Casting Emission Reduction Program

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Baseline: Core Making and PCS of Oil Sand Cores in Greensand without Seacoal, Iron

Technikon # 1411-124 GM

October 2005
(revised for public distribution)

United States Environmental Protection Agency

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Core Making and PCS of Oil Sand Cores in Greensand without Seacoal, Iron

Technikon # 1411-124 GM

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

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 was not collected to assess casting cost, or producibility.

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Executive Summary

This report contains the results of Test GM – Core Making and Pouring/Cooling/Shakeout of Oil Sand cores. The cores were made from H & G 840 Core Oil, cereal, clay, and water mixed with Wedron 530 sand. They were hand rammed into standard step cores. The cores were then baked in a preheated sampling enclosure for 120 minutes at a nominal temperature of 425°F during which emissions were sampled. Cores were cooled for three hours during which emissions were measured. The pouring/cooling/shakeout (PCS) test was conducted in a total enclosure meeting the specifications of US-EPA Method 204.

The emissions results from the core making/baking are reported in both pounds per pound (Lbs/Lb) of binder and pounds per ton (Lbs/Tn) of core. The PCS results are reported in both pounds per pound (Lbs/Lb) of binder and pounds per ton (Lbs/Tn) of metal poured.

Process and stack parameters were measured and include: the weights of the core, core binder, furnace and core temperatures; event timing; loss on ignition (LOI) values for the core prior to the test; stack temperature, pressure, 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 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 during both core making and PCS. Carbon monoxide, carbon dioxide, and NOx were also monitored continually during PCS.

Mass emission rates for all target analytes were calculated using continuous monitoring data, laboratory analytical results, measured source data and appropriate process data. Five emission indicators including TGOC as propane, Hydrocarbons (HC) as hexane, the Sum of target VOCs, the Sum of target HAPS, and the Sum of target polycyclic organic matter (POM) 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 tables reported as lbs/tn of core and lbs/lb of binder for the making/baking portion of the test and in lbs/tn of metal and lbs/lb of binder for the PCS portion of the test.

Table 1 Test Plan GM Core Making Average Emission Indicator Results

Test GM	Core Making Lb/Lb Binder	Core Making Lb/Tn of Cores
TGOC as Propane	0.2144	8.2221
HC as Hexane	0.0751	2.8779
Sum of Target VOCs	0.0106	0.4005
Sum of Target HAPs	0.0036	0.1393
Sum of Target POMs	ND	ND

Table 2 Test Plan GM PCS Average Emission Indicator Results

Test GM	PCS Lb/Lb Binder	PCS Lb/Tn of Metal
TGOC as Propane	0.0669	0.8886
HC as Hexane	0.0145	0.1927
Sum of Target VOCs	0.0131	0.1693
Sum of Target HAPs	0.0103	0.1373
Sum of Target POMs	0.0009	0.0121

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); the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). 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 reports for regulatory compliance data.

1.2. Objectives

The primary objective of CERP 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.

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.

1.3. 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, criteria pollutants, and greenhouse gas emissions from foundry materials and 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 data binder is maintained at the Technikon facility.

1.4. Specific Test Plan and Objectives

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

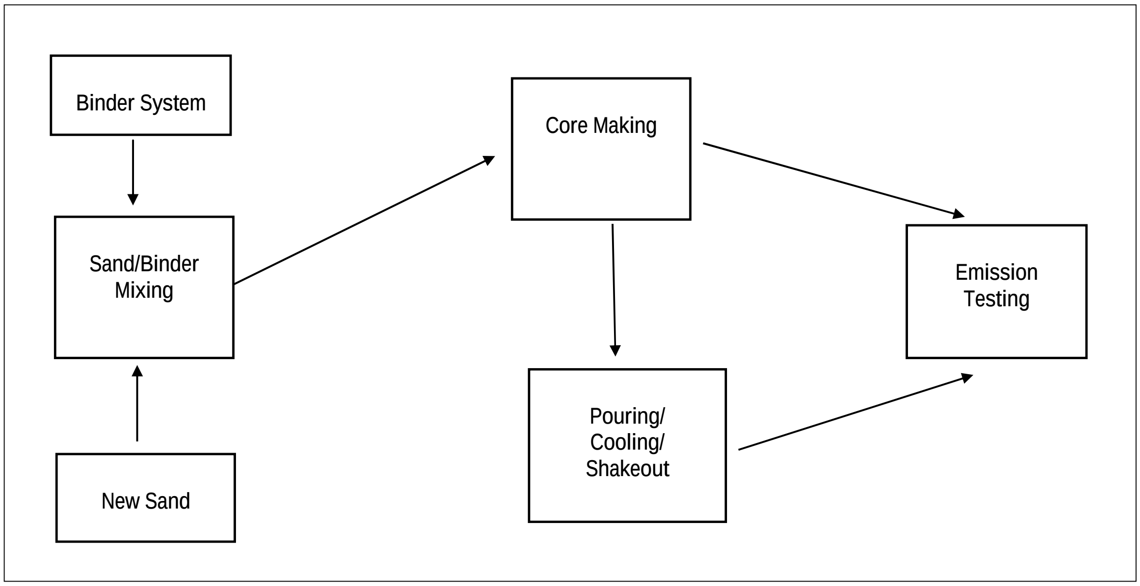
Table 1-1 Test Plan Summary

Test Plan Number	1411-124-GM Core Making	1411-124-GM PCS
Type of Process Tested	Oil Sand Core Making	Oil Sand Core PCS
Aggregate	Wedron 530 Silica Sand	Wedron 530 Silica Sand
Core Binder System	H & G 840 Core Oil	H & G 840 Core Oil
Mold Material	NA	Greensand without seacoal
Metal Poured	None	Iron
Core type	Step	Step
Number of Cores	6	9
Test Dates	03-02-05 through 03-08-05	03-14-05 through 03-16-05
Emissions Measured	TGOC as Propane, HC as Hexane, 68 Target Analytes	TGOC as Propane, Carbon Monoxide, Carbon Dioxide, Nitrogen Oxides, HC as Hexane, 68 Target Analytes
Process Parameters Measured	Total Core, and Binder Weights; core % LOI; Sand Temperature; Stack Temperature, Moisture Content, Pressure, and Volumetric Flow Rate	Total Core and Binder Weights; core % LOI; Sand Temperature; Stack Temperature, Moisture Content, Pressure, and Volumetric Flow Rate

2.0 TEST METHODOLOGY

2.1. Description of Process and Testing Equipment

Figure 2-1 Research Foundry Core Making, Baking, and PCS Process Flowchart



2.2. Description of Testing Program

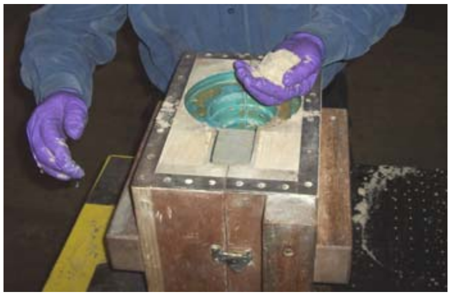
The process parameters not being evaluated were maintained within prescribed ranges in order to ensure the reproducibility of the tests. Emissions were continuously measured during core making and PCS according to US EPA Method 25A, Total Gaseous Organic Concentration, calibrated with propane. Carbon monoxide, carbon dioxide, and nitrogen oxides were also monitored during PCS according to US EPA Methods 10, 3A, and 7E, respectively. 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

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

1. **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.

2. **Core Preparation:** The cores were prepared with 2.0% H & G 840 Core oil, 1% cereal, 0.5%clay, and 1.5%-2.5%water by the Technikon production team. The cores were hand rammed (see Figure 2-2). Relevant process data was collected and recorded.

Figure 2-2 Core Preparation

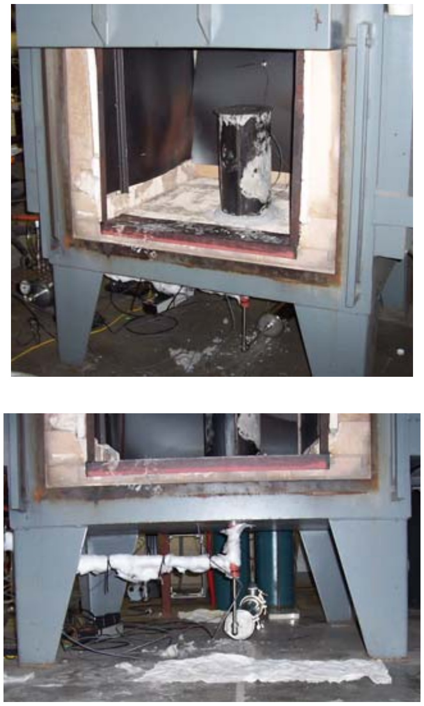


3. **Core Baking Oven**: An electric AccuTherm Oven was used for core baking (see Figure 2-3).

Figure 2-3 Core Baking Enclosure

4. **Enclosed Core Holder:** The test cores were placed in the preheated core holder. Heated oven air entered an opening in the top of the enclosure, flowed over the core, and exited the bottom into the insulated sample collection manifold (see Figure 2-4).

Figure 2-4 Enclosed Core Holder



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

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Core Weight	Mettler SB12001 Digital scale (Gravimetric)
Metal Weight	Ohaus DS 10 Digital scale (Gravimetric)
Binder Weight	Mettler SB12001 Digital Scale (Gravimetric)
LOI, % at Mold	Denver Instruments XE-100 (AFS procedure 5100-00-S)
Core Temperature	Recorder or data logger and J-thermocouples

6. **Emissions Measurement**: The specific sampling and analytical methods used in the Research Foundry tests 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
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, TO 17, TO11, NIOSH 2002
Target Analytes Concentration	EPA Method 18, TO 17, TO11, NIOSH 2002, NIOSH 1500
TGOC as Propane	EPA Method 25A
Carbon Monoxide	EPA Method 10
Carbon Dioxide	EPA Method 3A
Nitrogen Oxides	EPA Method 7E

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

7. **Data Reduction, Tabulation and Preliminary Report Preparation**: The analytical results of the emissions tests and average stack flow rate provided the mass emissions for the target VOCs, Target HAPs, criteria pollutants, and greenhouse gasses during each test

run. The mass of emissions is calculated and then divided by the casting weight, core weight or the weight of the binder to provide emissions data in pounds per ton of metal, pounds per ton of core or 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 average results of each test and the corresponding process data are included in Section 3 of this report.

8. **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-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 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 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.

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

3.0 TEST RESULTS

The average emission results from core making/baking are presented in Tables 3-1 and 3-2 in pounds per ton of cores and pounds per pound of binder, respectively. Results for pouring/cooling/shakeout are shown in Tables 3.3 and 3.4. 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 VOCs, Sum of Target HAPs, and Sum of Target POMs. The tables also include TGOC as propane, and HC as hexane. Appendix B contains the detailed emissions data including the results for all analytes measured.

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. Figures 3-4 to 3-6 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-3 in graphical form.

Table 3-5 and 3-6 includes the averages of the key process parameters. Detailed process data are presented in Appendix C.

Method 25A, Method 10, Method 3A, and Method 7E charts are included in Appendix D of this report. The charts are presented to show the profile of emissions for each test run.

Table 3-7 presents the comparison of casting surface quality.

Figures 3-7 through 3-12 present the visual comparison of casting surface quality.

Table 3-1 Average Core Making/Baking Emissions Results – Lb/Tn Cores

Analytes	Average	Standard Deviation
Emissions Indicators		
TGOC as Propane	8.2221	0.4342
HC as n-Hexane	2.8779	0.1850
Sum of Target VOCs	0.4005	0.0314
Sum of Target HAPs	0.1393	0.0158
Sum of Target POMs	ND	NA
Specific Target HAPs		
Cresols	0.0826	0.0029
Phenol	0.0364	0.0054
Hexane	0.0232	0.0134
Formaldehyde	0.0132	0.0038
Acrolein	0.0129	0.0036
Acetaldehyde	0.0023	0.0006
Other Target VOCs		
Octane	0.0606	0.0013
Heptane	0.0547	0.0023
Decane	0.0440	0.0036
Nonane	0.0274	0.0017
Cyclohexane	0.0168	0.0174
Undecane	0.0164	0.0006
Hexaldehyde	0.0141	0.0022
Dodecane	0.0091	0.0013
Dimethylphenols	0.0049	0.0043
Crotonaldehyde	0.0048	0.0017
Benzaldehyde	0.0034	0.0012
o,m,p-Tolualdehyde	0.0033	0.0013
Pentanal (Valeraldehyde)	0.0031	0.0012

Individual results constitute >95% of mass of all detected target analytes.
ND: Non Detected at the Reporting Limit of 0.0001 lb/tn of core
NA: Not Applicable

Table 3-2 Average Core Making/Baking Emissions Results – Lb/Lb Binder

Analytes	Average	Standard Deviation
Emissions Indicators		
TGOC as Propane	0.2144	0.0116
HC as n-Hexane	0.0751	0.0049
Sum of Target VOCs	0.0106	0.0011
Sum of Target HAPs	0.0036	0.0004
Sum of Target POMs	ND	NA
Specific Target HAPs		
Cresols-	0.0016	0.0001
Phenol	0.0010	0.0001
Hexane	0.0006	0.0003
Formaldehyde	0.0003	0.0001
Acrolein	0.0003	0.0001
Acetaldehyde	0.0001	0.00001
Other Target VOCs		
Octane	0.0016	0.00004
Heptane	0.0014	0.0001
Decane	0.0011	0.0001
Nonane	0.0007	0.00004
Cyclohexane	0.0004	0.0005
Hexaldehyde	0.0004	0.0001
Undecane	0.0004	0.00001
Dodecane	0.0002	0.00003
Dimethylphenols	0.0001	0.0001
Crotonaldehyde	0.0001	0.00005
Benzaldehyde	0.0001	0.00003
o,m,p-Tolualdehyde	0.0001	0.00003
Pentanal (Valeraldehyde)	0.0001	0.00003

Individual results constitute >95% of mass of all detected target analytes.
ND: Non Detected at the Reporting Limit of 0.0001 lb/lb of binder
NA: Not Applicable

Table 3-3 Average PCS Emissions Results – Lb/Tn Metal

PCS Average Emissions	Lb/Tn Metal		
Analytes	Reference Test FR	Test GM	% Change from Reference
Emissions Indicators			
TGOC as Propane	0.9259	0.8886	-4%
HC as n-Hexane	0.3016	0.1927	-36%
Sum of Target VOCs	0.3705	0.1693	-54%
Sum of Target HAPs	0.3474	0.1373	-60%
Sum of Target POMs	0.1059	0.0121	-89%
Specific Target HAPs			
Benzene	0.1088	0.0402	-63%
Acetaldehyde	0.0034	0.0247	627%
Toluene	0.0161	0.0200	24%
Propionaldehyde (Propanal)	0.0002	0.0109	5351%
Methylnaphthalenes	0.0533	0.0090	-83%
Hexane	0.0006	0.0065	988%
Xylenes	0.0064	0.0038	-40%
Ethylbenzene	0.0007	0.0036	411%
Phenol	0.0707	0.0030	-96%
Naphthalene	0.0389	0.0031	-92%
Formaldehyde	0.0008	0.0024	199%
Acrolein	ND	0.0022	NA
Styrene	0.0017	0.0021	24%
Cresols	0.0187	0.0017	-91%
Other Target VOCs			
Heptane	ND	0.0059	NA
Octane	ND	0.0033	NA
Cyclohexane	ND	0.0029	NA
Indene	0.0027	0.0024	-10%
Benzaldehyde	0.0002	0.0023	1071%
Butyraldehyde/Methacrolein	0.0004	0.0023	466%
Pentanal (Valeraldehyde)	ND	0.0017	NA
Ethyltoluenes	0.0028	0.0016	-44%
Nonane	ND	0.0014	NA
Dimethylphenols	0.0017	0.0013	-24%
Decane	ND	0.0013	NA
Crotonaldehyde	ND	0.0013	NA
Indan	ND	0.0011	NA
Trimethylbenzene, 1,2,3-	0.0079	0.0010	-88%
Hexaldehyde	ND	0.0009	NA
Propylbenzene, n-	0.001	0.0008	-18%
Criteria Pollutants and Greenhouse Gases			
CO	I	2.4034	NA
CO2	NT	6.6659	NA
NOx	NT	0.0036	NA

Individual results constitute >95% of mass of all detected target analytes.
ND: Non Detected at the Reporting Limit of 0.0001 lb/tn of core
NA: Not Applicable - I: Invalidated – NT: Not Tested

Table 3-4 Average PCS Emissions Results – Lb/Lb Binder

PCS Average Emissions Lb/Lb Binder

Analytes	Reference Test FR	Test GM	% Change from Reference Test FR
Emissions Indicators			
TGOC as Propane	0.1480	0.0669	-55%
HC as n-Hexane	0.0482	0.0145	-70%
Sum of Target VOCs	0.0591	0.0131	-78%
Sum of Target HAPs	0.0554	0.0103	-81%
Sum of Target POMs	0.0169	0.0009	-95%
Specific Target HAPs			
Benzene	0.0174	0.0030	-83%
Acetaldehyde	0.0005	0.0019	271%
Toluene	0.0026	0.0015	-42%
Propionaldehyde (Propanal)	<0.0001	0.0008	NA
Methylnaphthalenes	0.0085	0.0006	-92%
Hexane	0.0001	0.0005	391%
Xylenes	0.001	0.0008	-20%
Ethylbenzene	0.0001	0.0003	169%
Phenol	0.0113	0.0002	-98%
Naphthalene	0.0062	0.0002	-96%
Formaldehyde	0.0001	0.0002	80%
Acrolein	ND	0.0002	NA
Styrene	0.0003	0.0002	-47%
Cresols	0.003	0.0001	-97%
Other Target VOCs			
Heptane	ND	0.0004	NA
Octane	ND	0.0002	NA
Cyclohexane	ND	0.0002	NA
Indene	0.0004	0.0002	-54%
Benzaldehyde	<0.0001	0.0002	NA
Butyraldehyde/Methacrolein	0.0001	0.0002	71%
Pentanal (Valeraldehyde)	ND	0.0001	NA
Ethyltoluenes	0.0005	0.0001	-76%
Nonane	ND	0.0001	NA
Dimethylphenols	0.0003	0.0001	-67%
Decane	ND	0.0001	NA
Crotonaldehyde	ND	0.0001	NA
Indan	ND	0.0001	NA
Trimethylbenzene, 1,2,3-	0.0013	0.0001	-94%
Hexaldehyde	ND	0.0001	NA
Propylbenzene, n-	0.0002	0.0001	-69%
Criteria Pollutants and Greenhouse Gases			
CO	I	0.1811	NA
CO2	NT	0.5019	NA
NOx	NT	0.0003	NA

Individual results constitute >95% of mass of all detected target analytes.
ND: Non Detected at the Reporting Limit of 0.0001 lb/lb of binder
NA: Not Applicable - I: Invalidated – NT: Not Tested

Table 3-5 Summary of Core Baking Process Parameters

Baking & Cooling	Test GM
Test Dates	2-8 March 2005
Sand in Oil Core Sand mix, Lbs	24.99
Core Oil in Oil Core Sand Mix' Lbs,	0.50
Cereal in Oil Core Sand Mix, Lbs	0.25
Clay in Oil Core Sand Mix, Lbs	0.12
Water in Oil Core Sand Mix, Lbs	0.24
Oil Content, % (BOS)	2.00
Cereal Content, % (BOS)	1.00
Clay Content, % (BOS)	0.5
Water content, % (BOS)	0.96
Oil Content, % of Sand Mix	1.92
Cereal Content, % of Sand mix	0.96
Clay Content, % of Sand Mix	0.48
Water content, of Sand mix	0.92
Weight of Un-baked Core, Lbs	4.30
Weight of Baked Cores, Lbs.	4.249
Weight loss during baking, % of unbaked core weight	1.28
Unbaked Oil Binder Weight in Core Step Section, Lbs.	0.08
Unbaked Oil + Cereal Weight in Core Step Section, Lbs	0.12
Core LOI, % (note 1)	2.34
Approximate Core Age when baked, Min.	<6
Core Oven Temperature, F	425
Average heated investment time, Minutes	120

Table 3-6 Summary of PCS Process Parameters

Greensand PCS	Test FR	Test GM
Test Dates	15-16 Jan 2004	11-16 March 2005
Cast Weight (all metal inside mold), Lbs.	111.1	112.6
Pouring Time, sec.	28	17
Pouring Temp ,°F	2632	2629
Pour Hood Process Air Temp at Start of Pour, ºF	87	87
Liquid binder Content, % of Sand Mix	1.38	1.92
Cereal Content, % of Sand mix	NA	0.96
Clay Content, % of Sand Mix	NA	0.48
Water content, % of Sand mix	NA	0.96
Total Weight of Un-baked Cores in Mold, Lbs	NA	30.12
Total Weight of Baked Cores in Mold, Lbs.	25.25	29.76
Total Unbaked Oil Binder Weight in Mold, Lbs.	0.35	0.58
Total Unbaked Oil + Cereal Weight in Mold, Lbs	NA	0.87
Core LOI, %	1.26	2.38
Dogbone Tensile Strength, psi	40	207
Approximate Core Age, hrs.	61	130
Baking Oven nominal temperature, F	NA	425
Average heated investment time, Minutes	NA	121
Greensand Muller Batch Weight, Lbs.	900	904
GS Mold Sand Weight, Lbs.	620	642
Greensand Muller Compactability, %	56	54
Greensand Mold Temperature, ºF	70	82
Average Green Compression , psi	11.0	23.4
GS Compactability, %	53	41
GS Moisture Content, %	2.27	2.15
GS MB Clay Content, %	6.02	8.04
MB Clay Reagent, ml	26	39
1800°F LOI - Mold Sand, %	0.7125	0.99
900°F Volatiles , %	0.235	0.47

Figure 3-1 Core Baking Emission Indicators

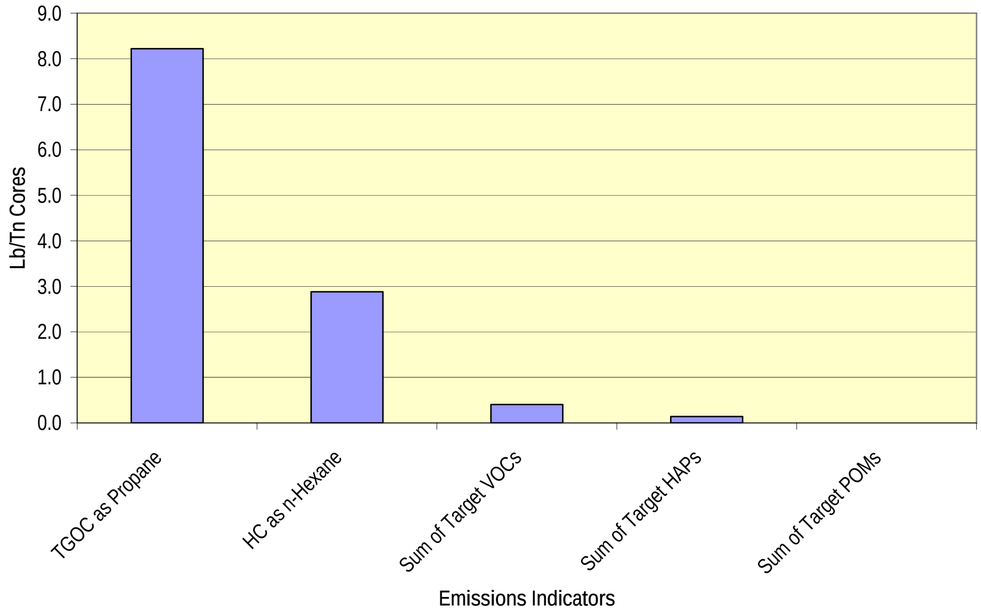


Figure 3-2 Core Baking Selected HAPS

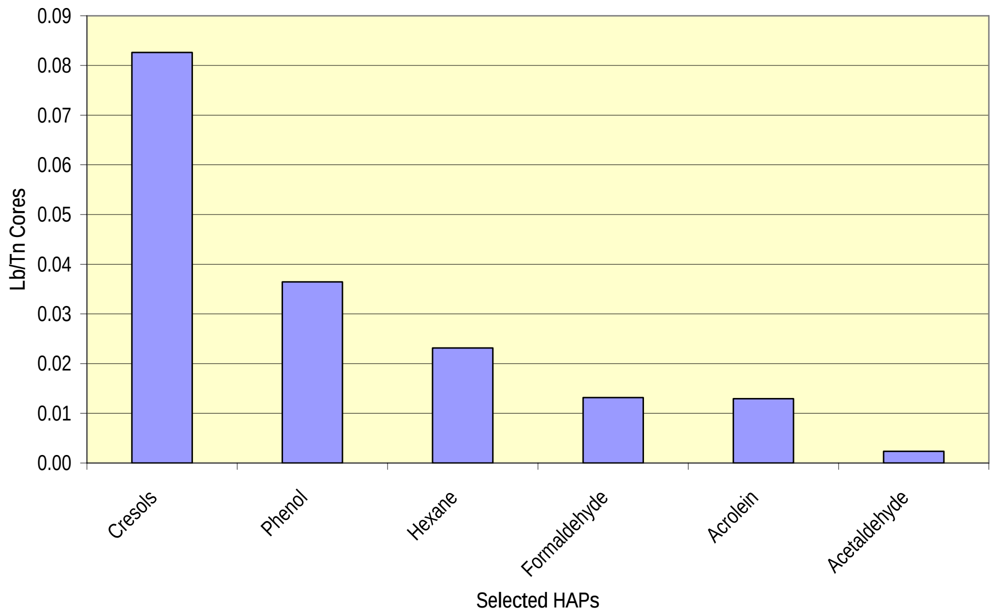


Figure 3-3 Core Baking Selected VOCs

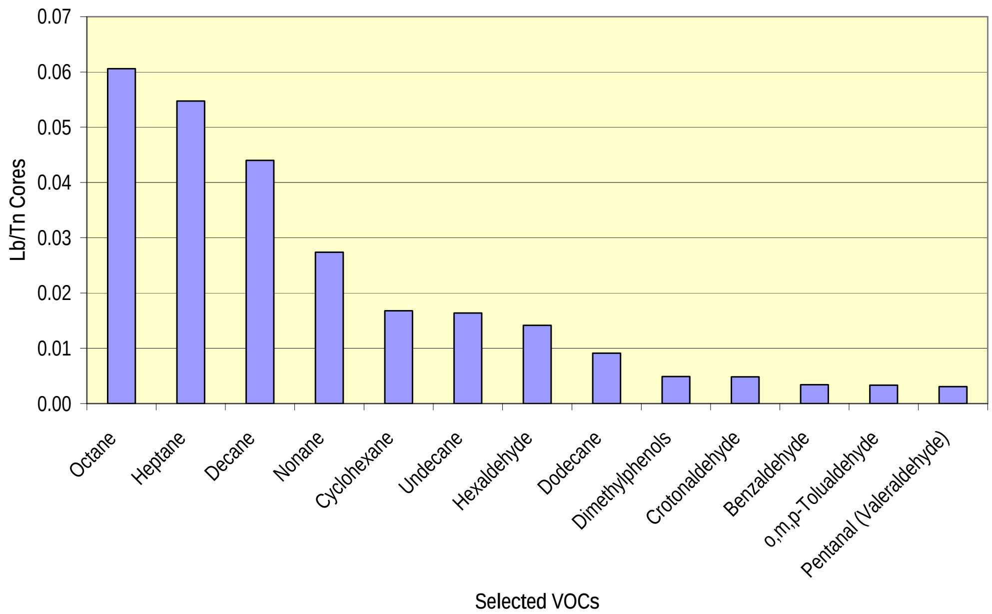


Figure 3-4 PCS Emission Indicators

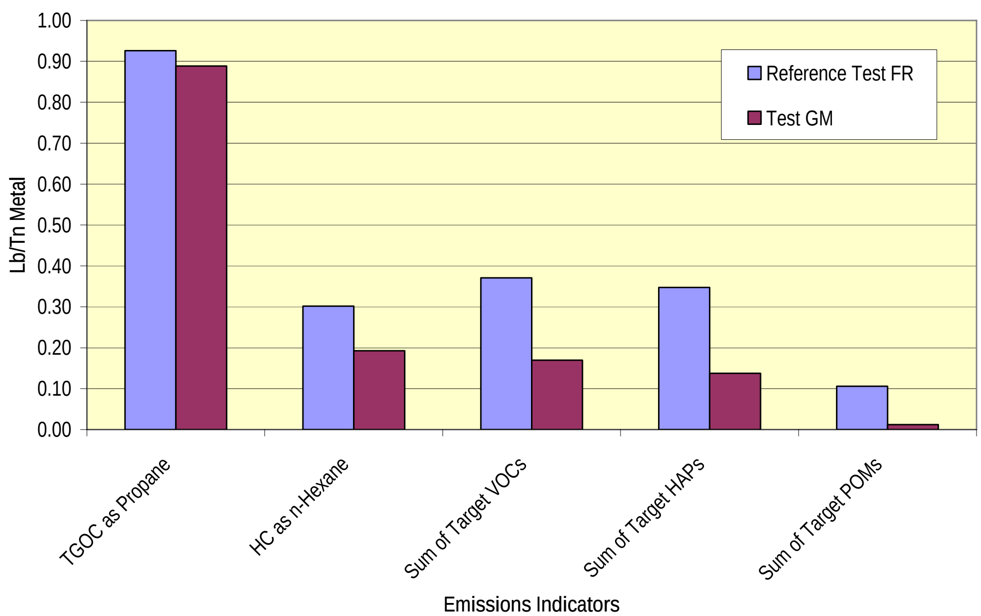


Figure 3-5 PCS Selected HAPs

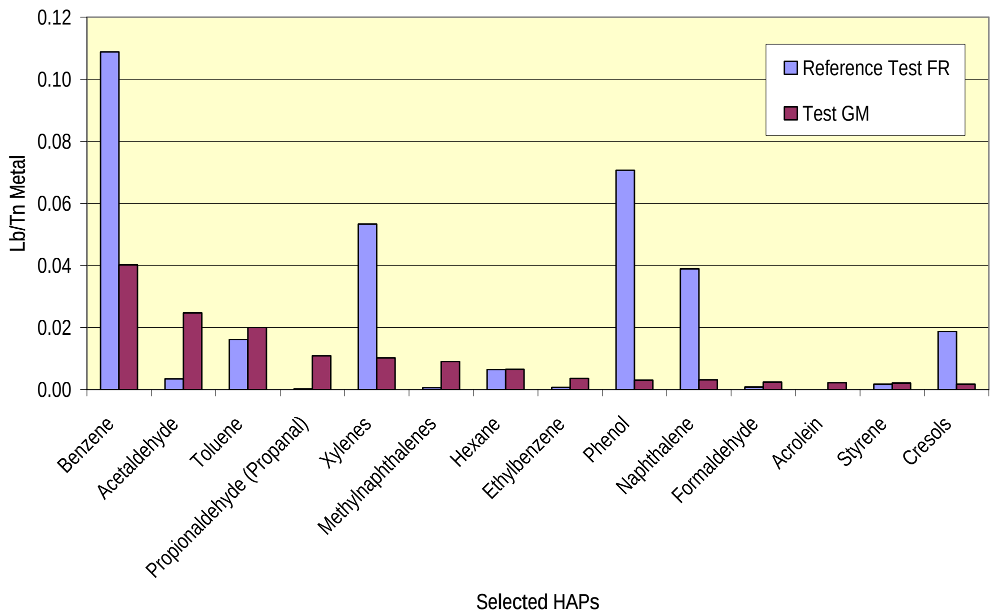


Figure 3-6 PCS Selected VOCs

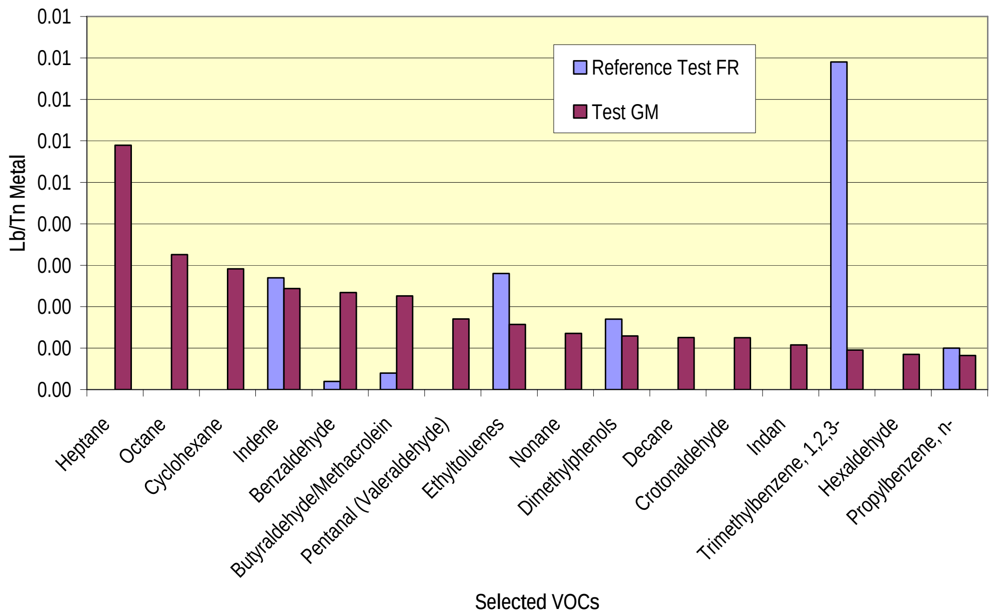


Table 3-7 Comparison of Casting Surface Quality

Rank order GM to reference FR		
	TEST FR	TEST GM
	Production Mold Number	
Rank 1	FR003 Best	
Rank 2		GM006 Best
Rank 3		GM007
Rank 4		GM011
Rank 5	FR002 Median	
Rank 6		GM004
Rank 7		GM009 Median
Rank 8		GM012
Rank 9		GM005
Rank 10		GM008
Rank 11		GM010 Worst
Rank 12	FR004 Worst	

Figure 3-7 Best Casting Surface Quality - FR003

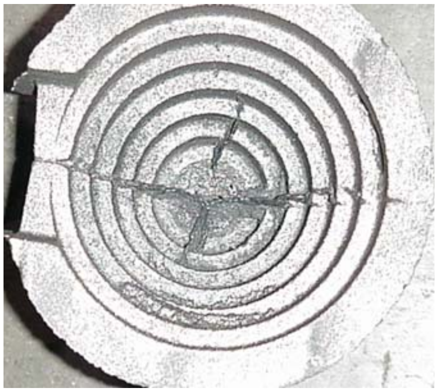


Figure 3-8 Best Casting Surface Quality - GM006

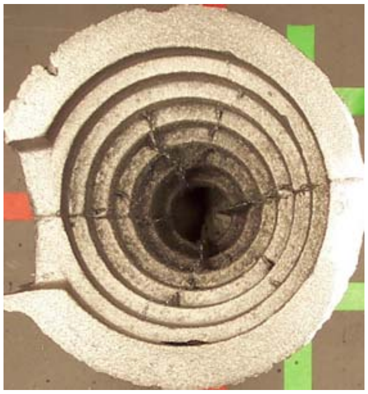


Figure 3-9 Median Casting Surface Quality - FR002

Figure 3-10 Median Casting Surface Quality - GM009

Figure 3-11 Worst Casting Surface Quality - FR004

Figure 3-12 Worst Casting Surface Quality - GM010

4.0 DISCUSSION OF RESULTS

This report contains the results of testing to measure the core making/baking and pouring/cooling/shakeout emissions from core oil cores. For the convenience of the reader, the oil sand PCS results were compared to similar results from the CERP phenolic urethane baseline binder system. Core making results from the oil sand were not compared to phenolic urethane core making emissions because of the dissimilar nature of the two processes.

An open top core holder was developed that provided total capture of the core emissions during the baking and cooling segments of the core making process.

The compounds emitted during the core making/baking portion of the test were predominantly phenols, aldehydes, and aliphatic hydrocarbons. The compounds emitted during the PCS portion of the test were predominantly aromatic hydrocarbons and aldehydes. Relatively small amounts of phenols were emitted.

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

Two methods were employed to measure undifferentiated hydrocarbon emissions, TGOC (THC) 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 quantitation limits expressed in pounds per ton of core and pounds per pound of binder are shown in Appendix B.

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APPENDIX A TEST PLANS, SAMPLING PLANS AND PROCESS INSTRUCTIONS FOR SERIES FR AND GM

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TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1410 **TASK NUMBER:** 1.1.4 **SERIES:** FR
- **SITE**: Pre-production
- **TEST TYPE:** Product Test: Pouring, cooling, & shakeout of uncoated Phenolic urethane step cores with anti-veining compounds.
- **METAL TYPE:** Class-30 gray iron
- **MOLD TYPE:** Virgin, no seacoal, greensand with 4-on PU step-cores recycled after each pour.
- **NUMBER OF MOLDS:** Three engineering & conditioning runs + 4 sampling runs each from reference cores w/o anti-veining additive and two (2) anti-veining compounds. Twenty-one (21) runs total.
- **CORE TYPE:** Step: 1.4% Ashland ISOCURE® Phenolic Urethane LF305 part I (55%), 904GR Part II (45%), amine cured. 50-120 hrs old. Reference cores shall not contain anti-veining material. Test cores shall contain 1% (BOS) Ashland 070359 red iron oxide fine or 2% (BOS) Chesapeake Specialty Products SpherOX® black iron oxide fine.
- **CORE COATING:** Cores shall be uncoated.
- **SAMPLE EVENTS:** 4 runs each for reference cores and two core sets containing different anti-veining materials, total twelve sample runs (12).
- **TEST DATE:** **START:** 12 Jan 2004
  FINISHED: 30 Jan 2004

TEST OBJECTIVES:

Measure the airborne pouring, cooling, & shakeout emissions for organic step cores containing anti-veining compounds in a mechanically-produced clay, water, and coal-less 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, no seacoal, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 80-90°F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10°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 Amador-70 silica sand heated to 85-90°F and made in an 80-90°F heated enclosed core machine. No emission sampling will be done during core manufacture.

BRIEF OVERVIEW:

This is the first test to include materials contained in the core in addition to the binder. The purpose of the included core additives is to reduce the veining defect common to silica sand cores poured with iron. This test and test FT, using different anti-veining materials, are intended to determine if the anti-veining compounds impact the emissions from the base binder in an uncoated core poured with iron.

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

The emission results will be compared to an internal baseline of uncoated step cores of the same binder content. In addition to a suite of selected emission analytes TGOC, CO & CO2 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 1300 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. Cores will be produced with Amador A-70 silica sand at 85-90°F. The core shall be maintained at 80-90°F awaiting insertion in the mold. The cores shall be stabilized for 50-120 hours when tested.

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/14/2004											**FR CONDITIONING - RUN 1**
FR CR-1											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/14/2004											**FR CONDITIONING - RUN 2**
FR CR-2											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/15/2004											**FR CONDITIONING - RUN 3**
FR CR-3											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/15/2004											
RUN 1											
THC	FR001	X									TOTAL
M-18	FR00101		1						60	1	Carbopak charcoal
M-18 MS	FR00102		1						60	2	Carbopak charcoal
M-18 MS	FR00103			1					60	3	Carbopak charcoal
Gas, CO, CO2	FR00104		1						60	4	Tedlar Bag
Gas, CO, CO2	FR00105				1				0		Tedlar Bag
NIOSH 1500	FR00106		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00107				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00108		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00109				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00110		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00111				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/15/2004											
RUN 2											
THC	FR002	X									TOTAL
M-18	FR00201		1						60	1	Carbopak charcoal
M-18	FR00202			1					60	2	Carbopak charcoal
M-18	FR00203				1				0		Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FR00204		1						60	4	Tedlar Bag
NIOSH 1500	FR00205		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00206			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FR00207		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00208			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FR00209		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00210			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/16/2004											
RUN 3											
THC	FR003	X									TOTAL
M-18	FR00301		1						60	1	Carbopak charcoal
M-18	FR00302					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR00303		1						60	4	Tedlar Bag
NIOSH 1500	FR00304		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00305		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00306		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/16/2004											
RUN 4											
THC	FR004	X									TOTAL
M-18	FR00401		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR00402		1						60	4	Tedlar Bag
NIOSH 1500	FR00403		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00404		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00405		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/20/2004											**FR CONDITIONING - RUN 4**
FR CR-4											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/20/2004											**FR CONDITIONING - RUN 5**
FR CR-5											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/20/2004											**FR CONDITIONING - RUN 6**
FR CR-6											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/21/2004											
RUN 5											
THC	FR005	X									TOTAL
M-18	FR00501		1						60	1	Carbopak charcoal
M-18	FR00502			1					60	2	Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FR00503		1						60	4	Tedlar Bag
NIOSH 1500	FR00504		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00505			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FR00506		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00507			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FR00508		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00509			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/21/2004											
RUN 6											
THC	FR006	X									TOTAL
M-18	FR00601		1						60	1	Carbopak charcoal
M-18	FR00602					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR00603		1						60	4	Tedlar Bag
NIOSH 1500	FR00604		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00605		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00606		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/22/2004											
RUN 7											
THC	FR007	X									TOTAL
M-18	FR00701		1						60	1	Carbopak charcoal
M-18 MS	FR00702		1						60	2	Carbopak charcoal
M-18 MS	FR00703			1					60	3	Carbopak charcoal
Gas, CO, CO2	FR00704		1						60	4	Tedlar Bag
NIOSH 1500	FR00705		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00706		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00707		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/22/2004											
RUN 8											
THC	FR008A	X									TOTAL
M-18	FR008A01		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR008A02		1						60	4	Tedlar Bag
NIOSH 1500	FR008A03		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR008A04		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR008A05		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/27/2004											**FR CONDITIONING - RUN 7**
FR CR-7											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/27/2004											**FR CONDITIONING - RUN 8**
FR CR-8											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/27/2004											**FR CONDITIONING - RUN 9**
FR CR-9											
THC		X									

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/28/2004											
RUN 9											
THC	FR009	X									TOTAL
M-18	FR00901		1						60	1	Carbopak charcoal
M-18	FR00902			1					60	2	Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FR00903		1						60	4	Tedlar Bag
NIOSH 1500	FR00904		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00905			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FR00906		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00907			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FR00908		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00909			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/28/2004											
RUN 10											
THC	FR010	X									TOTAL
M-18	FR01001		1						60	1	Carbopak charcoal
M-18	FR01002					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR01003		1						60	4	Tedlar Bag
NIOSH 1500	FR01004		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR01005		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR01006		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/29/2004											
RUN 11											
THC	FR011	X									TOTAL
M-18	FR01101		1						60	1	Carbopak charcoal
M-18 MS	FR01102		1						60	2	Carbopak charcoal
M-18 MS	FR01103			1					60	3	Carbopak charcoal
Gas, CO, CO2	FR01104		1						60	4	Tedlar Bag
NIOSH 1500	FR01105		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR01106		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR01107		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/29/2004											
RUN 12											
THC	FR012	X									TOTAL
M-18	FR01201		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR01202		1						60	4	Tedlar Bag
NIOSH 1500	FR01203		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR01204		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR01205		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

Series FR

PCS Core Product Test in Greensand with Ashland 305/904 Core Binder, anti-veining compound, & Mechanized Molding

Process Instructions

A. Experiment: Measure pouring, cooling, & shakeout emissions from uncoated organic cores, containing an anti-veining compound, in a greensand 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, & no 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 Amador A-70 sand and 1.4% Ashland ISOCURE® LF305/52-904GR regular phenolic urethane binder in a 55/45 ratio, TEA catalyzed. Reference cores shall be made without any anti-veining compound and the test cores shall include an anti-veining compound.
3. Anti Vein Compounds: To the test core sand mixes shall be added:
   1) 1% (BOS) Ashland (070359)Red Iron Oxide Fine (Fe_2O_3) or
   2) 2% (BOS) of Chesapeake Specialty Products SpherOX® Black Iron Oxide Fine (Fe_3O_4).

4. Metal: Class-30 gray cast iron poured at 2630 +/- 10°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. Premix anti-veining compound in blue R/C mixer.
   a. Make 2 batches of sand. The first containing 1% (BOS) Ashland red iron oxide fine anti-veining compound, and the other 2% (BOS) Chesapeake Specialty Products' black iron oxide fine anti-veining compound.
   b. For each batch add 400 pounds of dry A-70 sand to the R/C mixer.

c. Distribute 4.00 pounds of Ashland red iron oxide to one batch and 8.00 pounds of black iron oxide to the remaining batch. Clean the mixer with 50 pounds of clean sand between batches.
d. Mix each batch for 10 minutes.
e. Place the respective batches in clean containers to be heated to 85-90°F degrees prior to mixing with the core binder.

2. 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°F.
b. On the main control panel turn the AUTO/MAN switch to MANUAL, turn on the 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.
1) 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°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.

e. Turn on the mixer and turn the AUTO/MAN switch to AUTO.
f. 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.

- **g.** 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.
- **h.** Clean the mixer after each material.
- **i.** Approximately 7 batches will be needed for each core material type.
- **j.** Mix the sand without anti-veining compound first, then the material containing the 1% red iron oxide, and finally the material containing the
- **k.** 2% black iron oxide.

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

3. Redford/Carver core machine.

- **a.** Mount the Step-Core core box on the Carver/Redford core machine.
- **b.** Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
- **c.** 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.
- **d.** Core process setup
  - **1)** Set the TEA to a nominal 5 grams per blow (gas time 0.75 sec (R/C), flow .019 lbs/sec (Luber).
  - **2)** Set the blow pressure to 30+/-2 psi for 3 seconds (R/C).
  - **3)** Set the max purge pressure to 45 psi on the Luber gas generator.
  - **4)** Purge for 20 seconds(R/C) with a 10 second rise time (Luber).
  - **5)** Total cycle time approximately 1 minute.

- **e.** 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.
- **f.** 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.
- **g.** 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°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.

- **h.** 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 oF core LOI test method and reported out associated with the test mold it is to represent.

E. Sand preparation

1. Start up batch: make 3, FRCD1, FRCD4, & FRCD7. One batch is for each type of core material.

- **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 oF loss on ignition (LOI), and 900 oF 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: FRCD2, FRCD5, & FRCD8

- **a.** Add to the sand recovered from poured mold FRCD1, FRCD4, or FRCD 7 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.

3. Re-mulling: FRCD3, FRCD6, FRCD9 & FR001-FR0XX

- **a.** Add to the sand recovered from the previous poured mold, mold machine spill sand, the residual mold hopper sand and sufficient pre-blended sand to total 900 +/- 10 pounds.
- **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.

F. 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.

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

H. 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 oF 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.

I. 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 on top.
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°F.
f. Slag the furnace and add the balance of the alloys.
g. Raise the temperature of the melt to 2700 oF and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
h. Hold the furnace at 2500-2550°F until near ready to tap.
i. When ready to tap raise the temperature to 2700°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.

J. Pouring:
1. Preheat the ladle.
a. Tap 400 pounds more or less of 2700°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°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°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

K. 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 the casting from mold FN001, compare it to castings from mold FN002.
- **c.** Place the better appearing casting in the first position and the lesser appearing casting in the second position.
- **d.** Repeat this procedure with FN001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than FN001 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

TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1411 **TASK NUMBER:** 1.2.4 **SERIES:** GM
- **SITE:** Pre-production
- **TEST TYPE:** Baseline: Uncoated Linseed Oil sand Core in Greensand: Baking; Cooling Storage; and Pouring, Cooling, & Shake-out.
- **METAL TYPE:** Class 30 gray iron
- **MOLD TYPE:** 4-on step-cored Wexford W450 greensand, 7 % western and Southern bentonite in 5:2 ratio with no seacoal.
- **NUMBER OF MOLDS:** 3 engineering/conditioning + 9 Sampling
- **CORE TYPE:** Step: Wedron 530 sand, 2.0% (BOS) H & G 840 Core oil, 1% (BOS) Heavy weight cereal, 0.5% (BOS) Southern bentonite, 1.5-2.5% (BOS) water.
- **CORE COATING:** None
- **SAMPLE EVENTS:** 6 baking & 9 PCS
- **ANALYTE LIST:** PCS: List E; Baking and cooling storage: TBD
- **TEST DATE:** **START:** 21 Mar 2005
  FINISHED: 8 Apr 2005

TEST OBJECTIVES:

Establish an emission reference baseline (1. baking, 2. pouring, cooling, & shakeout) for a typical uncoated oil sand core baked then set in a mechanically-produced clay, water, coal-less greensand mold. The baseline will become a reference against which future oil sand vendor test materials can be compared. The emissions and casting shall be compared to baseline test FR, an uncoated phenolic urethane core in a coal free greensand.

VARIABLES:

The oil sand cores shall be hand made in a plastic lined wooden 2-piece core box from oil sand mixed to an agreed upon recipe. The oil baring core sand shall be mixed in a Redford/Carver mixer for a total for 8 minutes. The dry materials shall be mixed with the sand for 1 minute, followed by the water for 1 minute, and the oil for 6 additional minutes. The cores shall be baked in a preheated ventilated oven at 400°F for 2 hours.

The pattern will be the 4-on step core. The mold will be made with Wexford W450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB Clay, no seacoal, and tempered to

45-50% compactability, mechanically compacted. The molds will be maintained at 70-90°F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10°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.

BRIEF OVERVIEW:

These greensand molds will be produced on mechanically assisted Osborne molding machines. (Ref. CERP test FH). The 4-on step-core standard mold, is a 24 x 24 x 10/10 inch 4-on array of AFS standard drag only step core castings to make a new baseline against which future oil sand core products can be compared.

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 a 1300 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 bagged in plastic as soon as sufficiently cooled. The cores will be approximately 1-2 weeks old when tested.

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/2/2005											**Baking Test**
RUN 1											
M-18	GM01001		1						**30**	1	Carbopak charcoal
M-18	GM01002					1			**30**	1	Carbopak charcoal
M-18	GM01003				1				**0**		Carbopak charcoal
	Excess								**30**	2	Excess
	Excess								**30**	3	Excess
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01004		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
NIOSH 1500	GM01005				1				**0**		400/600 mg Charcoal (SKC 226-16)
	Excess								**200**	8	Excess
TO11	GM01006		1						**200**	9	DNPH Silica Gel (SKC 226-119)
TO11	GM01007				1				**0**		DNPH Silica Gel (SKC 226-119)
	Excess								**200**	10	Excess
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/3/2005											**Baking Test**
RUN 2											
M-18	GM01101		1						**30**	1	Carbopak charcoal
M-18	GM01102					1			**30**	1	Carbopak charcoal
	Excess								**30**	2	Excess
	Excess								**30**	3	Excess
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01103		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
	Excess								**200**	8	Excess
TO11	GM01104		1						**200**	9	DNPH Silica Gel (SKC 226-119)
	Excess								**200**	10	Excess
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/3/2005											**Baking Test**
RUN 3											
M-18	GM01201		1						**30**	1	Carbopak charcoal
M-18	GM01202					1			**30**	1	Carbopak charcoal
M-18	GM01203			1					**30**	2	Carbopak charcoal
M-18	GM01204					1			**30**	2	Carbopak charcoal
	Excess								**30**	3	Excess
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01205		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
	Excess								**200**	8	Excess
TO11	GM01206		1						**200**	9	DNPH Silica Gel (SKC 226-119)
	Excess								**200**	10	Excess
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/7/2005											**Baking Test**
RUN 4											
M-18	GM01301		1						**30**	1	Carbopak charcoal
M-18	GM01302					1			**30**	1	Carbopak charcoal
M-18 MS	GM01303		1						**30**	2	Carbopak charcoal
M-18 MS	GM01304					1			**30**	2	Carbopak charcoal
M-18 MS	GM01305			1					**30**	3	Carbopak charcoal
M-18 MS	GM01306					1			**30**	3	Carbopak charcoal
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01307		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
NIOSH 1500	GM01308			1					**200**	8	400/600 mg Charcoal (SKC 226-16)
TO11	GM01309		1						**200**	9	DNPH Silica Gel (SKC 226-119)
TO11	GM01310			1					**200**	10	DNPH Silica Gel (SKC 226-119)
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/7/2005											**Baking Test**
RUN 5											
M-18	GM01401		1						**30**	1	Carbopak charcoal
M-18	GM01402					1			**30**	1	Carbopak charcoal
M-18	GM01403					1			**30**	1	Carbopak charcoal
	Excess								**30**	2	Excess
	Excess								**30**	3	Excess
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01404		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
	Excess								**200**	8	Excess
TO11	GM01405		1						**200**	9	DNPH Silica Gel (SKC 226-119)
TO11	GM01406					1			**200**	9	DNPH Silica Gel (SKC 226-119)
	Excess								**200**	10	Excess
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/8/2005											**Baking Test**
RUN 6											
M-18	GM01501		1						**30**	1	Carbopak charcoal
M-18	GM01502					1			**30**	1	Carbopak charcoal
	Excess								**30**	2	Excess
	Excess								**30**	3	Excess
	Excess								**30**	4	Excess
	Excess								**200**	5	Excess
	Excess								**200**	6	Excess
NIOSH 1500	GM01503		1						**200**	7	400/600 mg Charcoal (SKC 226-16)
	Excess								**200**	8	Excess
TO11	GM01504		1						**200**	9	DNPH Silica Gel (SKC 226-119)
	Excess								**200**	10	Excess
	Moisture		1						**500**	11	TOTAL
	THC	X							**1400**	12	TOTAL
	Excess								**7700**	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/11/2005											**GM CONDITIONING - RUN 1**
GM CR-1											
THC, CO,CO2, NOX		x									

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/11/2005											**GM CONDITIONING - RUN 2**
GM CR-2											
THC, CO,CO2, NOX		x									

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/11/2005											**GM CONDITIONING - RUN 3**
GM CR-3											
THC, CO,CO2, NOX		x									

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/14/2005											
RUN 1											
THC, CO,CO2, NOX	GM001	X									TOTAL
M-18	GM00101		1						60	1	Carbopak charcoal
M-18	GM00102				1				0		Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00103		1						850	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GM00104				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00105		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	GM00106				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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/14/2005											
RUN 2											
THC, CO,CO2, NOX	GM002	X									TOTAL
M-18	GM00201		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00202		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00203		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/14/2005											
RUN 3											
THC, CO,CO2, NOX	GM003	X									TOTAL
M-18	GM00301		1						60	1	Carbopak charcoal
M-18	GM00302			1					60	2	Carbopak charcoal
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00303		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00304		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/15/2005											
RUN 4											
THC, CO,CO2, NOX	GM004	X									TOTAL
M-18	GM00401		1						60	1	Carbopak charcoal
M-18 MS	GM00402		1						60	2	Carbopak charcoal
M-18 MS	GM00403			1					60	3	Carbopak charcoal
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00404		1						850	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GM00405			1					850	8	100/50 mg Charcoal (SKC 226-01)
TO11	GM00406		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	GM00407			1					850	10	DNPH Silica Gel (SKC 226-119)
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/15/2005											
RUN 5											
THC, CO,CO2, NOX	GM005	X									TOTAL
M-18	GM00501		1						60	1	Carbopak charcoal
M-18	GM00502					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								40	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00503		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00504		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/15/2005											
RUN 6											
THC, CO,CO2, NOX	GM006	X									TOTAL
M-18	GM00601		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00602		1						850	7	lost
	Excess								850	8	Excess
TO11	GM00603		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/16/2005											
RUN 7											
THC, CO,CO2, NOX	GM007	X									TOTAL
M-18	GM00701		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00702		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00703		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/16/2005											
RUN 8											
THC, CO,CO2, NOX	GM008	X									TOTAL
M-18	GM00801		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00802		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00803		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 GM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
3/16/2005											
RUN 9											
THC, CO,CO2, NOX	GM009	X									TOTAL
M-18	GM00901		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
	Excess								850	5	Excess
	Excess								850	6	Excess
NIOSH 1500	GM00902		1						850	7	100/50 mg Charcoal (SKC 226-01)
	Excess								850	8	Excess
TO11	GM00903		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

Series GM

Linseed Oil Core Baking & Storage Baseline and Pouring, Cooling, Shakeout (PCS) of a Coal Free Greensand Mold with Uncoated Linseed Oil Core & Mechanized Molding

Process Instructions

A. Experiment: Create an organic linseed oil core-in-greensand baseline. Measure emissions from
   1. baking a linseed oil bound core,
   2. Post baking storage,
   3. PCS of a greensand 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, & no 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.

B. Materials:
   1. Mold sand: Virgin mix of Wexford W450 lake sand, western and southern bentonites in ratio of 5:2, and potable water per recipe.
   2. Core: Uncoated step core made with virgin Wedron 530 silica sand and 2.0% (BOS) H & G 840 Core Oil, 1.0% (BOS) Con Agra Heavy Weight cereal, 0.5% (BOS) Southern Bentonite, and 1.5-2.5% water, baked in a ventilated oven at 400°F.
   3. Core coating: None
   4. Metal: Class-30 gray cast iron poured at 2630 +/- 10°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. Linseed oil two-piece Step Cores:
   1. Experiment with the above composition and handling methods to efficiently produce 60 two piece baked cores.
      a. After manufacture and cooling the cores will be sealed in polyethylene bags.
      b. The sand lab will sample one (1) core 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 oF core LOI test method and reported out associated with the test mold it is to represent.

E. Engineering trials for oil core baking and post baking storage.

1. Baking.

a. The emission team will set up the THC and a sampling train to extract emissions from the AccuTherm oven.
b. Preheat the AccuTherm oven to 400°F.
c. Mix 65 grams of H & G 840 linseed oil with 7.25 pounds of Wedron 530 sand in the Hobart mixer for 2 minutes.
d. Shape the sand into a rough cone shape on a core drier plate.
e. Place the mixed sand & core drier plate in the center of the oven on an elevated plate.
f. Place a thermocouple in the center of the sand pile.
g. Record the oven & sand temperature and TGOC emissions for 2 hours.
h. Based on emission results chose how many cores shall be used in the core bake part of the test.

2. Post baking cooling.

a. The emission team will set up the THC to receive emissions from a storage cooling dome.
b. After two hours of baking at 400 oF open the door and remove one core.
c. Place that core under a dome and continue to measure the emissions.
d. Place a thermocouple in the sand.
e. Measure & record emissions and sand temperature for a 3 hour period or until the emission concentration gets low enough to be, in the judgment of the emission team, of no further interest.
f. Based on the emission results choose how long the storage emission should measured.

F. Measurement of emissions during core baking and storage; 6 replications.

1. Baking

a. The emission team will set up TGOC and sampling trains.
b. Preheat the AccuTherm oven to 400°F. Turn on circulating fan.
c. Mix core sand as determined section D. Record all component weights, sand temperature.
d. Make oil step part only cores by the method determined in section D.
e. Weigh freshly made core. Record the core weight.
f. Place the number of cores determined in stepE.1.h distributed in the oven and close the door.
g. Continuously collect and record emissions and oven temperature.
h. Bake core for 2 hours.
i. From the same sand batch make a dozen dogbone tensile bars. Bake in another oven at 400 oF for the same period of time.

G. Sand preparation

1. Start up batch: make 1, GMER1.

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 water 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 into the mold.
- **l.** The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, 1800°F loss on ignition (LOI), and 900°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: GMER2

- **a.** Add to the sand recovered from poured mold GHER1 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.

3. Re-mulling: GMER3, GM001-GM0XX

- **a.** Add to the sand recovered from the previous poured mold, mold machine spill sand, the residual mold hopper sand and sufficient pre-blended sand to total 900 +/- 10 pounds.
- **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. The operator will grab a sand sample for the Lab. The sand technician will quickly measure the sand temperature and compactability and record the results.
n. Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.
o. 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.

p. 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 no re-approach the machine until the squeeze head has stopped at the side of the machine.

q. Screed the bottom of the drag mold flat to the bottom of the flask if required.
r. Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
s. 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.
t. 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 uncoated 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°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 on top.
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°F.
f. Slag the furnace and add the balance of the alloys.
g. Raise the temperature of the melt to 2700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
h. Hold the furnace at 2500-2550°F until near ready to tap.
i. When ready to tap raise the temperature to 2700°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°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°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°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 each cavity :
  a. Place each casting initially in sequential mold number order.
  b. Beginnings with the casting from mold GM001 compare it to castings from mold GM002.
  c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
  d. Repeat this procedure with GM001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than GM001 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.
5. Compare GM rankings to those in test FR cavity 3.

N. Engineering trials for oil core baking and post baking storage.

1. Baking.

- **a.** The emission team will set up the THC and a sampling train to extract emissions from the AccuTherm oven.
- **b.** Preheat the AccuTherm oven to 400°F.
- **c.** Mix 65 grams of H & G 840 linseed oil with 7.25 pounds of Wedron 530 sand in the Hobart mixer for 2 minutes.
- **d.** Shape the sand into a rough cone shape on a core drier plate.
- **e.** Place the mixed sand & core drier plate in the center of the oven on an elevated plate.
- **f.** Place a thermocouple in the center of the sand pile.
- **g.** Record the oven & sand temperature and TGOC emissions for 2 hours.
- **h.** Based on emission results chose how many cores shall be used in the core bake part of the test.

2. Post baking cooling.

- **a.** The emission team will set up the THC to receive emissions from a storage cooling dome.
- **b.** After two hours of baking at 400 oF open the door and remove one core.
- **c.** Place that core under a dome and continue to measure the emission for a 3 hour period or until the emission concentration gets near the ambient background concentration.
- **d.** Based on the emission results choose how long the storage emission should measured.

Steven M. Knight
Mgr. Process Engineering

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APPENDIX B DETAILED EMISSIONS DATA AND QUANTITATION LIMITS FOR TEST FR & GM

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Test Plan FR – PCS Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
		Test Dates	1/15/04	1/15/04	1/16/04	1/16/04	1/21/04	1/21/04		
		Emissions Indicators								
		TGOC as Propane	1.55E-01	1.41E-01	1.57E-01	1.39E-01	1.39E-01	1.40E-01	1.45E-01	8.50E-03
		HC as Hexane	4.88E-02	5.06E-02	5.04E-02	4.30E-02	5.13E-02	4.00E-02	4.73E-02	4.71E-03
		Sum of Target VOCs	5.77E-02	5.84E-02	6.13E-02	I	5.08E-02	5.70E-02	5.70E-02	3.84E-03
		Sum of Target HAPs	5.37E-02	5.44E-02	5.82E-02	I	4.69E-02	5.27E-02	5.32E-02	4.07E-03
		Sum of Target POMs	1.47E-02	1.71E-02	1.88E-02	I	1.55E-02	1.68E-02	1.66E-02	1.58E-03
		Individual Target HAPs								
x		Benzene	1.93E-02	1.45E-02	1.85E-02	I	1.32E-02	1.33E-02	1.57E-02	2.93E-03
x		Phenol	1.02E-02	1.25E-02	1.11E-02	I	9.97E-03	1.27E-02	1.13E-02	1.28E-03
x	z	Naphthalene	5.89E-03	6.21E-03	6.50E-03	I	5.45E-03	5.95E-03	6.00E-03	3.91E-04
x	z	2-Methylnaphthalene	4.72E-03	5.70E-03	6.26E-03	I	5.18E-03	5.51E-03	5.48E-03	5.74E-04
x	z	1-Methylnaphthalene	2.48E-03	3.02E-03	3.30E-03	I	2.87E-03	3.15E-03	2.97E-03	3.14E-04
x		Toluene	2.75E-03	2.29E-03	2.66E-03	I	2.36E-03	2.44E-03	2.50E-03	1.99E-04
x		o-Cresol	2.18E-03	2.67E-03	2.56E-03	I	2.22E-03	2.37E-03	2.40E-03	2.09E-04
x		Aniline	1.80E-03	2.26E-03	1.88E-03	2.34E-03	1.29E-03	2.29E-03	1.98E-03	4.05E-04
x	z	1,3-Dimethylnaphthalene	7.16E-04	9.11E-04	1.02E-03	I	8.50E-04	9.56E-04	8.91E-04	1.17E-04
x		m,p-Xylene	8.81E-04	7.83E-04	8.23E-04	I	7.77E-04	7.95E-04	8.12E-04	4.27E-05
x		Acetaldehyde	4.97E-04	5.86E-04	5.20E-04	5.81E-04	5.31E-04	6.00E-04	5.53E-04	4.18E-05
x		m,p-Cresol	4.20E-04	5.58E-04	5.33E-04	I	3.45E-04	6.33E-04	4.98E-04	1.15E-04
x	z	1,6-Dimethylnaphthalene	2.88E-04	3.65E-04	4.14E-04	I	3.44E-04	3.81E-04	3.58E-04	4.69E-05
x	z	2,6-Dimethylnaphthalene	2.56E-04	3.27E-04	3.72E-04	I	3.22E-04	3.43E-04	3.24E-04	4.29E-05
x	z	2,7-Dimethylnaphthalene	2.56E-04	3.27E-04	3.72E-04	I	2.89E-04	3.43E-04	3.17E-04	4.58E-05
x		Styrene	1.64E-04	4.94E-04	1.56E-04	I	1.96E-04	2.01E-04	2.42E-04	1.42E-04
x		o-Xylene	1.97E-04	1.83E-04	1.81E-04	I	1.54E-04	1.67E-04	1.76E-04	1.63E-05
x	z	1,2-Dimethylnaphthalene	1.24E-04	1.65E-04	1.84E-04	I	1.27E-04	1.17E-04	1.43E-04	2.92E-05
x		Formaldehyde	1.61E-04	1.12E-04	1.15E-04	1.10E-04	1.08E-04	1.16E-04	1.20E-04	2.03E-05
x	z	2,3-Dimethylnaphthalene	ND	5.29E-05	3.15E-04	I	5.86E-05	1.13E-04	1.35E-04	1.23E-04

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
x		Biphenyl	9.52E-05	1.20E-04	1.43E-04	I	9.66E-05	1.05E-04	1.12E-04	2.00E-05
x		Ethylbenzene	1.11E-04	1.27E-04	1.08E-04	I	8.04E-05	8.23E-05	1.02E-04	1.99E-05
x		Hexane	8.21E-05	9.70E-05	9.69E-05	I	3.51E-05	3.92E-05	7.00E-05	3.07E-05
x		Propionaldehyde	3.85E-05	3.63E-05	3.51E-05	3.85E-05	4.82E-05	ND	3.93E-05	5.17E-06
x		2-Butanone	3.94E-05	4.46E-05	3.45E-05	2.61E-05	2.88E-05	3.60E-05	3.49E-05	6.78E-06
x	z	1,5-Dimethylnaphthalene	ND	ND	9.79E-05	I	ND	ND	ND	NA
x	z	Acenaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x	z	1,8-Dimethylnaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x	z	2,3,5-Trimethylnaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x		Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	NA
x		Acrolein	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		1,2,4-Trimethylbenzene	1.04E-03	8.72E-04	7.74E-04	I	1.10E-03	1.04E-03	9.63E-04	1.35E-04
		Indene	4.72E-04	4.18E-04	4.23E-04	I	3.37E-04	3.51E-04	4.00E-04	5.54E-05
		Dodecane	4.12E-04	4.40E-04	2.68E-04	I	2.48E-04	4.67E-04	3.67E-04	1.02E-04
		1,2,3-Trimethylbenzene	4.16E-04	3.56E-04	3.17E-04	I	4.49E-04	4.30E-04	3.94E-04	5.54E-05
		2,4-Dimethylphenol	2.19E-04	2.95E-04	2.76E-04	I	2.08E-04	2.68E-04	2.53E-04	3.76E-05
		3-Ethyltoluene	2.86E-04	2.58E-04	2.22E-04	I	2.97E-04	3.04E-04	2.73E-04	3.39E-05
		1,3-Diethylbenzene	3.95E-04	3.25E-04	ND	I	4.19E-04	3.77E-04	3.79E-04	3.97E-05
		Undecane	1.89E-04	2.54E-04	2.08E-04	I	1.99E-04	2.26E-04	2.15E-04	2.56E-05
		2-Ethyltoluene	1.99E-04	1.98E-04	1.97E-04	I	2.11E-04	2.19E-04	2.05E-04	9.93E-06
		Propylbenzene	1.44E-04	1.85E-04	1.42E-04	I	1.68E-04	2.57E-04	1.79E-04	4.69E-05
		Tetradecane	1.19E-04	1.47E-04	1.74E-04	I	1.34E-04	1.50E-04	1.45E-04	2.07E-05
		Butyraldehyde/Methacrolein	9.17E-05	6.72E-05	5.53E-05	6.35E-05	7.22E-05	7.54E-05	7.09E-05	1.24E-05
		Benzaldehyde	4.86E-05	4.04E-05	3.04E-05	3.34E-05	ND	9.91E-05	5.04E-05	2.81E-05
		Heptane	ND	1.06E-04	ND	I	3.65E-05	4.85E-05	6.37E-05	3.74E-05
		Cyclohexane	ND	ND	ND	I	ND	ND	ND	NA
		Decane	ND	ND	ND	I	ND	ND	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	ND	ND	NA
		Indan	ND	ND	ND	I	ND	ND	ND	NA
		Nonane	ND	ND	ND	I	ND	ND	ND	NA

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
		Octane	ND	ND	ND	I	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	ND	ND	NA
		Other Analytes								
		Carbon Dioxide	I	I	I	I	I	I	I	NA
		Methane	I	I	I	I	I	I	I	NA
		Carbon Monoxide	ND	I	ND	ND	ND	ND	ND	NA
		Ethane	ND	I	ND	ND	ND	ND	ND	NA
		Propane	ND	I	ND	ND	ND	ND	ND	NA
		Isobutane	ND	I	ND	ND	ND	ND	ND	NA
		Butane	ND	I	ND	ND	ND	ND	ND	NA
		Neopentane	ND	I	ND	ND	ND	ND	ND	NA
		Isopentane	ND	I	ND	ND	ND	ND	ND	NA
		Pentane	ND	I	ND	ND	ND	ND	ND	NA

Test Plan FR – PCS Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
		Test Dates	1/15/04	1/15/04	1/16/04	1/16/04	1/21/04	1/21/04		
		Emissions Indicators								
		TGOC as Propane	9.52E-01	9.14E-01	9.71E-01	8.66E-01	8.32E-01	8.35E-01	8.95E-01	6.00E-02
		HC as Hexane	2.99E-01	3.28E-01	3.12E-01	2.68E-01	3.08E-01	2.38E-01	2.92E-01	3.31E-02
		Sum of Target VOCs	3.54E-01	3.78E-01	3.80E-01	I	3.07E-01	3.39E-01	3.52E-01	3.00E-02
		Sum of Target HAPs	3.29E-01	3.52E-01	3.61E-01	I	2.84E-01	3.14E-01	3.28E-01	3.08E-02
		Sum of Target POMs	9.03E-02	1.11E-01	1.17E-01	I	9.30E-02	1.00E-01	1.02E-01	1.13E-02
		Individual Target HAPs								
x		Benzene	1.18E-01	9.36E-02	1.14E-01	I	7.91E-02	7.90E-02	9.69E-02	1.88E-02
x		Phenol	6.24E-02	8.11E-02	6.86E-02	I	5.98E-02	7.55E-02	6.95E-02	8.91E-03
x	z	Naphthalene	3.61E-02	4.02E-02	4.03E-02	I	3.27E-02	3.54E-02	3.69E-02	3.29E-03
x	z	2-Methylnaphthalene	2.90E-02	3.69E-02	3.88E-02	I	3.10E-02	3.28E-02	3.37E-02	4.08E-03
x	z	1-Methylnaphthalene	1.52E-02	1.95E-02	2.05E-02	I	1.72E-02	1.88E-02	1.82E-02	2.07E-03
x		Toluene	1.69E-02	1.48E-02	1.65E-02	I	1.41E-02	1.45E-02	1.54E-02	1.23E-03
x		o-Cresol	1.34E-02	1.73E-02	1.58E-02	I	1.33E-02	1.41E-02	1.48E-02	1.73E-03
x		Aniline	1.10E-02	1.47E-02	1.16E-02	1.46E-02	1.06E-02	1.36E-02	1.27E-02	1.83E-03
x	z	1,3-Dimethylnaphthalene	4.39E-03	5.90E-03	6.35E-03	I	5.09E-03	5.69E-03	5.48E-03	7.61E-04
x		m,p-Xylene	5.40E-03	5.07E-03	5.10E-03	I	4.66E-03	4.73E-03	4.99E-03	3.03E-04
x		Acetaldehyde	3.04E-03	3.79E-03	3.22E-03	3.62E-03	3.18E-03	3.57E-03	3.40E-03	2.96E-04
x		m,p-Cresol	2.58E-03	3.62E-03	3.30E-03	I	2.07E-03	3.76E-03	3.06E-03	7.23E-04
x	z	1,6-Dimethylnaphthalene	1.76E-03	2.36E-03	2.56E-03	I	2.06E-03	2.27E-03	2.20E-03	3.05E-04
x	z	2,6-Dimethylnaphthalene	1.57E-03	2.12E-03	2.30E-03	I	1.93E-03	2.04E-03	1.99E-03	2.74E-04
x	z	2,7-Dimethylnaphthalene	1.57E-03	2.12E-03	2.30E-03	I	1.73E-03	2.04E-03	1.95E-03	2.99E-04
x		Styrene	1.01E-03	3.20E-03	9.67E-04	I	1.17E-03	1.20E-03	1.51E-03	9.50E-04
x		o-Xylene	1.21E-03	1.18E-03	1.12E-03	I	9.24E-04	9.96E-04	1.09E-03	1.22E-04
x	z	1,2-Dimethylnaphthalene	7.61E-04	1.07E-03	1.14E-03	I	7.61E-04	6.97E-04	8.85E-04	2.02E-04
x		Formaldehyde	9.87E-04	7.23E-04	7.13E-04	6.84E-04	6.48E-04	6.92E-04	7.41E-04	1.23E-04
x	z	2,3-Dimethylnaphthalene	ND	3.43E-04	1.95E-03	I	3.51E-04	6.69E-04	8.28E-04	7.63E-04

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
x		Biphenyl	5.84E-04	7.78E-04	8.87E-04	I	5.79E-04	6.24E-04	6.90E-04	1.36E-04
x		Ethylbenzene	6.81E-04	8.20E-04	6.69E-04	I	4.82E-04	4.90E-04	6.28E-04	1.43E-04
x		Hexane	5.03E-04	6.28E-04	6.01E-04	I	2.10E-04	2.33E-04	4.35E-04	2.01E-04
x		Propionaldehyde	2.36E-04	2.35E-04	2.17E-04	2.40E-04	2.89E-04	ND	2.43E-04	2.68E-05
x		2-Butanone	2.41E-04	2.89E-04	2.13E-04	1.63E-04	1.72E-04	2.14E-04	2.15E-04	4.62E-05
x	z	1,5-Dimethylnaphthalene	ND	ND	6.06E-04	I	ND	ND	ND	NA
x	z	1,8-Dimethylnaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x	z	2,3,5-Trimethylnaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x	z	Acenaphthalene	ND	ND	ND	I	ND	ND	ND	NA
x		Acrolein	ND	ND	ND	ND	ND	ND	ND	NA
x		N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		1,2,4-Trimethylbenzene	6.35E-03	5.65E-03	4.79E-03	I	6.57E-03	6.18E-03	5.91E-03	7.10E-04
		Indene	2.89E-03	2.71E-03	2.62E-03	I	2.69E-03	2.56E-03	2.69E-03	1.25E-04
		Dodecane	2.52E-03	2.85E-03	1.66E-03	I	2.51E-03	2.24E-03	2.36E-03	4.46E-04
		1,2,3-Trimethylbenzene	2.55E-03	2.31E-03	1.96E-03	I	2.02E-03	2.09E-03	2.19E-03	2.42E-04
		2,4-Dimethylphenol	1.34E-03	1.91E-03	1.71E-03	I	1.48E-03	2.78E-03	1.85E-03	5.65E-04
		3-Ethyltoluene	1.75E-03	1.67E-03	1.37E-03	I	1.78E-03	1.81E-03	1.68E-03	1.78E-04
		1,3-Diethylbenzene	2.42E-03	2.11E-03	ND	I	1.25E-03	1.60E-03	1.84E-03	5.22E-04
		Undecane	1.16E-03	1.64E-03	1.29E-03	I	1.01E-03	1.53E-03	1.32E-03	2.61E-04
		2-Ethyltoluene	1.22E-03	1.28E-03	1.22E-03	I	1.26E-03	1.30E-03	1.26E-03	3.83E-05
		n-Propylbenzene	8.81E-04	1.20E-03	8.81E-04	I	1.19E-03	1.34E-03	1.10E-03	2.08E-04
		Tetradecane	7.27E-04	9.50E-04	1.08E-03	I	8.05E-04	8.93E-04	8.91E-04	1.36E-04
		Butyraldehyde/Methacrolein	5.61E-04	4.35E-04	3.43E-04	3.95E-04	4.31E-04	4.49E-04	4.36E-04	7.24E-05
		Benzaldehyde	2.98E-04	2.62E-04	1.88E-04	2.08E-04	ND	5.89E-04	3.09E-04	1.63E-04
		Heptane	ND	6.89E-04	ND	I	2.18E-04	2.88E-04	3.98E-04	2.54E-04
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	ND	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	ND	ND	NA
		Cyclohexane	ND	ND	ND	I	ND	ND	ND	NA
		Decane	ND	ND	ND	I	ND	ND	ND	NA
		Indan	ND	ND	ND	I	ND	ND	ND	NA

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	FR005	FR006	Average	STDEV
		Nonane	ND	ND	ND	I	ND	ND	ND	NA
		Octane	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	NA
		Other Analytes								
		Carbon Dioxide	I	I	I	I	I	I	I	NA
		Methane	I	I	I	I	I	I	I	NA
		Carbon Monoxide	ND	I	ND	ND	ND	ND	ND	NA
		Ethane	ND	I	ND	ND	ND	ND	ND	NA
		Propane	ND	I	ND	ND	ND	ND	ND	NA
		Isobutane	ND	I	ND	ND	ND	ND	ND	NA
		Butane	ND	I	ND	ND	ND	ND	ND	NA
		Neopentane	ND	I	ND	ND	ND	ND	ND	NA
		Isopentane	ND	I	ND	ND	ND	ND	ND	NA
		Pentane	ND	I	ND	ND	ND	ND	ND	NA

Test Plan GM – Core Baking Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND/RUN NUMBER	GK001	GK002	GK003	GK004	GK005	GK006	Average	STDEV
		Test Dates	03/02/05	03/03/05	03/03/05	03/07/05	03/07/05	03/08/05		
		Emissions Indicators								
		TGOC as Propane	1.99E-01	2.16E-01	2.35E-01	2.12E-01	2.11E-01	2.14E-01	2.14E-01	1.16E-02
		HC as n-Hexane	6.63E-02	7.40E-02	8.03E-02	7.48E-02	7.81E-02	7.70E-02	7.51E-02	4.85E-03
		Sum of Target VOCs	9.72E-03	9.81E-03	1.04E-02	I	1.06E-02	1.24E-02	1.06E-02	1.09E-03
		Sum of Target HAPs	3.15E-03	3.24E-03	3.79E-03	I	4.01E-03	3.98E-03	3.63E-03	4.11E-04
		Sum of Target POMs	ND	ND	ND	ND	ND	ND	ND	NA
		Selected Target HAPs								
x		Cresol, mp-	1.05E-03	9.97E-04	1.10E-03	I	9.21E-04	9.31E-04	1.00E-03	7.64E-05
x		Phenol	I	1.03E-03	1.16E-03	7.92E-04	8.99E-04	8.77E-04	9.50E-04	1.43E-04
x		Cresol, o-	6.50E-04	5.78E-04	6.34E-04	I	6.83E-04	6.55E-04	6.40E-04	3.90E-05
x		Formaldehyde	3.10E-04	3.03E-04	5.37E-04	3.50E-04	2.91E-04	2.66E-04	3.43E-04	9.92E-05
x		Acrolein	3.02E-04	2.08E-04	2.73E-04	4.46E-04	4.31E-04	3.63E-04	3.37E-04	9.29E-05
x		Acetaldehyde	5.44E-05	4.80E-05	8.49E-05	5.91E-05	4.89E-05	7.12E-05	6.11E-05	1.44E-05
x	z	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	NA
x		Benzene	ND	ND	ND	ND	ND	ND	ND	NA
x		Biphenyl	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	NA
x		Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Methylnaphthalene, 1-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Methylnaphthalene, 2-	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUN NUMBER	GK001	GK002	GK003	GK004	GK005	GK006	Average	STDEV
x	z	Naphthalene	ND	ND	ND	ND	ND	ND	ND	NA
x		Styrene	ND	ND	ND	ND	ND	ND	ND	NA
x		Toluene	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	NA
x		Xylene, mp-	ND	ND	ND	ND	ND	ND	ND	NA
x		Xylene, o-	ND	ND	ND	ND	ND	ND	ND	NA
x		2-Butanone (MEK)	ND	ND	ND	ND	ND	ND	ND	NA
x		Propionaldehyde (Propanal)	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		Octane	1.53E-03	1.57E-03	1.64E-03	1.57E-03	1.58E-03	1.59E-03	1.58E-03	3.63E-05
		Heptane	1.37E-03	1.45E-03	1.52E-03	1.35E-03	1.43E-03	1.44E-03	1.43E-03	6.09E-05
		Decane	1.04E-03	1.10E-03	1.10E-03	1.24E-03	1.12E-03	1.29E-03	1.15E-03	9.52E-05
		Nonane	6.90E-04	7.33E-04	7.25E-04	7.84E-04	6.50E-04	7.07E-04	7.15E-04	4.49E-05
		Cyclohexane	7.94E-04	4.74E-05	3.06E-05	I	8.36E-04	9.18E-04	4.37E-04	4.53E-04
		Hexaldehyde	3.65E-04	4.07E-04	4.32E-04	3.59E-04	3.81E-04	2.68E-04	3.69E-04	5.63E-05
		Undecane	I	4.37E-04	4.43E-04	4.22E-04	4.30E-04	4.06E-04	4.27E-04	1.46E-05
		Dodecane	2.77E-04	2.47E-04	2.41E-04	1.88E-04	2.63E-04	2.09E-04	2.38E-04	3.34E-05
		Dimethylphenol, 2,4-	1.57E-04	ND	ND	2.91E-04	1.68E-04	1.48E-04	1.27E-04	1.12E-04
		Crotonaldehyde	1.32E-04	1.53E-04	1.99E-04	9.98E-05	8.41E-05	8.48E-05	1.25E-04	4.51E-05
		Benzaldehyde	6.94E-05	5.84E-05	5.99E-05	1.13E-04	1.05E-04	1.28E-04	8.90E-05	3.01E-05
		o,m,p-Tolualdehyde	7.54E-05	3.67E-05	6.65E-05	1.13E-04	1.28E-04	1.02E-04	8.69E-05	3.37E-05
		Pentanal (Valeraldehyde)	7.19E-05	1.08E-04	1.28E-04	6.38E-05	6.09E-05	4.76E-05	7.99E-05	3.09E-05
		Diethylbenzene, 1,3-	ND	ND	ND	ND	ND	ND	ND	NA
		Dimethylphenol, 2,6-	ND	ND	ND	ND	ND	ND	ND	NA
		Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	NA
		Ethyltoluene, 3-	ND	ND	ND	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	ND	ND	ND	NA
		Indene	ND	ND	ND	ND	ND	ND	ND	NA
		Propylbenzene, n-	ND	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	ND	I	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,2,3-	ND	ND	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUN NUMBER	GK001	GK002	GK003	GK004	GK005	GK006	Average	STDEV
		Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	ND	ND	ND	NA
		Butyraldehyde/Methacrolein	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GM – Core Baking Individual Emissions Results – Lb/Tn Cores

HAPs	POMs	COMPOUND/RUM NUMBER	GM010	GM011	GM012	GM013	GM014	GM015	Average	STDEV
		Test Dates	03/02/05	03/03/05	03/03/05	03/07/05	03/07/05	03/08/05		
		Emissions Indicators								
		TGOC as Propane	7.65E+00	8.26E+00	8.99E+00	8.14E+00	8.11E+00	8.18E+00	8.22E+00	4.34E-01
		HC as n-Hexane	2.54E+00	2.83E+00	3.07E+00	2.87E+00	3.00E+00	2.95E+00	2.88E+00	1.85E-01
		Sum of Target VOCs	3.73E-01	3.67E-01	3.97E-01	I	4.32E-01	4.33E-01	4.01E-01	3.14E-02
		Sum of Target HAPs	1.21E-01	1.24E-01	1.45E-01	I	1.54E-01	1.52E-01	1.39E-01	1.58E-02
		Sum of Target POMs	ND	ND	ND	ND	ND	ND	ND	NA
		Selected Target HAPs								
x		Cresol, mp-	4.02E-02	3.82E-02	4.21E-02	I	3.54E-02	3.56E-02	3.83E-02	2.90E-03
x		Phenol	I	3.93E-02	4.43E-02	3.04E-02	3.45E-02	3.36E-02	3.64E-02	5.43E-03
x		Cresol, o-	2.49E-02	2.21E-02	2.43E-02	I	2.63E-02	2.51E-02	2.45E-02	1.53E-03
x		Hexane	3.00E-02	3.16E-03	I	I	2.84E-02	3.12E-02	2.32E-02	1.34E-02
x		Formaldehyde	1.19E-02	1.16E-02	2.06E-02	1.34E-02	1.12E-02	1.02E-02	1.32E-02	3.81E-03
x		Acrolein	1.16E-02	7.98E-03	1.05E-02	1.71E-02	1.65E-02	1.39E-02	1.29E-02	3.56E-03
x		Acetaldehyde	2.09E-03	1.84E-03	3.26E-03	2.27E-03	1.88E-03	2.73E-03	2.34E-03	5.52E-04
x	z	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	NA
x		Benzene	ND	ND	ND	ND	ND	ND	ND	NA
x		Biphenyl	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	NA
x		Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Methylnaphthalene, 1-	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUM NUMBER	GM010	GM011	GM012	GM013	GM014	GM015	Average	STDEV
x	z	Methylnaphthalene, 2-	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Naphthalene	ND	ND	ND	ND	ND	ND	ND	NA
x		Styrene	ND	ND	ND	ND	ND	ND	ND	NA
x		Toluene	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	NA
x		Xylene, mp-	ND	ND	ND	ND	ND	ND	ND	NA
x		Xylene, o-	ND	ND	ND	ND	ND	ND	ND	NA
x		2-Butanone (MEK)	ND	ND	ND	ND	ND	ND	ND	NA
x		Propionaldehyde (Propanal)	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs								
		Octane	5.87E-02	6.01E-02	6.28E-02	6.02E-02	6.08E-02	6.09E-02	6.06E-02	1.34E-03
		Heptane	5.25E-02	5.54E-02	5.83E-02	5.20E-02	5.49E-02	5.52E-02	5.47E-02	2.26E-03
		Decane	3.99E-02	4.23E-02	4.20E-02	4.76E-02	4.29E-02	4.94E-02	4.40E-02	3.65E-03
		Nonane	2.65E-02	2.81E-02	2.77E-02	3.01E-02	2.50E-02	2.71E-02	2.74E-02	1.72E-03
		Cyclohexane	3.04E-02	1.81E-03	1.17E-03	I	3.21E-02	3.51E-02	2.01E-02	1.71E-02
		Undecane	I	1.67E-02	1.70E-02	1.62E-02	1.65E-02	1.55E-02	1.64E-02	5.55E-04
		Hexaldehyde	1.40E-02	1.56E-02	1.66E-02	1.38E-02	1.46E-02	1.03E-02	1.41E-02	2.16E-03
		Dodecane	1.06E-02	9.46E-03	9.23E-03	7.22E-03	1.01E-02	8.00E-03	9.11E-03	1.28E-03
		Dimethylphenols	6.03E-03	ND	ND	1.12E-02	6.46E-03	5.67E-03	4.89E-03	4.29E-03
		Dimethylphenol, 2,4-	6.03E-03	ND	ND	1.12E-02	6.46E-03	5.67E-03	4.89E-03	4.29E-03
		Crotonaldehyde	5.05E-03	5.88E-03	7.62E-03	3.83E-03	3.23E-03	3.26E-03	4.81E-03	1.73E-03
		Benzaldehyde	2.66E-03	2.24E-03	2.30E-03	4.34E-03	4.03E-03	4.92E-03	3.41E-03	1.16E-03
		o,m,p-Tolualdehyde	2.89E-03	1.41E-03	2.55E-03	4.35E-03	4.91E-03	3.90E-03	3.34E-03	1.29E-03
		Pentanal (Valeraldehyde)	2.76E-03	4.13E-03	4.89E-03	2.45E-03	2.34E-03	1.83E-03	3.07E-03	1.18E-03
		Diethylbenzene, 1,3-	ND	ND	ND	ND	ND	ND	ND	NA
		Dimethylphenol, 2,6-	ND	ND	ND	ND	ND	ND	ND	NA
		Ethyltoluenes	ND	ND	ND	ND	ND	ND	ND	NA
		Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	NA
		Ethyltoluene, 3-	ND	ND	ND	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	ND	ND	ND	NA
		Indene	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUM NUMBER	GM010	GM011	GM012	GM013	GM014	GM015	Average	STDEV
		Propylbenzene, n-	ND	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	ND	I	ND	ND	ND	ND	ND	NA
		Trimethylbenzenes	ND	ND	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,2,3-	ND	ND	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	ND	ND	ND	NA
		Butyraldehyde/Methacrolein	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan GM – PCS Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND/RUN NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
		Test Dates	3/14/2005	3/14/2005	3/14/2005	3/15/2005	3/15/2005	3/15/2005	3/16/2005	3/16/2005	3/16/2005		
		Emissions Indicators											
		TGOC as Propane	6.79E-02	6.00E-02	6.28E-02	7.09E-02	6.21E-02	6.17E-02	6.70E-02	8.04E-02	6.95E-02	6.69E-02	6.35E-03
		HC as n-Hexane	1.14E-02	1.35E-02	1.32E-02	1.50E-02	1.35E-02	1.39E-02	1.57E-02	1.68E-02	1.76E-02	1.45E-02	1.94E-03
		Sum of Target VOCs	1.11E-02	1.28E-02	1.25E-02	1.34E-02	1.29E-02	1.29E-02	1.40E-02	1.48E-02	1.26E-02	1.31E-02	1.04E-03
		Sum of Target HAPs	9.51E-03	1.03E-02	1.01E-02	1.05E-02	1.01E-02	1.02E-02	1.09E-02	1.14E-02	1.09E-02	1.03E-02	7.71E-04
		Sum of Target POMs	2.15E-03	1.33E-03	1.22E-03	8.84E-04	9.40E-04	6.10E-04	6.64E-04	5.92E-04	6.83E-04	9.15E-04	3.04E-04
		Specific Target HAPs											
x		Benzene	2.91E-03	2.62E-03	2.63E-03	3.02E-03	2.87E-03	3.01E-03	3.32E-03	3.57E-03	3.30E-03	3.03E-03	3.20E-04
x		Acetaldehyde	I	1.83E-03	1.84E-03	1.83E-03	1.81E-03	1.82E-03	1.92E-03	1.96E-03	1.83E-03	1.85E-03	5.47E-05
x		Toluene	1.46E-03	1.34E-03	1.36E-03	1.51E-03	1.46E-03	1.45E-03	1.63E-03	1.72E-03	1.63E-03	1.51E-03	1.28E-04
x		Propionaldehyde (Propanal)	7.08E-04	7.84E-04	7.89E-04	8.45E-04	7.68E-04	7.95E-04	9.22E-04	9.58E-04	8.14E-04	8.20E-04	7.75E-05
x	z	Methylnaphthalene, 1-	1.03E-03	1.07E-03	9.62E-04	6.26E-04	6.75E-04	3.60E-04	4.10E-04	2.53E-04	3.64E-04	6.39E-04	3.17E-04
x		Hexane	4.92E-04	4.22E-04	4.35E-04	5.05E-04	4.67E-04	4.71E-04	5.62E-04	5.79E-04	4.90E-04	4.91E-04	5.22E-05
x		Xylene, mp-	4.68E-04	4.40E-04	4.48E-04	4.85E-04	4.61E-04	4.54E-04	4.99E-04	5.55E-04	5.29E-04	4.82E-04	3.89E-05
x		Xylene, o-	2.82E-04	2.64E-04	2.70E-04	2.88E-04	2.71E-04	2.66E-04	3.10E-04	3.34E-04	3.07E-04	2.88E-04	2.42E-05
x		Ethylbenzene	2.52E-04	2.42E-04	2.54E-04	2.69E-04	2.57E-04	2.48E-04	2.88E-04	3.20E-04	2.95E-04	2.69E-04	2.62E-05
x		Phenol	2.13E-04	2.44E-04	1.93E-04	2.52E-04	1.30E-04	3.60E-04	1.16E-04	1.66E-04	3.47E-04	2.25E-04	8.62E-05
x	z	Naphthalene	2.30E-04	2.22E-04	2.18E-04	2.20E-04	2.28E-04	2.14E-04	2.18E-04	2.89E-04	2.71E-04	2.34E-04	2.67E-05
x		Formaldehyde	1.94E-04	2.29E-04	2.06E-04	1.47E-04	1.78E-04	1.84E-04	1.63E-04	1.36E-04	1.84E-04	1.80E-04	2.88E-05
x		Acrolein	1.78E-04	2.00E-04	1.84E-04	1.89E-04	1.55E-04	1.81E-04	1.69E-04	1.33E-04	1.04E-04	1.66E-04	3.04E-05
x		Styrene	1.50E-04	1.42E-04	1.45E-04	1.57E-04	1.35E-04	1.51E-04	1.69E-04	1.94E-04	1.87E-04	1.59E-04	2.04E-05
x		Cresol, o-	5.98E-05	7.06E-05	7.15E-05	6.99E-05	7.62E-05	7.44E-05	7.18E-05	9.42E-05	9.76E-05	7.62E-05	1.21E-05
x		Cresol, mp-	ND	5.02E-05	5.50E-05	ND	5.53E-05	8.33E-05	5.13E-05	7.08E-05	7.84E-05	4.94E-05	3.04E-05
x	z	Methylnaphthalene, 2-	4.31E-05	4.12E-05	3.99E-05	3.80E-05	3.77E-05	3.59E-05	3.58E-05	4.97E-05	4.85E-05	4.11E-05	5.14E-06
x		2-Butanone (MEK)	ND	4.12E-05	2.14E-05	4.84E-05	5.07E-05	3.97E-05	2.59E-05	4.30E-05	3.94E-05	3.44E-05	1.61E-05
x	z	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUN NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
x	z	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs											
		Heptane	5.02E-04	3.87E-04	3.92E-04	5.00E-04	4.06E-04	4.05E-04	4.94E-04	4.93E-04	4.19E-04	4.44E-04	5.12E-05
		Acetone	9.84E-05	3.79E-04	3.37E-04	3.90E-04	4.88E-04	4.45E-04	3.96E-04	4.24E-04	4.72E-04	3.81E-04	1.16E-04
		Octane	2.57E-04	2.17E-04	2.23E-04	2.49E-04	2.28E-04	2.29E-04	2.81E-04	2.84E-04	2.40E-04	2.45E-04	2.45E-05
		Cyclohexane	2.36E-04	1.49E-04	1.81E-04	2.39E-04	2.15E-04	2.15E-04	2.46E-04	2.61E-04	2.33E-04	2.19E-04	3.48E-05
		Indene	1.89E-04	1.74E-04	1.73E-04	1.80E-04	1.74E-04	1.73E-04	1.86E-04	2.11E-04	1.92E-04	1.84E-04	1.27E-05
		Benzaldehyde	1.28E-04	2.31E-04	1.22E-04	2.04E-04	1.55E-04	1.50E-04	1.78E-04	3.14E-04	1.05E-04	1.76E-04	6.54E-05
		Butyraldehyde/Methacrolein	1.54E-04	1.84E-04	1.50E-04	1.89E-04	1.47E-04	1.55E-04	1.71E-04	1.97E-04	1.87E-04	1.71E-04	1.94E-05
		Pentanal (Valeraldehyde)	1.35E-04	9.58E-05	9.75E-05	1.30E-04	1.23E-04	1.55E-04	1.65E-04	1.36E-04	1.18E-04	1.28E-04	2.33E-05
		Ethyltoluene, 3-	1.14E-04	1.08E-04	1.10E-04	1.15E-04	1.19E-04	1.11E-04	1.21E-04	1.38E-04	1.30E-04	1.19E-04	9.96E-06
		Nonane	1.09E-04	9.81E-05	9.60E-05	1.02E-04	9.27E-05	9.32E-05	1.16E-04	1.16E-04	9.76E-05	1.02E-04	9.10E-06
		Dimethylphenol, 2,6-	9.90E-05	9.43E-05	9.39E-05	9.70E-05	9.12E-05	7.96E-05	1.08E-04	1.15E-04	1.01E-04	9.78E-05	1.02E-05
		Decane	8.84E-05	8.67E-05	8.83E-05	9.12E-05	9.03E-05	8.61E-05	1.01E-04	1.14E-04	1.07E-04	9.47E-05	9.97E-06
		Crotonaldehyde	6.89E-05	1.01E-04	7.43E-05	9.21E-05	9.79E-05	8.01E-05	8.39E-05	1.13E-04	1.38E-04	9.44E-05	2.16E-05
		Indan	7.55E-05	7.39E-05	7.61E-05	7.96E-05	7.67E-05	7.58E-05	8.46E-05	9.80E-05	9.13E-05	8.13E-05	8.38E-06
		Trimethylbenzene, 1,2,3-	6.17E-05	6.11E-05	6.29E-05	6.74E-05	7.67E-05	7.16E-05	7.62E-05	8.61E-05	8.51E-05	7.21E-05	9.60E-06
		Hexaldehyde	7.51E-05	9.03E-05	4.55E-05	7.21E-05	4.10E-05	5.79E-05	6.57E-05	6.44E-05	6.67E-05	6.43E-05	1.50E-05
		Propylbenzene, n-	5.88E-05	5.64E-05	5.86E-05	6.02E-05	6.07E-05	5.79E-05	6.55E-05	7.27E-05	6.68E-05	6.19E-05	5.30E-06
		Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	9.17E-05	0.00E+00	8.46E-05	9.37E-05	ND	3.00E-05	4.51E-05
		Diethylbenzene, 1,3-	ND	ND	ND	ND	5.44E-05	5.27E-05	5.03E-05	4.83E-05	ND	2.29E-05	2.72E-05
		Ethyltoluene, 2-	ND	ND	ND	ND	0.00E+00	0.00E+00	ND	9.61E-06	1.32E-05	2.53E-06	5.10E-06
		Dimethylphenol, 2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUN NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
		Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Criteria Pollutants and Green House Gases											
		CO	1.79E-01	1.62E-01	1.47E-01	1.86E-01	1.74E-01	1.87E-01	1.96E-01	1.89E-01	2.09E-01	1.81E-01	1.84E-02
		CO2	4.08E-01	5.60E-01	5.35E-01	5.42E-01	4.75E-01	4.88E-01	5.47E-01	4.21E-01	5.41E-01	5.02E-01	5.71E-02
		NOx	3.42E-04	3.15E-04	3.04E-04	2.48E-04	3.19E-04	2.41E-04	2.25E-04	1.71E-04	2.95E-04	2.73E-04	5.53E-05

Test Plan GM - PCS Individual Emissions Results – Lb/Tn metal

HAPs	POMs	COMPOUND/RUM NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
		Test Dates	3/14/2005	3/14/2005	3/14/2005	3/15/2005	3/15/2005	3/15/2005	3/16/2005	3/16/2005	3/16/2005		
		Emissions Indicators											
		TGOC as Propane	8.79E-01	7.79E-01	8.59E-01	9.42E-01	8.32E-01	8.34E-01	9.02E-01	1.08E+00	8.93E-01	8.89E-01	8.51E-02
		HC as n-Hexane	1.47E-01	1.75E-01	1.81E-01	2.00E-01	1.81E-01	1.88E-01	2.11E-01	2.25E-01	2.26E-01	1.93E-01	2.54E-02
		Sum of Target VOCs	1.43E-01	1.62E-01	1.66E-01	1.72E-01	1.67E-01	1.68E-01	1.82E-01	1.93E-01	1.71E-01	1.69E-01	1.38E-02
		Sum of Target HAPs	1.12E-01	1.33E-01	1.38E-01	1.39E-01	1.35E-01	1.38E-01	1.46E-01	1.53E-01	1.40E-01	1.37E-01	1.12E-02
		Sum of Target POMs	1.69E-02	1.73E-02	1.67E-02	1.17E-02	1.26E-02	8.25E-03	8.94E-03	7.93E-03	8.77E-03	1.21E-02	3.95E-03
		Specific Target HAPs											
x		Benzene	3.77E-02	3.40E-02	3.59E-02	4.02E-02	3.85E-02	4.07E-02	4.47E-02	4.79E-02	4.24E-02	4.02E-02	4.32E-03
x		Acetaldehyde	I	2.38E-02	2.52E-02	2.42E-02	2.43E-02	2.46E-02	2.58E-02	2.63E-02	2.35E-02	2.47E-02	9.69E-04
x		Toluene	1.89E-02	1.74E-02	1.86E-02	2.00E-02	1.95E-02	1.96E-02	2.19E-02	2.30E-02	2.09E-02	2.00E-02	1.73E-03
x		Propionaldehyde (Propanal)	9.16E-03	1.02E-02	1.08E-02	1.12E-02	1.03E-02	1.08E-02	1.24E-02	1.28E-02	1.04E-02	1.09E-02	1.13E-03
x	z	Methylnaphthalene, 1-	1.34E-02	1.39E-02	1.32E-02	8.31E-03	9.05E-03	4.87E-03	5.52E-03	3.39E-03	4.67E-03	8.47E-03	4.15E-03
x		Hexane	6.37E-03	5.48E-03	5.95E-03	6.70E-03	6.26E-03	6.37E-03	7.57E-03	7.75E-03	6.30E-03	6.53E-03	7.27E-04
x		Xylene, mp-	6.06E-03	5.71E-03	6.13E-03	6.45E-03	6.18E-03	6.14E-03	6.71E-03	7.43E-03	6.79E-03	6.40E-03	5.11E-04
x		Xylene, o-	3.64E-03	3.43E-03	3.69E-03	3.83E-03	3.64E-03	3.60E-03	4.18E-03	4.47E-03	3.94E-03	3.82E-03	3.26E-04
x		Ethylbenzene	3.26E-03	3.14E-03	3.47E-03	3.57E-03	3.45E-03	3.35E-03	3.88E-03	4.29E-03	3.78E-03	3.58E-03	3.56E-04
x		Phenol	2.75E-03	3.17E-03	2.65E-03	3.35E-03	1.74E-03	4.86E-03	1.57E-03	2.23E-03	4.45E-03	2.98E-03	1.13E-03
x	z	Naphthalene	2.98E-03	2.89E-03	2.98E-03	2.92E-03	3.06E-03	2.89E-03	2.93E-03	3.88E-03	3.47E-03	3.11E-03	3.39E-04
x		Formaldehyde	2.50E-03	2.97E-03	2.82E-03	1.96E-03	2.39E-03	2.49E-03	2.19E-03	1.82E-03	2.37E-03	2.39E-03	3.71E-04
x		Acrolein	2.30E-03	2.60E-03	2.52E-03	2.51E-03	2.07E-03	2.44E-03	2.28E-03	1.78E-03	1.34E-03	2.20E-03	4.12E-04
x		Styrene	1.94E-03	1.85E-03	1.98E-03	2.08E-03	1.81E-03	2.04E-03	2.27E-03	2.60E-03	2.40E-03	2.11E-03	2.65E-04
x		Cresol, o-	7.73E-04	9.17E-04	9.79E-04	9.28E-04	1.02E-03	1.01E-03	9.67E-04	1.26E-03	1.25E-03	1.01E-03	1.57E-04
x		Cresol, mp-	ND	6.52E-04	7.53E-04	0.00E+00	7.42E-04	1.13E-03	6.91E-04	9.48E-04	1.01E-03	6.58E-04	4.04E-04
x	z	Methylnaphthalene, 2-	5.58E-04	5.35E-04	5.45E-04	5.05E-04	5.06E-04	4.86E-04	4.82E-04	6.66E-04	6.23E-04	5.45E-04	6.30E-05
x		2-Butanone (MEK)	ND	5.34E-04	2.92E-04	6.43E-04	6.81E-04	5.38E-04	3.49E-04	5.77E-04	5.06E-04	4.58E-04	2.13E-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	ND	ND	NA

HAPs	POMs	COMPOUND/RUM NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
x	z	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Other Target VOCs											
		Heptane	6.49E-03	5.02E-03	5.36E-03	6.64E-03	5.44E-03	5.48E-03	6.65E-03	6.60E-03	5.38E-03	5.89E-03	6.77E-04
		Acetone	1.27E-03	4.93E-03	4.62E-03	5.18E-03	6.54E-03	6.02E-03	5.34E-03	5.68E-03	6.06E-03	5.07E-03	1.55E-03
		Octane	3.33E-03	2.82E-03	3.05E-03	3.31E-03	3.05E-03	3.09E-03	3.78E-03	3.80E-03	3.09E-03	3.26E-03	3.38E-04
		Cyclohexane	3.05E-03	1.94E-03	2.48E-03	3.18E-03	2.89E-03	2.91E-03	3.31E-03	3.50E-03	2.99E-03	2.92E-03	4.65E-04
		Indene	2.44E-03	2.26E-03	2.37E-03	2.39E-03	2.34E-03	2.34E-03	2.51E-03	2.83E-03	2.47E-03	2.44E-03	1.66E-04
		Benzaldehyde	1.66E-03	3.00E-03	1.66E-03	2.71E-03	2.08E-03	2.03E-03	2.40E-03	4.20E-03	1.35E-03	2.34E-03	8.74E-04
		Butyraldehyde/Methacrolein	1.99E-03	2.39E-03	2.05E-03	2.51E-03	1.97E-03	2.09E-03	2.31E-03	2.64E-03	2.40E-03	2.26E-03	2.44E-04
		Pentanal (Valeraldehyde)	1.74E-03	1.24E-03	1.33E-03	1.72E-03	1.64E-03	2.09E-03	2.23E-03	1.82E-03	1.51E-03	1.70E-03	3.22E-04
		Ethyltoluene, 3-	1.47E-03	1.41E-03	1.50E-03	1.53E-03	1.60E-03	1.50E-03	1.63E-03	1.85E-03	1.67E-03	1.57E-03	1.32E-04
		Nonane	1.41E-03	1.27E-03	1.31E-03	1.36E-03	1.24E-03	1.26E-03	1.56E-03	1.55E-03	1.25E-03	1.36E-03	1.24E-04
		Dimethylphenol, 2,6-	1.28E-03	1.22E-03	1.29E-03	1.29E-03	1.22E-03	1.08E-03	1.46E-03	1.54E-03	1.30E-03	1.30E-03	1.36E-04
		Decane	1.14E-03	1.13E-03	1.21E-03	1.21E-03	1.21E-03	1.17E-03	1.36E-03	1.52E-03	1.37E-03	1.26E-03	1.32E-04
		Crotonaldehyde	8.91E-04	1.31E-03	1.02E-03	1.22E-03	1.31E-03	1.08E-03	1.13E-03	1.52E-03	1.78E-03	1.25E-03	2.70E-04
		Indan	9.77E-04	9.60E-04	1.04E-03	1.06E-03	1.03E-03	1.03E-03	1.14E-03	1.31E-03	1.17E-03	1.08E-03	1.11E-04
		Trimethylbenzene, 1,2,3-	7.98E-04	7.94E-04	8.61E-04	8.96E-04	1.03E-03	9.68E-04	1.03E-03	1.15E-03	1.09E-03	9.57E-04	1.28E-04
		Hexaldehyde	9.71E-04	1.17E-03	6.23E-04	9.58E-04	5.50E-04	7.83E-04	8.85E-04	8.63E-04	8.57E-04	8.51E-04	1.87E-04
		Propylbenzene, n-	7.61E-04	7.32E-04	8.02E-04	7.99E-04	8.14E-04	7.83E-04	8.82E-04	9.74E-04	8.58E-04	8.23E-04	7.27E-05
		Diethylbenzene, 1,3-	ND	ND	ND	ND	7.29E-04	7.13E-04	6.78E-04	6.47E-04	ND	3.07E-04	3.65E-04
		Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	1.23E-03	ND	1.14E-03	1.26E-03	ND	4.03E-04	6.05E-04
		Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	1.29E-04	1.69E-04	3.31E-05	6.64E-05
		Dimethylphenol, 2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

HAPs	POMs	COMPOUND/RUM NUMBER	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	Average	STDEV
		Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Criteria Pollutants and Green House Gases											
		CO	2.32E+00	2.10E+00	2.02E+00	2.48E+00	2.33E+00	2.53E+00	2.64E+00	2.54E+00	2.68E+00	2.40E+00	2.31E-01
		CO2	5.27E+00	7.28E+00	7.33E+00	7.20E+00	6.37E+00	6.60E+00	7.36E+00	5.63E+00	6.95E+00	6.67E+00	7.71E-01
		NOx	4.42E-03	4.09E-03	4.15E-03	3.29E-03	4.28E-03	3.25E-03	3.03E-03	2.29E-03	3.79E-03	3.62E-03	7.05E-04

Test Plan FR – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	1.87E-05
1,2,4-Trimethylbenzene	1.87E-05
1,3,5-Trimethylbenzene	1.87E-05
1,3-Dimethylnaphthalene	1.87E-05
1-Methylnaphthalene	1.87E-05
2-Ethyltoluene	1.87E-05
2-Methylnaphthalene	1.87E-05
Benzene	1.87E-05
Ethylbenzene	1.87E-05
Hexane	1.87E-05
m,p-Xylene	1.87E-05
Naphthalene	1.87E-05
o-Xylene	1.87E-05
Styrene	1.87E-05
Toluene	1.87E-05
Undecane	1.87E-05
1,2-Dimethylnaphthalene	9.33E-05
1,3-Diethylbenzene	9.33E-05
1,5-Dimethylnaphthalene	9.33E-05
1,6-Dimethylnaphthalene	9.33E-05
1,8-Dimethylnaphthalene	9.33E-05
2,3,5-Trimethylnaphthalene	9.33E-05
2,3-Dimethylnaphthalene	9.33E-05
2,4-Dimethylphenol	9.33E-05

Analytes	Lb/Lb Binder
2,6-Dimethylnaphthalene	9.33E-05
2,6-Dimethylphenol	9.33E-05
2,7- Dimethylnaphthalene	9.33E-05
3-Ethyltoluene	9.33E-05
Acenaphthalene	9.33E-05
Biphenyl	9.33E-05
Cyclohexane	9.33E-05
Decane	9.33E-05
Dodecane	9.33E-05
Heptane	9.33E-05
Indan	9.33E-05
Indene	9.33E-05
m,p-Cresol	9.33E-05
Nonane	9.33E-05
o-Cresol	9.33E-05
Octane	9.33E-05
Phenol	9.33E-05
Propylbenzene	9.33E-05
Tetradecane	9.33E-05
HC as Hexane	5.65E-04
2-Butanone (MEK)	1.67E-05
Acetaldehyde	1.67E-05
Acrolein	1.67E-05

Analytes	Lb/Lb Binder
Benzaldehyde	1.67E-05
Butyraldehyde	1.67E-05
Crotonaldehyde	1.67E-05
Formaldehyde	1.67E-05
Hexaldehyde	1.67E-05
Butyraldehyde/Methacrolein	2.78E-05
o,m,p-Tolualdehyde	4.45E-05
Pentanal (Valeraldehyde)	1.67E-05
Propionaldehyde (Propanal)	1.67E-05
Aniline	1.12E-04
Dimethylaniline	1.12E-04
Carbon Monoxide	4.40E-02
Methane	2.51E-03
Carbon Dioxide	6.91E-02
Ethane	4.71E-02
Propane	6.91E-02
Isobutane	9.11E-02
Butane	9.11E-02
Neopentane	1.13E-01
Isopentane	1.13E-01
Pentane	1.13E-01

Test Plan FR – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.17E-04
1,2,4-Trimethylbenzene	1.17E-04
1,3,5-Trimethylbenzene	1.17E-04
1,3-Dimethylnaphthalene	1.17E-04
1-Methylnaphthalene	1.17E-04
2-Ethyltoluene	1.17E-04
2-Methylnaphthalene	1.17E-04
Benzene	1.17E-04
Ethylbenzene	1.17E-04
Hexane	1.17E-04
m,p-Xylene	1.17E-04
Naphthalene	1.17E-04
o-Xylene	1.17E-04
Styrene	1.17E-04
Toluene	1.17E-04
Undecane	1.17E-04
1,2-Dimethylnaphthalene	5.85E-04
1,3-Diethylbenzene	5.85E-04
1,5-Dimethylnaphthalene	5.85E-04
1,6-Dimethylnaphthalene	5.85E-04
1,8-Dimethylnaphthalene	5.85E-04
2,3,5-Trimethylnaphthalene	5.85E-04
2,3-Dimethylnaphthalene	5.85E-04
2,4-Dimethylphenol	5.85E-04

Analytes	Lb/Tn Metal
2,6-Dimethylnaphthalene	5.85E-04
2,6-Dimethylphenol	5.85E-04
2,7- Dimethylnaphthalene	5.85E-04
3-Ethyltoluene	5.85E-04
Acenaphthalene	5.85E-04
Biphenyl	5.85E-04
Cyclohexane	5.85E-04
Decane	5.85E-04
Dodecane	5.85E-04
Heptane	5.85E-04
Indan	5.85E-04
Indene	5.85E-04
m,p-Cresol	5.85E-04
Nonane	5.85E-04
o-Cresol	5.85E-04
Octane	5.85E-04
Phenol	5.85E-04
Propylbenzene	5.85E-04
Tetradecane	5.85E-04
HC as Hexane	3.54E-03
2-Butanone (MEK)	1.05E-04
Acetaldehyde	1.05E-04
Acrolein	1.05E-04

Analytes	Lb/Tn Metal
Benzaldehyde	1.05E-04
Butyraldehyde	1.05E-04
Crotonaldehyde	1.05E-04
Formaldehyde	1.05E-04
Hexaldehyde	1.05E-04
Butyraldehyde/Methacrolein	1.74E-04
o,m,p-Tolualdehyde	2.79E-04
Pentanal (Valeraldehyde)	1.05E-04
Propionaldehyde (Propanal)	1.05E-04
Aniline	7.04E-04
Dimethylaniline	7.04E-04
Carbon Monoxide	2.76E-01
Methane	1.58E-02
Carbon Dioxide	4.33E-01
Ethane	4.18E-02
Propane	4.33E-01
Isobutane	5.71E-01
Butane	5.71E-01
Neopentane	7.09E-01
Isopentane	7.09E-01
Pentane	7.09E-01

Test Plan GM - Core Baking Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	2.83E-06
1,2,4-Trimethylbenzene	2.83E-06
1,3,5-Trimethylbenzene	2.83E-06
1,3-Dimethylnaphthalene	2.83E-06
1-Methylnaphthalene	2.83E-06
2-Ethyltoluene	2.83E-06
2-Methylnaphthalene	2.83E-06
Benzene	2.83E-06
Ethylbenzene	2.83E-06
Hexane	2.83E-06
m,p-Xylene	2.83E-06
Naphthalene	2.83E-06
o-Xylene	2.83E-06
Styrene	2.83E-06
Toluene	2.83E-06
Undecane	2.83E-06
1,2-Dimethylnaphthalene	1.42E-05
1,3-Diethylbenzene	1.42E-05
1,5-Dimethylnaphthalene	1.42E-05
1,6-Dimethylnaphthalene	1.42E-05
1,8-Dimethylnaphthalene	1.42E-05

Analytes	Lb/Lb Binder
2,3,5-Trimethylnaphthalene	1.41723E-05
2,3-Dimethylnaphthalene	1.41723E-05
2,4-Dimethylphenol	1.41723E-05
2,6-Dimethylnaphthalene	1.41723E-05
2,6-Dimethylphenol	1.41723E-05
2,7- Dimethylnaphthalene	1.41723E-05
3-Ethyltoluene	1.41723E-05
Acenaphthalene	1.41723E-05
Biphenyl	1.41723E-05
Cyclohexane	1.41723E-05
Decane	1.41723E-05
Dodecane	1.41723E-05
Heptane	1.41723E-05
Indan	1.41723E-05
Indene	1.41723E-05
m,p-Cresol	1.41723E-05
Nonane	1.41723E-05
o-Cresol	1.41723E-05
Octane	1.41723E-05
Phenol	1.41723E-05
Propylbenzene	1.41723E-05

Analytes	Lb/Lb Binder
Propylbenzene	1.41723E-05
Tetradecane	1.41723E-05
HC as Hexane	1.95E-04
2-Butanone (MEK)	5.68E-06
Acetaldehyde	5.68E-06
Acrolein	5.68E-06
Benzaldehyde	5.68E-06
Butyraldehyde	5.68E-06
Crotonaldehyde	5.68E-06
Formaldehyde	5.68E-06
Hexaldehyde	5.68E-06
Butyraldehyde/Methacrolein	9.47E-06
o,m,p-Tolualdehyde	1.51E-05
Pentanal (Valeraldehyde)	5.68E-06
Propionaldehyde (Propanal)	5.68E-06

Test Plan GM - Core Baking Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.09E-04
1,2,4-Trimethylbenzene	1.09E-04
1,3,5-Trimethylbenzene	1.09E-04
1,3-Dimethylnaphthalene	1.09E-04
1-Methylnaphthalene	1.09E-04
2-Ethyltoluene	1.09E-04
2-Methylnaphthalene	1.09E-04
Benzene	1.09E-04
Ethylbenzene	1.09E-04
Hexane	1.09E-04
m,p-Xylene	1.09E-04
Naphthalene	1.09E-04
o-Xylene	1.09E-04
Styrene	1.09E-04
Toluene	1.09E-04
Undecane	1.09E-04
1,2-Dimethylnaphthalene	5.47E-04
1,3-Diethylbenzene	5.47E-04
1,5-Dimethylnaphthalene	5.47E-04
1,6-Dimethylnaphthalene	5.47E-04
1,8-Dimethylnaphthalene	5.47E-04

Analytes	Lb/Tn Metal
2,3,5-Trimethylnaphthalene	5.47E-04
2,3-Dimethylnaphthalene	5.47E-04
2,4-Dimethylphenol	5.47E-04
2,6-Dimethylnaphthalene	5.47E-04
2,6-Dimethylphenol	5.47E-04
2,7- Dimethylnaphthalene	5.47E-04
3-Ethyltoluene	5.47E-04
Acenaphthalene	5.47E-04
Biphenyl	5.47E-04
Cyclohexane	5.47E-04
Decane	5.47E-04
Dodecane	5.47E-04
Heptane	5.47E-04
Indan	5.47E-04
Indene	5.47E-04
m,p-Cresol	5.47E-04
Nonane	5.47E-04
o-Cresol	5.47E-04
Octane	5.47E-04
Phenol	5.47E-04
Propylbenzene	5.47E-04

Analytes	Lb/Tn Metal
Tetradecane	5.47E-04
HC as Hexane	5.47E-02
2-Butanone (MEK)	1.64E-03
Acetaldehyde	1.64E-03
Acrolein	1.64E-03
Benzaldehyde	1.64E-03
Butyraldehyde	1.64E-03
Crotonaldehyde	1.64E-03
Formaldehyde	1.64E-03
Hexaldehyde	1.64E-03
Butyraldehyde/Methacrolein	2.73E-03
o,m,p-Tolualdehyde	4.37E-03
Pentanal (Valeraldehyde)	1.64E-03
Propionaldehyde (Propanal)	1.64E-03

Test Plan GM - PCS Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	9.66E-06
1,2,4-Trimethylbenzene	9.66E-06
1,3,5-Trimethylbenzene	9.66E-06
1,3-Dimethylnaphthalene	9.66E-06
1-Methylnaphthalene	9.66E-06
2-Ethyltoluene	9.66E-06
2-Methylnaphthalene	9.66E-06
Benzene	9.66E-06
Ethylbenzene	9.66E-06
Hexane	9.66E-06
m,p-Xylene	9.66E-06
Naphthalene	9.66E-06
o-Xylene	9.66E-06
Styrene	9.66E-06
Toluene	9.66E-06
Undecane	9.66E-06
1,2-Dimethylnaphthalene	4.83E-05
1,3-Diethylbenzene	4.83E-05
1,5-Dimethylnaphthalene	4.83E-05
1,6-Dimethylnaphthalene	4.83E-05
1,8-Dimethylnaphthalene	4.83E-05

Analytes	Lb/Lb Binder
2,3,5-Trimethylnaphthalene	4.82813E-05
2,3-Dimethylnaphthalene	4.82813E-05
2,4-Dimethylphenol	4.82813E-05
2,6-Dimethylnaphthalene	4.82813E-05
2,6-Dimethylphenol	4.82813E-05
2,7- Dimethylnaphthalene	4.82813E-05
3-Ethyltoluene	4.82813E-05
Acenaphthalene	4.82813E-05
Biphenyl	4.82813E-05
Cyclohexane	4.82813E-05
Decane	4.82813E-05
Dodecane	4.82813E-05
Heptane	4.82813E-05
Indan	4.82813E-05
Indene	4.82813E-05
m,p-Cresol	4.82813E-05
Nonane	4.82813E-05
o-Cresol	4.82813E-05
Octane	4.82813E-05
Phenol	4.82813E-05
Propylbenzene	4.82813E-05

Analytes	Lb/Lb Binder
Propylbenzene	4.82813E-05
Tetradecane	4.82813E-05
HC as Hexane	3.18E-04
2-Butanone (MEK)	9.72E-06
Acetaldehyde	9.72E-06
Acrolein	9.72E-06
Benzaldehyde	9.72E-06
Butyraldehyde	9.72E-06
Crotonaldehyde	9.72E-06
Formaldehyde	9.72E-06
Hexaldehyde	9.72E-06
Butyraldehyde/Methacrolein	1.62E-05
o,m,p-Tolualdehyde	2.59E-05
Pentanal (Valeraldehyde)	9.72E-06
Propionaldehyde (Propanal)	9.72E-06

Test Plan GM - PCS Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.28E-04
1,2,4-Trimethylbenzene	1.28E-04
1,3,5-Trimethylbenzene	1.28E-04
1,3-Dimethylnaphthalene	1.28E-04
1-Methylnaphthalene	1.28E-04
2-Ethyltoluene	1.28E-04
2-Methylnaphthalene	1.28E-04
Benzene	1.28E-04
Ethylbenzene	1.28E-04
Hexane	1.28E-04
m,p-Xylene	1.28E-04
Naphthalene	1.28E-04
o-Xylene	1.28E-04
Styrene	1.28E-04
Toluene	1.28E-04
Undecane	1.28E-04
1,2-Dimethylnaphthalene	6.41E-04
1,3-Diethylbenzene	6.41E-04
1,5-Dimethylnaphthalene	6.41E-04
1,6-Dimethylnaphthalene	6.41E-04
1,8-Dimethylnaphthalene	6.41E-04

Analytes	Lb/Tn Metal
2,3,5-Trimethylnaphthalene	6.41E-04
2,3-Dimethylnaphthalene	6.41E-04
2,4-Dimethylphenol	6.41E-04
2,6-Dimethylnaphthalene	6.41E-04
2,6-Dimethylphenol	6.41E-04
2,7- Dimethylnaphthalene	6.41E-04
3-Ethyltoluene	6.41E-04
Acenaphthalene	6.41E-04
Biphenyl	6.41E-04
Cyclohexane	6.41E-04
Decane	6.41E-04
Dodecane	6.41E-04
Heptane	6.41E-04
Indan	6.41E-04
Indene	6.41E-04
m,p-Cresol	6.41E-04
Nonane	6.41E-04
o-Cresol	6.41E-04
Octane	6.41E-04
Phenol	6.41E-04
Propylbenzene	6.41E-04

Analytes	Lb/Tn Metal
Tetradecane	6.41E-04
HC as Hexane	6.41E-02
2-Butanone (MEK)	1.92E-03
Acetaldehyde	1.92E-03
Acrolein	1.92E-03
Benzaldehyde	1.92E-03
Butyraldehyde	1.92E-03
Crotonaldehyde	1.92E-03
Formaldehyde	1.92E-03
Hexaldehyde	1.92E-03
Butyraldehyde/Methacrolein	3.20E-03
o,m,p-Tolualdehyde	5.13E-03
Pentanal (Valeraldehyde)	1.92E-03
Propionaldehyde (Propanal)	1.92E-03

APPENDIX C DETAILED PROCESS DATA FOR TEST GM

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Test Series GM - Detailed Core Baking Process Data

Oil Core Baking and Cooling							
Test Dates	3/2/05	3/3/05	3/3/05	3/7/05	3/7/05	3/8/05	Averages
Emissions Sample #	GM010	GM011	GM012	GM013	GM014	GM015	
Production Sample #	GM020	GM021	GM022	GM023	GM024	GM025	
Sand in Oil Core Sand mix, Lbs	17.64	26.46	26.46	26.46	26.46	26.46	24.99
Core Oil in Oil Core Sand Mix' Lbs,	0.35	0.53	0.53	0.53	0.53	0.53	0.50
Cereal in Oil Core Sand Mix, Lbs	0.18	0.26	0.26	0.26	0.26	0.26	0.25
Clay in Oil Core Sand Mix, Lbs	0.09	0.13	0.13	0.13	0.13	0.13	0.12
Water in Oil Core Sand Mix, Lbs	0.13	0.26	0.26	0.26	0.26	0.26	0.24
Oil Content, % (BOS)	2.00	2.00	2.00	2.01	2.01	2.00	2.00
Cereal Content, % (BOS)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Clay Content, % (BOS)	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Water content, % (BOS)	0.75	1.00	1.00	1.00	1.00	1.00	0.96
Oil Content, % of Sand Mix	1.92	1.91	1.91	1.92	1.92	1.91	1.92
Cereal Content, % of Sand mix	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Clay Content, % of Sand Mix	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Water content, of Sand mix	0.72	0.96	0.96	0.96	0.96	0.96	0.92
Weight of Un-baked Core, Lbs	4.259	4.350	3.975	4.409	4.385	4.450	4.30
Weight of Baked Cores, Lbs.	4.210	4.291	3.923	4.354	4.329	4.390	4.249
Weight loss during baking, % of unbaked core weight	1.15	1.34	1.33	1.26	1.27	1.35	1.28
Unbaked Oil Binder Weight in Core Step Section, Lbs.	0.082	0.083	0.076	0.085	0.084	0.085	0.08
Unbaked Oil + Cereal Weight in Core Step Section, Lbs	0.123	0.125	0.114	0.127	0.126	0.128	0.12
Core LOI, % (note 1)	2.44	2.35	2.25	2.35	2.30	2.36	2.34
Approximate Core Age when baked, Min.	<10	<5	<5	<5	<5	<5	<6
Core Oven Temperature, F	425	425	425	425	425	425	425
Average heated investment time, Minutes	120	120	120	120	120	120	120

Note 1: LOI determination done 360-504 hours after baking

Test Series GM - Detailed PCS Process Data

Greensand PCS													
Test Dates	3/11/05	3/11/05	3/11/05	3/14/05	3/14/05	3/14/05	3/15/05	3/15/05	3/15/05	3/16/05	3/16/05	3/16/05	Averages
Emissions Sample #	GMER01	GMER02	GMER03	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	
Production Sample #	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	GM010	GM011	GM012	
Cast Weight (all metal inside mold), Lbs.	115.45	115.45	113.60	114.45	114.80	110.85	112.65	111.15	110.95	110.70	111.35	116.75	112.63
Pouring Time, sec.	14	11	14	14	15	14	21	16	18	16	24	13	17
Pouring Temp ,°F	2638	2618	2622	2629	2639	2623	2637	2626	2619	2628	2635	2623	2629
Pour Hood Process Air Temp at Start of Pour, ºF	85	89	87	89	87	89	86	86	86	85	89	88	87
Sand in Oil Core Sand mix, Lbs	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48	37.48
Core Oil in Oil Core Sand Mix' Lbs,	0.76	0.75	0.75	0.75	0.75	0.77	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Cereal in Oil Core Sand Mix, Lbs	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Clay in Oil Core Sand Mix, Lbs	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Water in Oil Core Sand Mix, Lbs	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Oil Content, % (BOS)	2.03	2.00	2.00	2.00	2.00	2.05	2.00	2.00	2.01	2.00	2.00	2.00	2.01
Cereal Content, % (BOS)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Clay Content, % (BOS)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Water content, % (BOS)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Oil Content, % of Sand Mix	1.94	1.91	1.91	1.91	1.91	1.96	1.92	1.91	1.92	1.91	1.91	1.91	1.92
Cereal Content, % of Sand mix	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Clay Content, % of Sand Mix	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Water content, % of Sand mix	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Total Weight of Un-baked Cores in Mold, Lbs	30.60	30.25	30.25	30.45	30.45	30.55	30.20	30.10	29.85	30.10	30.10	29.25	30.12
Total Weight of Baked Cores in Mold, Lbs.	30.14	29.93	29.96	30.17	30.15	30.22	29.85	29.57	29.39	29.78	29.79	28.90	29.76
Total Unbaked Oil Binder Weight in Mold, Lbs.	0.59	0.58	0.58	0.58	0.58	0.60	0.58	0.58	0.57	0.58	0.58	0.56	0.58
Total Unbaked Oil + Cereal Weight in Mold, Lbs	0.89	0.87	0.87	0.87	0.87	0.89	0.87	0.86	0.86	0.86	0.86	0.84	0.87
Core LOI, %	1.95	2.47	2.28	2.31	2.41	2.40	2.39	2.36	2.37	2.36	2.46	2.40	2.38
Dogbone Tensile Strength, psi	133.6	153.8	176.2	193.8	160.8	212.7	161.4	185.8	268.9	190.3	261.1	231.7	207.4
Approximate Core Age, hrs.	65	66	67	119	120	121	137	137	116	140	141	142	130
Baking Oven nominal temperature, F	425	425	425	425	425	425	425	425	425	425	425	425	425

Greensand PCS													
Test Dates	3/11/05	3/11/05	3/11/05	3/14/05	3/14/05	3/14/05	3/15/05	3/15/05	3/15/05	3/16/05	3/16/05	3/16/05	Averages
Emissions Sample #	GMER01	GMER02	GMER03	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	
Production Sample #	GM001	GM002	GM003	GM004	GM005	GM006	GM007	GM008	GM009	GM010	GM011	GM012	
Average heated investment time, Minutes	120	120	120	120	120	120	120	120	126	120	120	122	121
Greensand Muller Batch Weight, Lbs.	1301	900	900	900	900	900	910	910	900	900	910	910	904
GS Mold Sand Weight, Lbs.	645	645	655	653	647	647	634	641	645	633	638	639	642
Greensand Muller Compactability, %	51	57	57	52	55	53	52	55	56	52	56	56	54
Greensand Mold Temperature, ºF	78	86	90	70	85	86	80	85	86	75	84	85	82
Average Green Compression , psi	17.89	20.98	20.91	20.38	24.59	21.86	22.32	26.44	24.60	23.84	23.63	22.83	23.39
GS Compactability, %	56	50	46	37	44	41	37	39	39	36	47	50	41
GS Moisture Content, %	2.42	2.14	2.04	2.12	2.06	1.96	2.14	2.62	1.94	2.02	2.32	2.21	2.15
GS MB Clay Content, %	7.67	8.09	8.29	8.50	8.29	8.50	8.50	8.09	7.88	7.05	7.88	7.67	8.04
MB Clay Reagent, ml	37	39	40	41	40	41	41	39	38	34	38	37	39
1800°F LOI - Mold Sand, %	1.04	1.03	1.01	0.95	0.98	0.98	1.00	0.97	0.95	1.07	1.03	1.01	0.99
900°F Volatiles , %	0.38	0.36	0.34	0.48	0.40	0.52	0.44	0.44	0.50	0.52	0.44	0.50	0.47
Core Surface Appearance Ranking 1 = Best, 9 = Worst	3a	8a	7a	4	7	1	2	8	5	9	3	6	

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APPENDIX D CONTINUOUS MONITORING CHARTS

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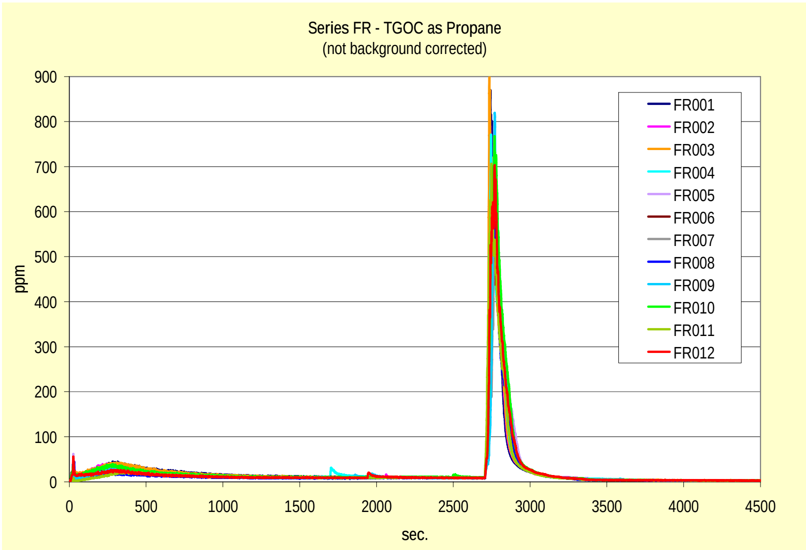
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2500
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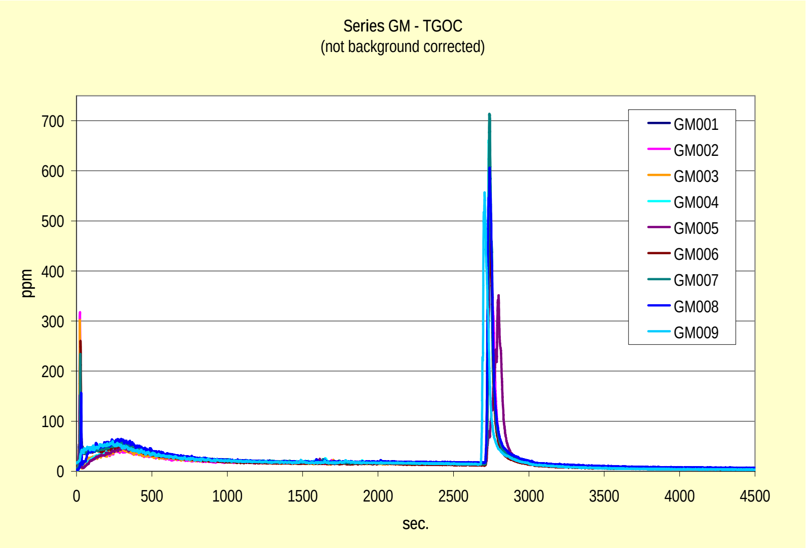
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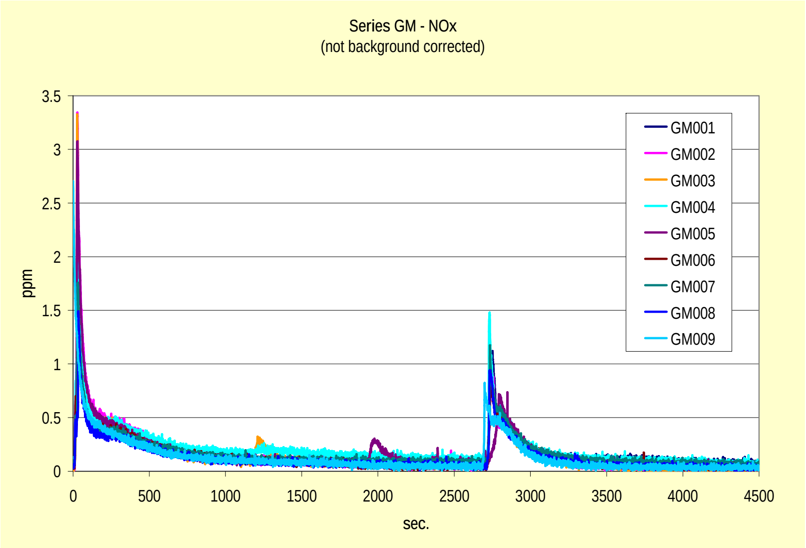
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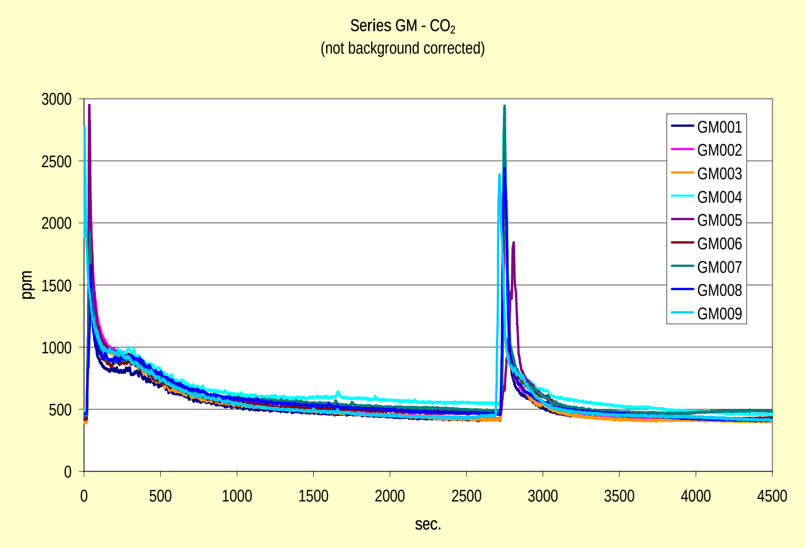
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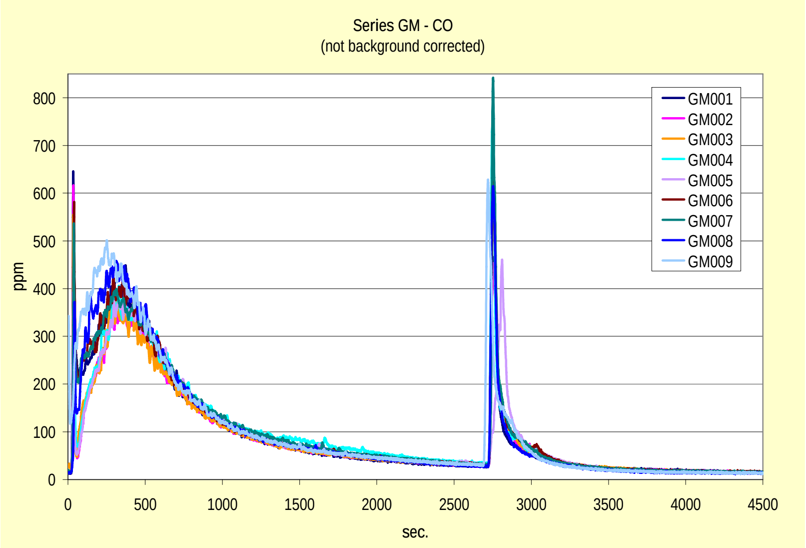
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GM005
GM006
GM007
GM008
GM009

APPENDIX E ACRONYMS AND ABBREVIATIONS

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ACFM	Actual Cubic Feet Per Minute
BO	Based on ( ).
BOA	Based on Aggregate
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
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