/16/04**	**7/16/04**	**7/16/04**		
			Other Analytes										
		Acetone	8.69E-03	8.45E-03	8.13E-03	8.58E-03	9.04E-03	9.00E-03	8.01E-03	8.64E-03	I	8.57E-03	3.67E-04
		Carbon Dioxide	1.10E+01	7.04E+00	1.08E+01	1.22E+01	7.57E+00	1.17E+01	7.77E+00	1.10E+01	1.09E+01	1.00E+01	1.96E+00
		Carbon Monoxide	3.96E+00	5.15E+00	3.93E+00	4.03E+00	5.30E+00	3.28E+00	4.93E+00	3.70E+00	3.79E+00	4.23E+00	7.11E-01

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

All "Other Analytes" are not included in the Sum of VOCS or HAPs.

Test GB Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	3.40E-05
1,2,4-Trimethylbenzene	3.40E-05
1,3,5-Trimethylbenzene	3.40E-05
1,3-Dimethylnaphthalene	3.40E-05
1-Methylnaphthalene	3.40E-05
2-Ethyltoluene	3.40E-05
2-Methylnaphthalene	3.40E-05
Benzene	3.40E-05
Ethylbenzene	3.40E-05
Hexane	3.40E-05
m,p-Xylene	3.40E-05
Naphthalene	3.40E-05
o-Xylene	3.40E-05
Styrene	3.40E-05
Toluene	3.40E-05
Undecane	3.40E-05
1,2-Dimethylnaphthalene	1.70E-04
1,3-Diethylbenzene	1.70E-04
1,5-Dimethylnaphthalene	1.70E-04
1,6-Dimethylnaphthalene	1.70E-04
1,8-Dimethylnaphthalene	1.70E-04

Analytes	Lb/Lb Binder
2,3,5-Trimethylnaphthalene	1.70E-04
2,3-Dimethylnaphthalene	1.70E-04
2,4-Dimethylphenol	1.70E-04
2,6-Dimethylnaphthalene	1.70E-04
2,6-Dimethylphenol	1.70E-04
2,7- Dimethylnaphthalene	1.70E-04
3-Ethyltoluene	1.70E-04
Acenaphthalene	1.70E-04
Biphenyl	1.70E-04
Cyclohexane	1.70E-04
Decane	1.70E-04
Dodecane	1.70E-04
Heptane	1.70E-04
Indan	1.70E-04
Indene	1.70E-04
m,p-Cresol	1.70E-04
Nonane	1.70E-04
o-Cresol	1.70E-04
Octane	1.70E-04
Phenol	1.70E-04
Propylbenzene	1.70E-04

Analytes	Lb/Lb Binder
Tetradecane	1.70E-04
HC as Hexane	1.97E-03
2-Butanone (MEK)	3.45E-05
Acetaldehyde	3.45E-05
Acetone	3.45E-05
Acrolein	3.45E-05
Benzaldehyde	3.45E-05
Butyraldehyde	3.45E-05
Crotonaldehyde	3.45E-05
Formaldehyde	3.45E-05
Hexaldehyde	3.45E-05
Butyraldehyde/Methacrolein	5.75E-05
o,m,p-Tolualdehyde	9.20E-05
Pentanal (Valeraldehyde)	3.45E-05
Propionaldehyde (Propanal)	3.45E-05
Aniline	3.87E-04
Dimethylaniline	7.73E-04
Carbon Monoxide	8.15E-03
Carbon Dioxide	1.28E-02

Test GB Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	2.62E-04
1,2,4-Trimethylbenzene	2.62E-04
1,3,5-Trimethylbenzene	2.62E-04
1,3-Dimethylnaphthalene	2.62E-04
1-Methylnaphthalene	2.62E-04
2-Ethyltoluene	2.62E-04
2-Methylnaphthalene	2.62E-04
Benzene	2.62E-04
Ethylbenzene	2.62E-04
Hexane	2.62E-04
m,p-Xylene	2.62E-04
Naphthalene	2.62E-04
o-Xylene	2.62E-04
Styrene	2.62E-04
Toluene	2.62E-04
Undecane	2.62E-04
1,2-Dimethylnaphthalene	1.31E-03
1,3-Diethylbenzene	1.31E-03
1,5-Dimethylnaphthalene	1.31E-03
1,6-Dimethylnaphthalene	1.31E-03
1,8-Dimethylnaphthalene	1.31E-03

Analytes	Lb/Tn Metal
2,3,5-Trimethylnaphthalene	1.31E-03
2,3-Dimethylnaphthalene	1.31E-03
2,4-Dimethylphenol	1.31E-03
2,6-Dimethylnaphthalene	1.31E-03
2,6-Dimethylphenol	1.31E-03
2,7- Dimethylnaphthalene	1.31E-03
3-Ethyltoluene	1.31E-03
Acenaphthalene	1.31E-03
Biphenyl	1.31E-03
Cyclohexane	1.31E-03
Decane	1.31E-03
Dodecane	1.31E-03
Heptane	1.31E-03
Indan	1.31E-03
Indene	1.31E-03
m,p-Cresol	1.31E-03
Nonane	1.31E-03
o-Cresol	1.31E-03
Octane	1.31E-03
Phenol	1.31E-03
Propylbenzene	1.31E-03

Analytes	Lb/Tn Metal
Tetradecane	1.31E-03
HC as Hexane	1.52E-02
2-Butanone (MEK)	2.66E-04
Acetaldehyde	2.66E-04
Acetone	2.66E-04
Acrolein	2.66E-04
Benzaldehyde	2.66E-04
Butyraldehyde	2.66E-04
Crotonaldehyde	2.66E-04
Formaldehyde	2.66E-04
Hexaldehyde	2.66E-04
Butyraldehyde/Methacrolein	4.44E-04
o,m,p-Tolualdehyde	7.10E-04
Pentanal (Valeraldehyde)	2.66E-04
Propionaldehyde (Propanal)	2.66E-04
Aniline	2.99E-03
Dimethylaniline	5.97E-03
Carbon Monoxide	6.29E-02
Carbon Dioxide	9.89E-02

APPENDIX C TEST SERIES GB DETAILED PROCESS DATA

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Test GB Detailed Process Data

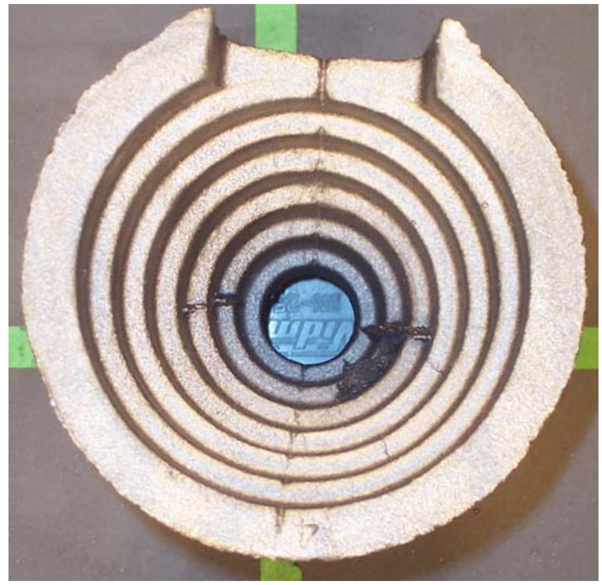
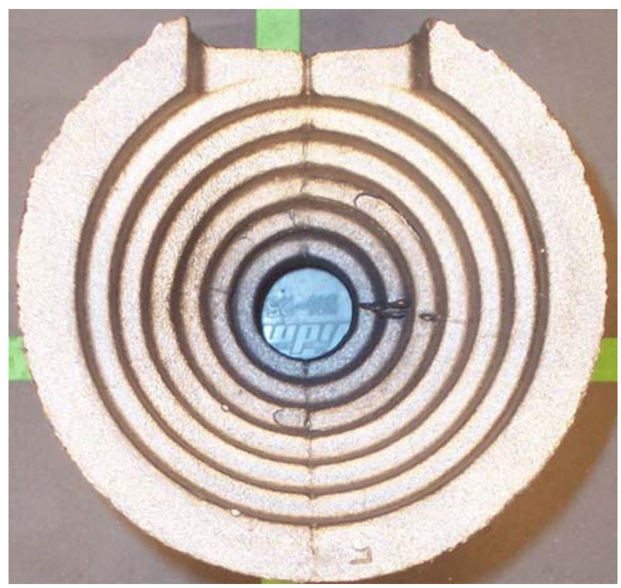
Greensand PCS													
Test Dates				7/14/04	7/14/04	7/14/04	7/15/04	7/15/04	7/15/04	7/16/04	7/16/04	7/16/04	
Emissions Sample #	**GBER1**	**GBER2**	**GBER3**	**GB001**	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**	**Averages**
Production Sample #	**GB001**	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**	**GB010**	**GB011**	**GB012**	
Cast Weight (all metal inside mold), Lbs.	110.85	88.85	108.85	105.85	106.90	105.95	106.45	105.10	106.70	107.25	107.45	106.40	**106.45**
Pouring Time, sec.	22	18	20	25	22	29	25	26	23	20	19	28	**24**
Pouring Temp ,°F	2638	2622	2634	2629	2618	2636	2640	2639	2638	2627	2640	2633	**2633**
Pour Hood Process Air Temp at Start of Pour, °F	86	86	86	85	88	86	86	86	86	86	86	86	**86**
Core Mixer auto dispensed batch weight, Lbs	49.08	49.08	49.08	49.08	49.08	49.08	49.08	49.08	49.08	49.08	49.08	49.08	**49.08**
Calibrated auto dispensed core binder weight, Lbs	0.690	0.690	0.690	0.690	0.690	0.690	0.690	0.690	0.690	0.690	0.690	0.690	**0.690**
Core binder calibrated weight, %BOS	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	**1.41**
Core binder calibrated weight, %	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	**1.39**
Total uncoated core weight in mold, Lbs.	30	30	29.5	29.50	29.50	30.00	29.50	29.50	29.50	30.00	29.50	29.50	**29.61**
Total binder weight in mold, Lbs.	0.416	0.416	0.409	0.409	0.409	0.416	0.409	0.409	0.409	0.416	0.409	0.409	**0.411**
Core LOI, % Note 2	1.19	1.23	1.21	ND	1.17	1.22	1.19	1.21	1.17	1.19	1.19	1.19	**1.19**
Total dried core coating weight in mold. Lbs	0.39	0.38	0.36	0.39	0.38	0.36	0.34	0.35	0.36	0.35	0.35	0.32	**0.36**
Dogbone tensile test (Thwing-Albert psi)	227	235	235	228	236	232	235	233	240	240	234	242	**236**
Core age, hrs.	25	28	31	49	52	54	73	75	78	96	98	100	**75**
Muller Batch Weight, Lbs.	1303	900	900	1300	900	900	900	900	900	900	900	900	**944**
GS Mold Sand Weight, Lbs.	609	606	614	620	602	607	610	624	626	622	607	614	**615**
Mold compactability, %	54	52	55	52	53	56	52	57	59	55	58	55	**55**
Mold Temperature, °F	77	79	86	75	85	89	74	ND	80	83	87	89	**83**
Average Green Compression , psi	19.1	13.78	19.91	19.45	21.45	22.27	22.60	22.23	21.14	21.35	21.04	21.32	**21.43**
GS Compactability, %	47	35	52	43	54	47	43	49	49	50	53	49	**49**
GS Moisture Content, %	2.46	2.08	2.94	2.26	2.81	2.54	2.60	2.31	2.37	2.22	3.04	2.40	**2.51**
GS MB Clay Content, %	7.8	7.65	7.78	7.91	7.65	7.91	7.26	7.54	7.39	7.39	7.13	7.26	**7.49**
MB Clay reagent, ml	30.1	29.5	30.0	30.5	29.5	30.5	28.0	29.1	28.5	28.5	27.5	28.0	**28.9**
1800°F LOI - Mold Sand, %	5.07	5.05	4.85	5.08	5.07	5.18	5.39	5.33	5.2	5.40	5.48	5.59	**5.30**
900°F Volatiles , %	0.94	0.68	0.22	0.78	0.50	0.28	0.92	0.60	0.16	0.68	0.44	0.20	**0.51**

	GBER1	**GBER2**	**GBER3**	**GB001**	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**
GS Surface Appearance Ranking 1= Best 23 = Worst	**GB001**	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**	**GB010**	**GB011**	**GB012**
Greensand surface Cavity 1	18	7	19	3	2	9	15	1	16	10	14	21
Greensand surface Cavity 2	15	Note 1	8	14	17	9	23	7	10	22	6	16
Greensand surface Cavity 3 (reference cavity)	6	14	4	5	15	9	18	10	20	19	8	16
Greensand surface Cavity 4	9	1	2	1	6	11	7	7	20	12	13	14
Core Surface Appearance Ranking 1 = Best, 18 = Worst												
Core Surface Cavity 1	6	8	4	10	5	2	12	7	3	15	16	1
Core Surface Cavity 2	15	Note 1	2	12	4	9	16	8	11	18	13	14
Core Surface Cavity 3 (reference cavity)	12	10	2	9	1	3	16	5	7	14	6	17
Core Surface Cavity 4	8	5	3	9	6	4	10	12	13	15	11	14

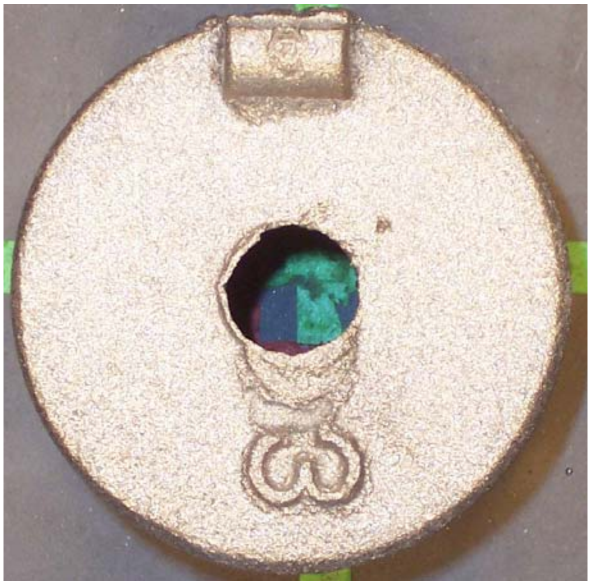
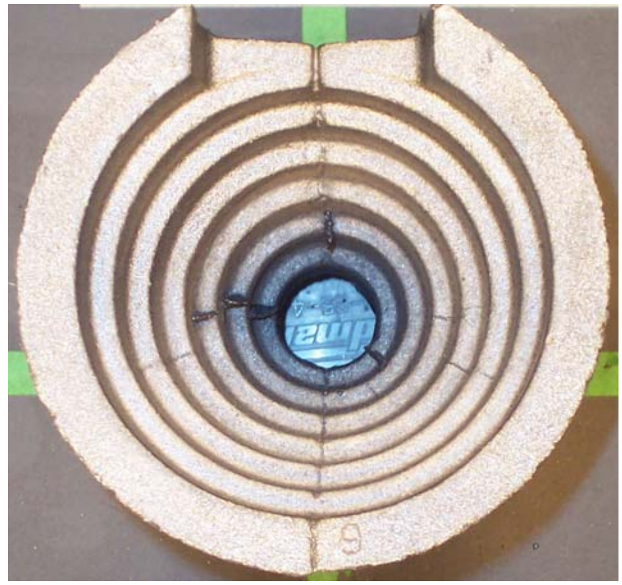
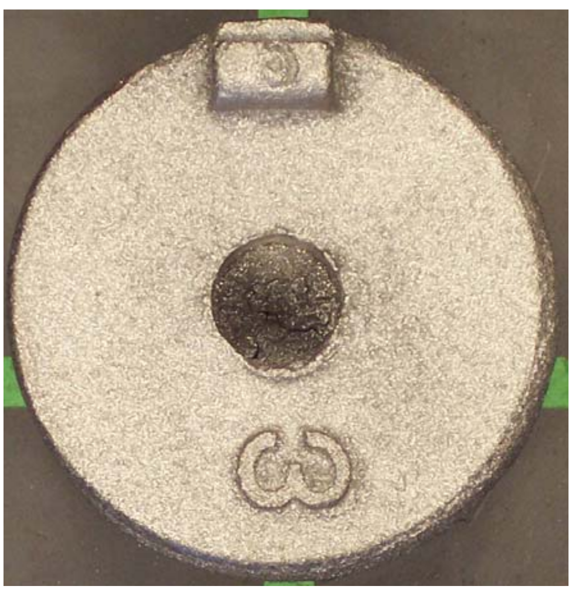
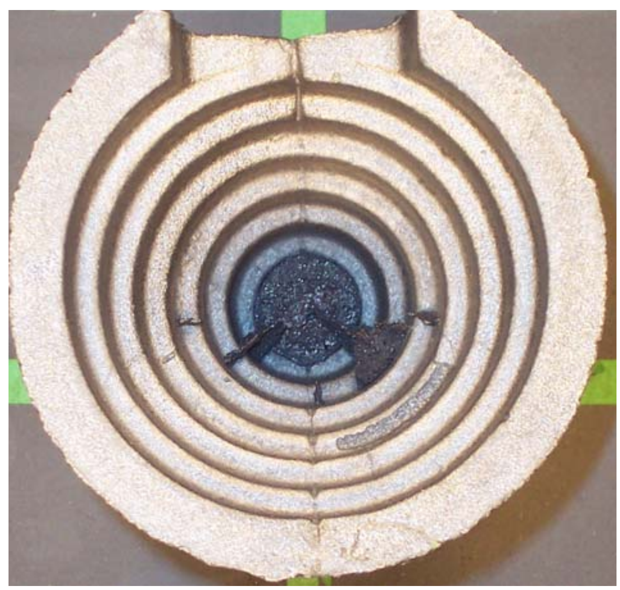
Note 1: Cavity 2 run 2 misran, no casting
Note 2: Emission sample GB001 appeared incompletely cured or improperly mixed.
There were 23 GS quality levels; There were 18 core quality levels

For product test to compare to	**GBER1**	**GBER2**	**GBER3**	**GB001**	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**
	GB001	**GB002**	**GB003**	**GB004**	**GB005**	**GB006**	**GB007**	**GB008**	**GB009**	**GB010**	**GB011**	**GB012**
Relative quality level of reference cavity 3 GS surface	2a	4a	0a	1	5	3	7	4	9	8	2	6
Relative quality level of reference cavity 3 core surface	5b	5a	1a	5	1	2	8	3	4	6	7	9

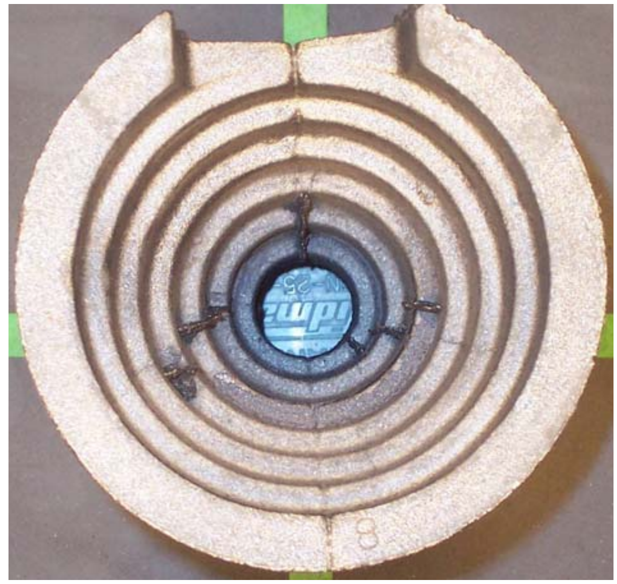
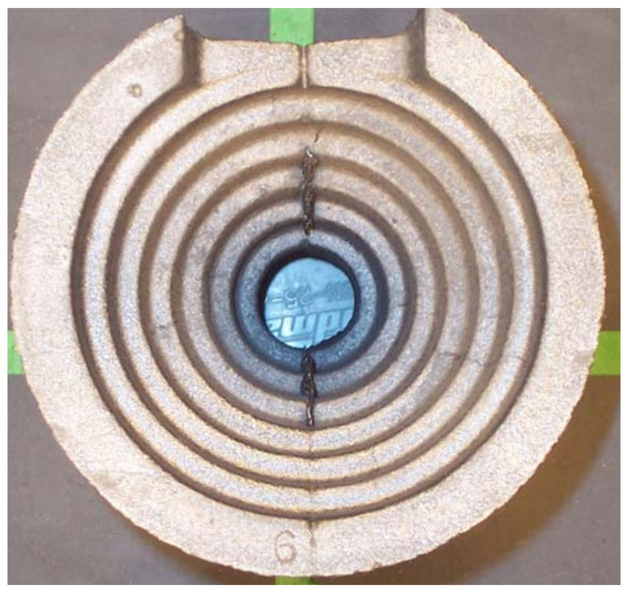
Cavity 3 Greensand Surface and Core Surface Photos

Emission Run Number	Greensand Surface	Core Surface
GB001		
GB002		

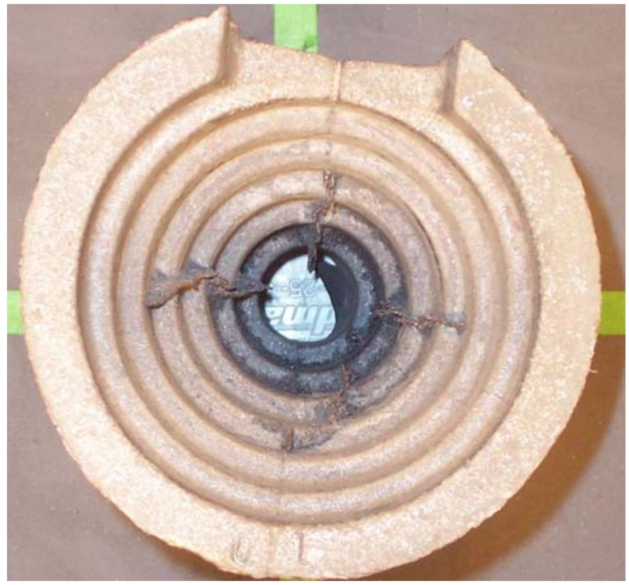
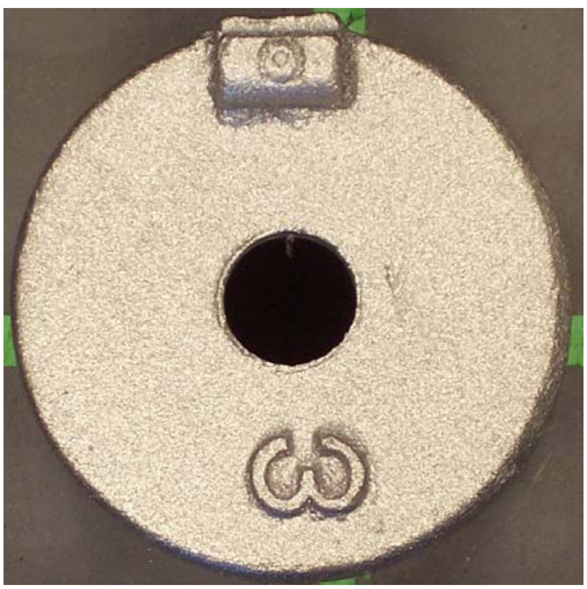
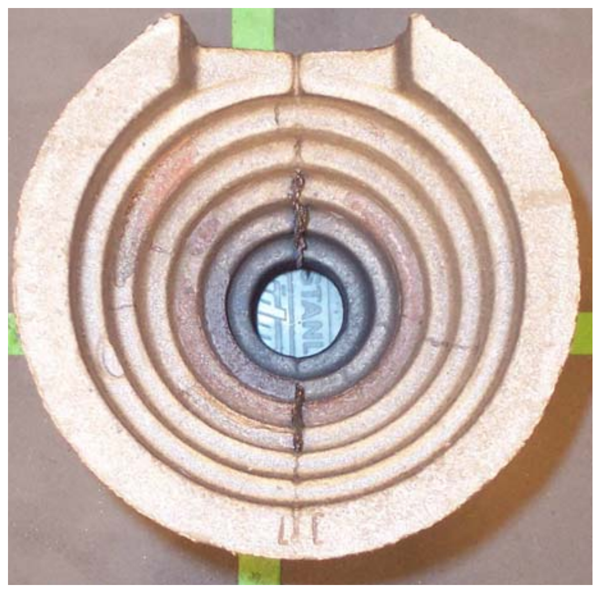
Cavity 3 Greensand Surface and Core Surface Photos

Emission Run Number	Greensand Surface	Core Surface
GB003		
GB004		

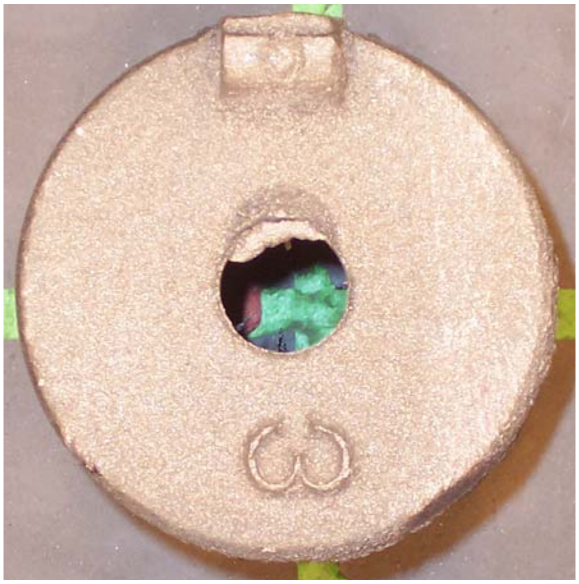
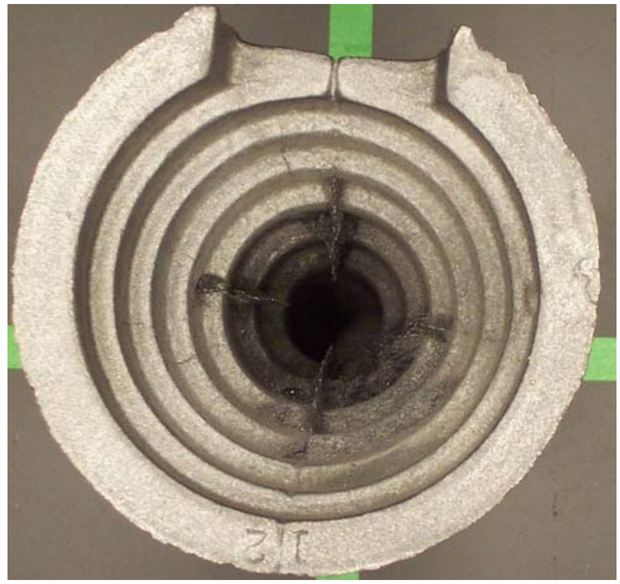
Cavity 3 Greensand Surface and Core Surface Photos

Emission Run Number	Greensand Surface	Core Surface
GB005		
GB006		

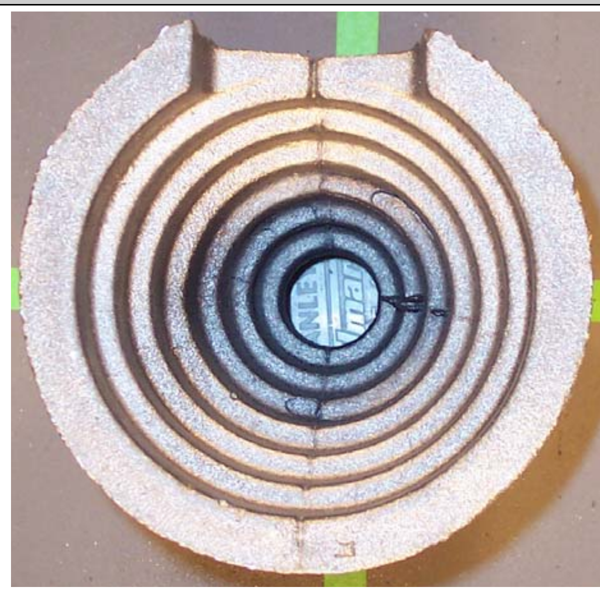
Cavity 3 Greensand Surface and Core Surface Photos

Emission Run Number	Greensand Surface	Core Surface
GB007		
GB008		

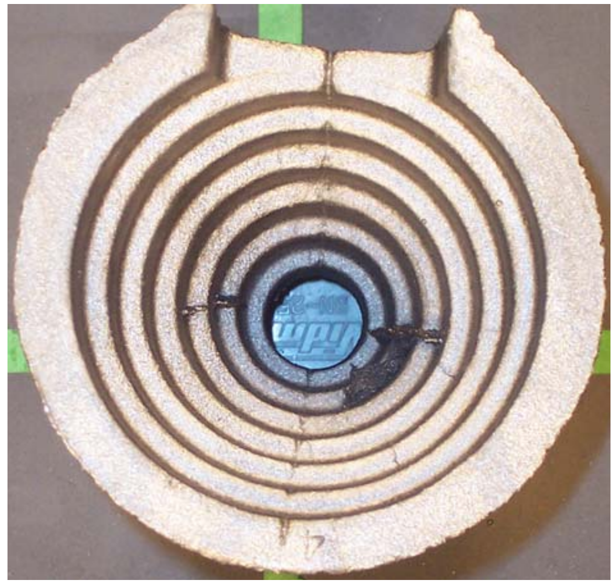
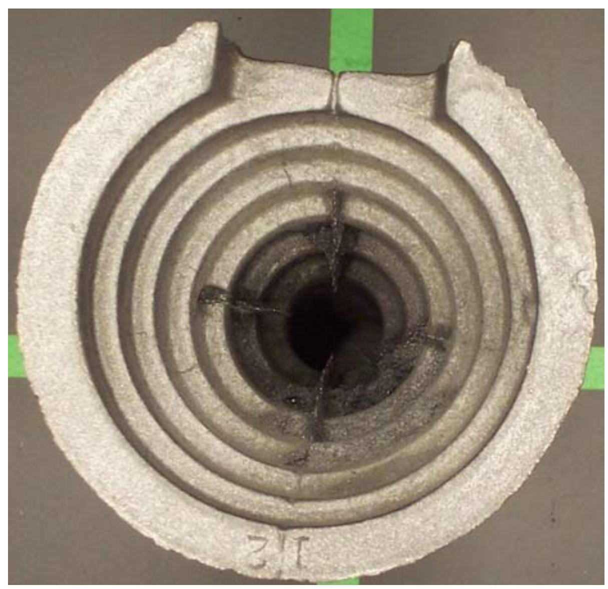
Cavity 3 Greensand Surface and Core Surface Photos

Emission Run Number	Greensand Surface	Core Surface
GB009		

Cavity 3 Comparison - Best, Median, Worst Photos

Rank	Greensand Surface	Core Surface
Best		

Cavity 3 Comparison - Best, Median, Worst Photos

Rank	Greensand Surface	Core Surface
Median		
Worst		

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APPENDIX D METHOD 25A CHARTS

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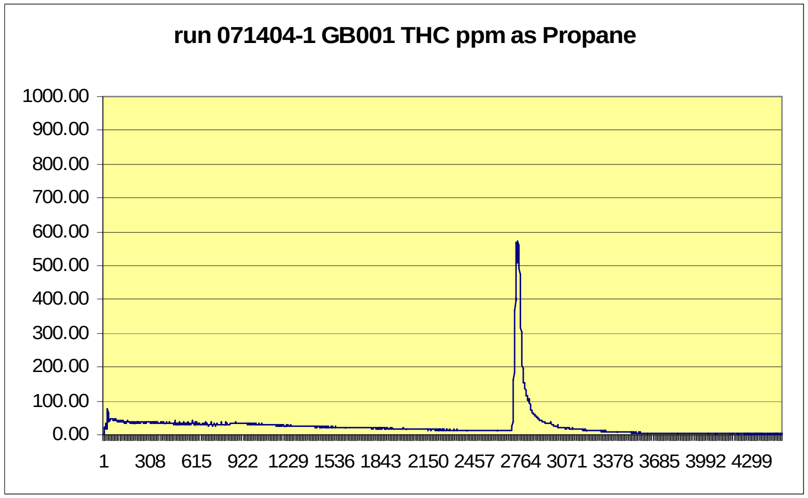
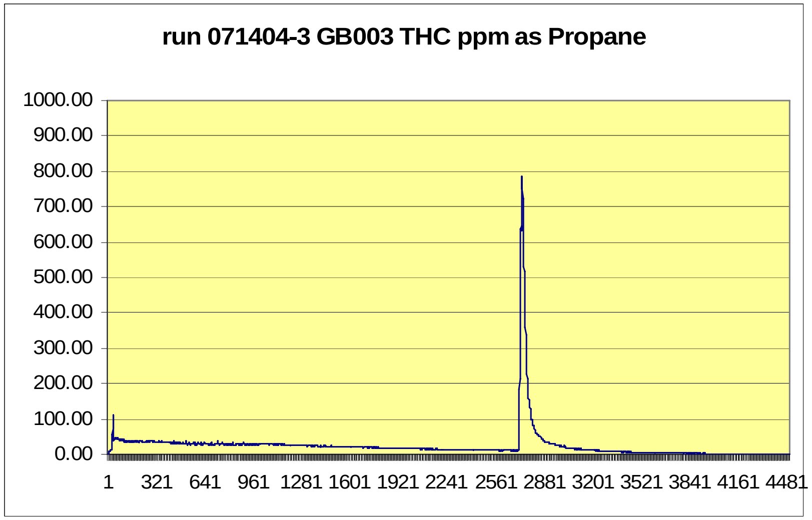
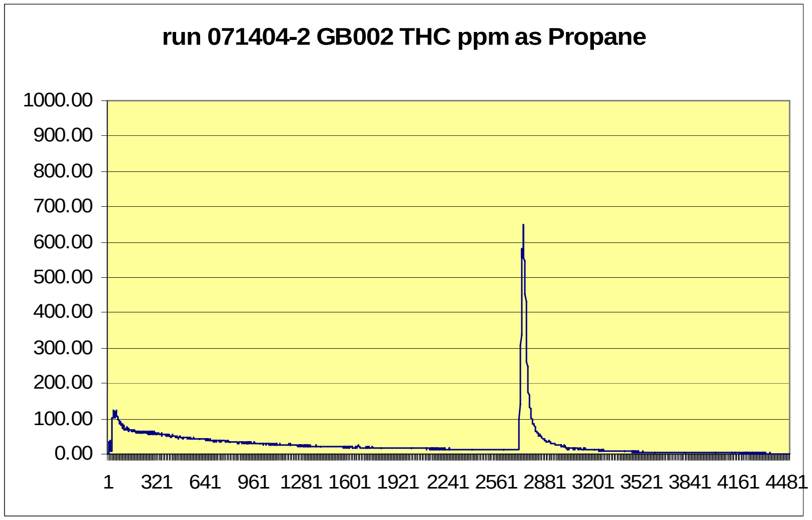
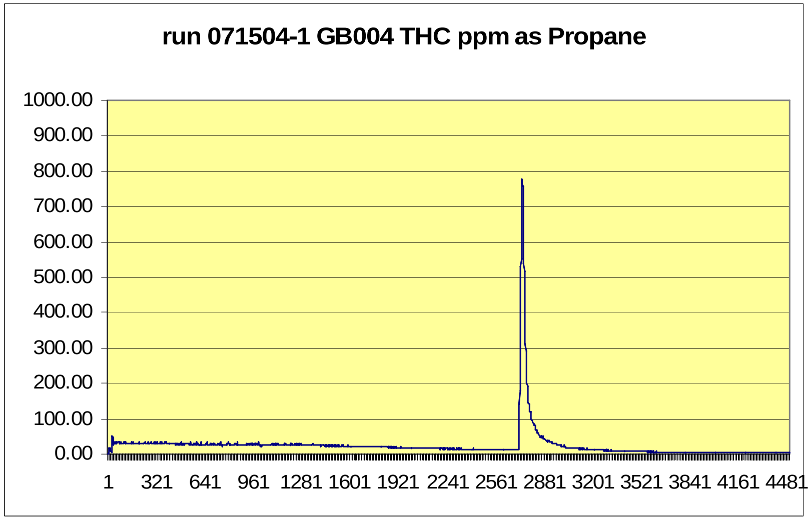
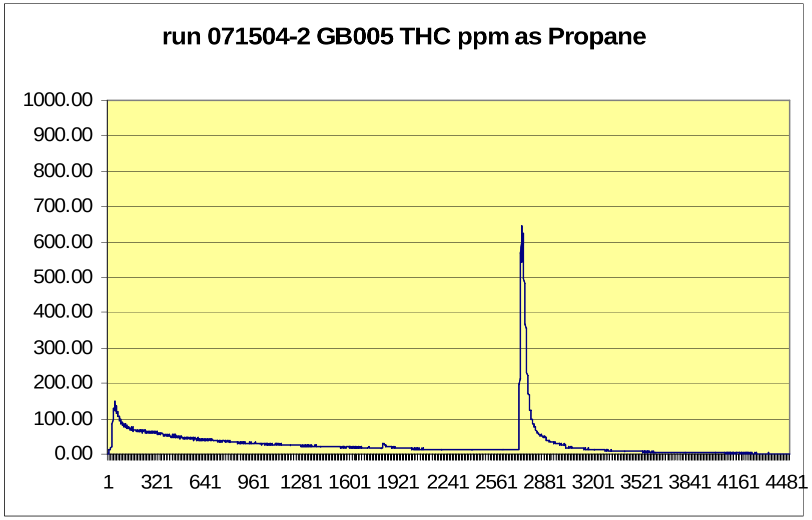
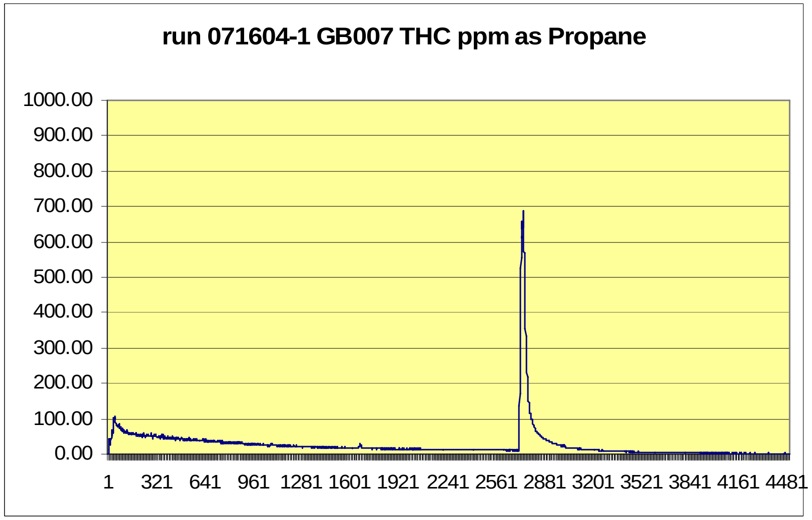

run 071404-1 GB001 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 308 615 922 1229 1536 1843 2150 2457 2764 3071 3378 3685 3992 4299

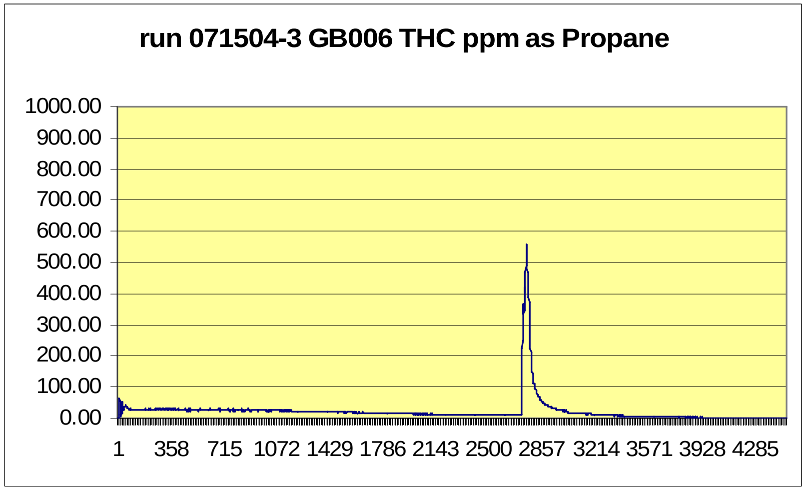

run 071404-3 GB003 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481

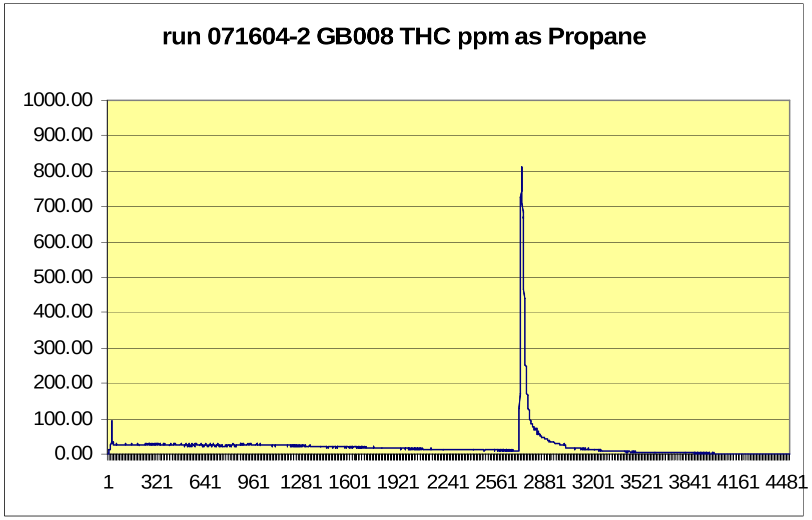

run 071404-2 GB002 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481

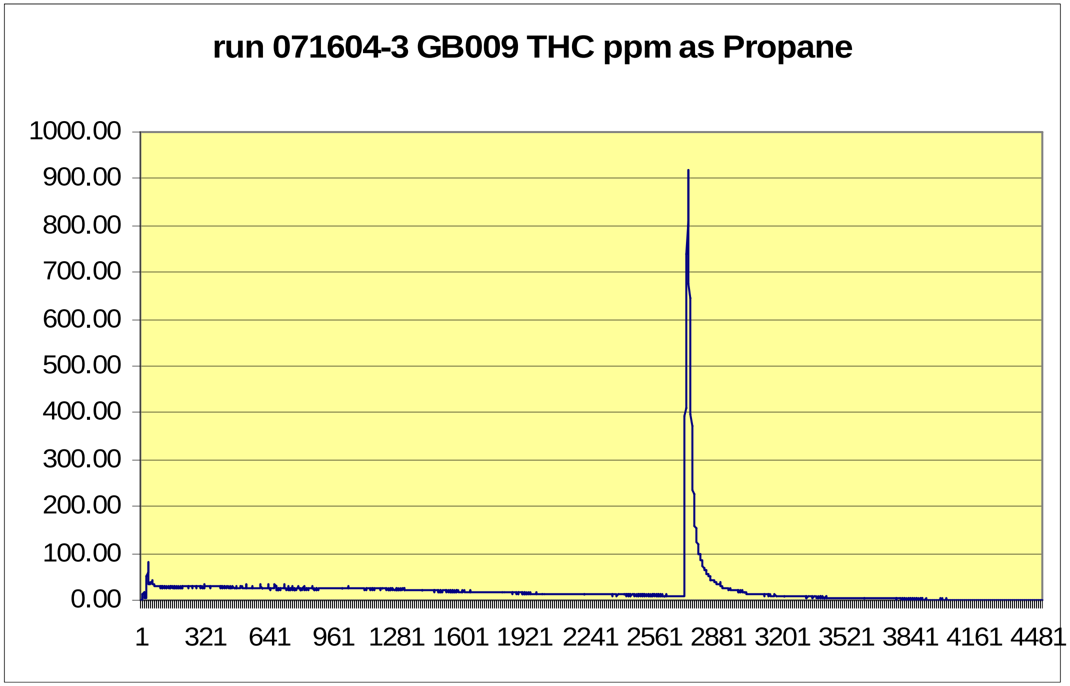

run 071504-1 GB004 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 071504-2 GB005 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 071604-1 GB007 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 071504-3 GB006 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 358 715 1072 1429 1786 2143 2500 2857 3214 3571 3928 4285


run 071604-2 GB008 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 071604-3 GB009 THC ppm as Propane
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1
321
641
961
1281
1601
1921
2241
2561
2881
3201
3521
3841
4161
4481

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APPENDIX E GLOSSARY

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Glossary

ACFM	Actual Cubic Feet Per Minute
BO	Based on ( ).
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 quantity 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.
I	Invalid, Data rejected based on data validation considerations
LOI	Loss On Ignition
NA	Not Applicable, Not Available
ND	Non-Detect
NT	Not Tested, Lab testing was not done
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	Parts Per Million by Volume
SCFM	Standard Cubic Feet per Minute
TGOC	Total Gaseous Organic Carbon
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