CERP

Casting Emission Reduction Program

Prepared by:

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Product Test: Uncoated Shell Core in Greensand, Iron, PCS

Technikon #1410-117 FU

September 2004

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United States Environmental Protection Agency

CISA

AFS

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

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Product Test: Uncoated Shell Core in Greensand, Iron, PCS

1410-117 FU

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

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The data contained in this report were developed to 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 cost or producability.

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Executive Summary

This report contains the results of emission testing to evaluate the pouring, cooling, and shakeout emissions from Test FU, a Novolac® shell step core greensand system without seacoal. The testing was conducted to compare a shell core system with a standard phenolic urethane core system. The results from Test FU will be compared to the baseline Test FR. All testing was conducted by Technikon, LLC in its research foundry. The emissions results are reported in both pounds of analyte per pound of binder and pounds of analyte per ton of metal poured.

The testing performed involved the collection of continuous air samples over a seventy-five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and include: the weights of the casting, mold, core, and binder; Loss on Ignition (LOI) values for the cores and mold prior to the test; metallurgical data; and 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. Samples were collected and analyzed for sixty-nine (69) target compounds using procedures based on US EPA Method 18. Continuous monitoring of the Total Gaseous Organic Concentration (TGOC) of the emissions was conducted according to US EPA Method 25A.

The mass emission rate of each parameter or target compound was calculated using the Method 25A data or the laboratory analytical results, the measured source data and the weight of each casting and/or the binder weight. Results for structural isomers have been grouped and reported as a single entity. For example, ortho-, meta-, and para-xylene are the three (3) structural isomers of dimethyl benzene. The separate isomer results are available in Appendix B of this report. Other "emissions indicators," in addition to the TGOC as Propane, were also calculated. The HC as Hexane results represent the sum of all organic compounds detected and expressed as Hexane. All of the following sums are sub-groups of this measure. The "Sum of VOCs" is based on the sum of the individual target VOCs measured and includes the selected HAPs and selected Polycyclic Organic Material (POMs) listed in the Clean Air Act Amendments of 1990. The "Sum of HAPs" is the sum of the individual target HAPs measured and includes the selected POMs. Finally, the "Sum of POMs" is the sum of all of the polycyclic organic material measured.

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

Test Plan FR and FU Emissions Indicators – Lb/Lb Binder

Analytes	TGOC as Propane	HC as Hexane	Sum of VOCs	Sum of HAPs	Sum of POMs
Test FR (Lb/Lb Binder)	0.1480	0.0482	0.0591	0.0554	0.0169
Test FU (Lb/Lb Binder)	0.0619	0.0304	0.0304	0.0281	0.0004

Test Plan FR and FU Emissions Indicators – Lb/Tn Metal

Analytes	TGOC as Propane	HC as Hexane	Sum of VOCs	Sum of HAPs	Sum of POMs
Test FR (Lb/Tn Metal)	0.9259	0.3016	0.3705	0.3474	0.1059
Test FU (Lb/Tn Metal)	0.6504	0.3190	0.3193	0.2949	0.0040

A pictorial casting record was made of the NE (northeast) cavity from each mold. The pictures are shown in rank-order in Appendix C.

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

1.0 Introduction

1.1 BACKGROUND

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a Cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Research Consortium (ERC), a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development and Engineering Command, Armament Research, Development, and Engineering Center (RDECOM-ARDEC), a laboratory of the United States Army; the American Foundry Society; and the Casting Industry Suppliers Association.

1.2 TECHNIKON OBJECTIVES

The primary objective of Technikon is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions, especially for the 1990 Clean Air Act Amendment. The facility has two principal testing arenas: a Pre-Production Foundry designed to measure airborne emissions from individually poured molds, and a Production Foundry designed to measure air emissions in a continuous full scale production process. Each of these testing arenas has been specially designed to facilitate the collection and evaluation of airborne emissions and associated process data.

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

It must be noted that the results from the reference and product testing performed are not suitable for use as emission factors or for other purposes other than evaluating the relative emission reductions associated with the use of alternative materials, equipment, or manufacturing processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests. These measurements 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 VOC emissions from a cored greensand system. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test are summarized in Section 3 of this report, with detailed data included in the appendices of this report. Section 4 of this report contains a discussion of the results.

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

1.4 SPECIFIC TEST PLAN AND OBJECTIVES

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

Table 1-1 Test Plan Summary

	Test Plan	Test Plan
Type of Process tested	Phenolic Urethane Core with Anti-Veining Compounds, Greensand without Seacoal, Iron PCS*	Novolac® Shell Step Core, Greensand without Seacoal, Iron PCS
Test Plan Number	1410 114 FR	1410 117 FU
Greensand System	Wexford W450 Lakesand, Western and Southern Bentonite in a 5:2 ratio, No Seacoal	Wexford W450 Lakesand, Western and Southern Bentonite in a 5:2 ratio, No Seacoal
Metal Poured	Iron	Iron
Casting Type	4-on Step Core	4-on Step Core
Core Binder	1.4% Ashland ISOCURE® 305/904	XCB630MP Novolac® with 6% HEXA and Calcium Stearate Wax
Core Sand	Amador A-70 Silica Sand	Technisand® XCB630 mp
Number of Molds Poured	For each Configuration: 3 Conditioning and 4 Sampling (Total of 7 Molds)	For each Configuration: 3 Conditioning and 9 Sampling (Total of 12 Molds)
Test Dates	1/15/04 > 1/29/04	5/24/04 > 5/27/04
Emissions Measured	TGOC as Propane, HC as Hexane, 68 Organic HAPs and VOCs	TGOC as Propane, HC as Hexane, 69 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate

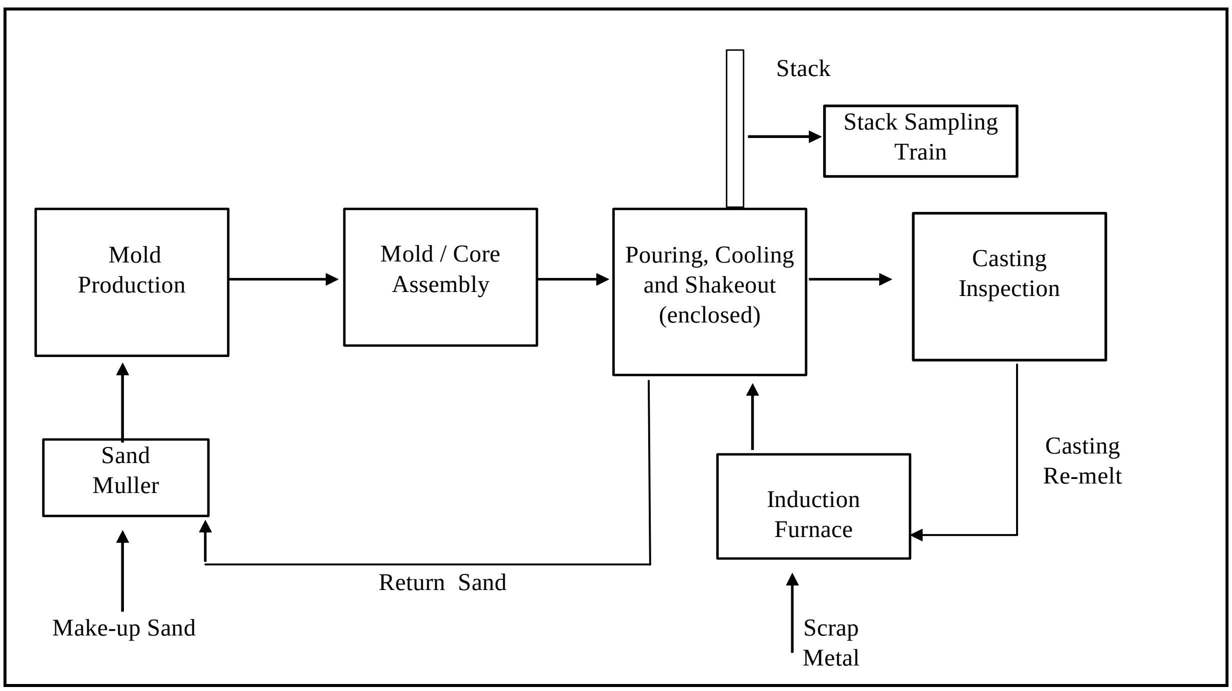
*An internal baseline within Test 1410-114 FR contained no anti veining compounds in the core. Test 1410-117 FU was compared to this part of test 1410-114 FR only.

2.0 Test Methodology

2.1 DESCRIPTION OF PROCESS AND TESTING EQUIPMENT

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

Figure 2-1 Research Foundry Layout Diagram



2.2 DESCRIPTION OF TESTING PROGRAM

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

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

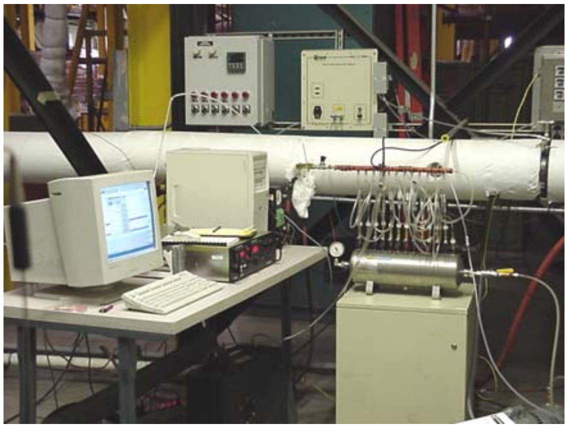
2. **<u>Mold, Core and Metal Preparation:</u>** The molds were prepared to a standard composition by the Technikon production team. The shell cores were provided by the client. Relevant process data was collected and recorded. Iron was melted in a 1000 lb. Ajax induction furnace. The amount of metal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

4-On Step Core

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

Total Enclosure Test Stand

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



Method 25A (TGOC) and
Method 18 Sampling Train

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

Table 2-1 Process Parameters Measured

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

5. **Air Emissions Analysis:** The specific sampling and analytical methods used in the Pre-Production Foundry tests are based on the US EPA reference methods shown in Table 2-2. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Standard Operating Procedures.

Table 2-2 Sampling and Analytical Methods

Measurement Parameter	Test Method
Port Location	EPA Method 1
Number of Traverse Points	EPA Method 1
Gas Velocity and Temperature	EPA Method 2
Gas Density and Molecular Weight	EPA Method 3a
Gas Moisture	EPA Method 4, gravimetric
HAPs Concentration	EPA Method 18, TO11, NIOSH 1500, 2002
VOCs Concentration	EPA Method 18, 25A, TO11, NIOSH 1500, 2002, NIOSH 6016

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

6. **Data Reduction, Tabulation and Preliminary Report Preparation:** The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter, and corrected to dry standard conditions us-

ing the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the binder and the weight of the casting poured to provide emissions data in both pounds of analyte per pound of binder and pounds of analyte per ton of metal.

The results of each of the sampling events are included in the appendices of this report. The emissions results are also averaged and are shown in Tables 3-1 and 3-2.

7. **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 laboratory analytical procedures are included in the Technikon Emissions Testing and Analytical Testing Standard Operating Procedures. In order to ensure the timely review of critical quality control parameters, the following procedures are followed:

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

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

3.0 Test Results

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

Table 3-3 includes the detailed data from Test FU for ammonia expressed in pounds per pound of binder as well as pounds per ton of metal.

Table 3-4 includes the averages of the key process parameters. Detailed process data are presented in Appendix C.

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

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

Appendix B contains the detailed emissions data including the results for all analytes measured.

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

The best, median, and worst NE Cavity castings for all test runs are shown in Appendix C.

Table 3-1 Summary of Test Plans FR and FU Average Results – Lb/Lb Binder

Analytes	Test FR (Lb/Lb Binder)	Test FU (Lb/Lb Binder)	% Change from Test FR
TGOC as Propane	0.1480	0.0619	**-58**
HC as Hexane	0.0482	0.0304	**-37**
Sum of VOCs	0.0591	0.0304	**-49**
Sum of HAPs	0.0554	0.0281	**-49**
Sum of POMs	0.0169	0.0004	**-98**
Individual Organic HAPs			
Benzene	0.0174	0.0118	**-32**
Phenol	0.0113	0.0041	**-64**
Methylnaphthalenes	0.0085	0.0001	**-99**
Naphthalene	0.0062	0.0003	**-95**
o,m,p-Cresol	0.0030	0.0036	20
Toluene	0.0026	0.0050	**92**
Aniline	0.0022	ND	**NA**
Dimethylnaphthalenes	0.0022	ND	**NA**
o,m,p-Xylene	0.0010	0.0023	**130**
Acetaldehyde	0.0005	0.0003	-40
Hexane	0.0001	0.0002	100
Other VOCs			
Trimethylbenzenes	0.0013	0.0003	**-77**
Ethyltoluenes	0.0005	0.0001	-80
Dimethylphenols	0.0003	0.0009	**200**
Octane	ND	0.0002	NA
Other Analytes			
Ammonia*	NT	0.0010	**NA**
Carbon Dioxide	2.996	0.4305	**-86**
Carbon Monoxide	ND	0.2391	**NA**

ND: Non Detect; NA: Not Applicable; NT: Not Tested

Individual results constitute >95% of mass of all detected VOCs.

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

"Percent Change from Test FR" values in bold have a 95% probability that the differences in the average values were not from test variability.

*** See Table 3-3**

Table 3-2 Summary of Test Plans FR and FU Average Results – Lb/Tn Metal

Analytes	Test FR (Lb/Tn Metal)	Test FU (Lb/Tn Metal)	% Change from Test FR
TGOC as Propane	0.9259	0.6504	**-30**
HC as Hexane	0.3016	0.3190	6
Sum of VOCs	0.3705	0.3193	**-14**
Sum of HAPs	0.3474	0.2949	**-15**
Sum of POMs	0.1059	0.0040	**-96**
Individual Organic HAPs			
Benzene	0.1088	0.1236	14
Phenol	0.0707	0.0433	**-39**
Methylnaphthalenes	0.0533	0.0008	**-98**
Naphthalene	0.0389	0.0032	**-92**
o,m,p-Cresol	0.0187	0.0384	**105**
Toluene	0.0161	0.0522	**224**
Dimethylnaphthalenes	0.0137	ND	**NA**
Aniline	0.0130	ND	**NA**
o,m,p-Xylene	0.0064	0.0243	**280**
Acetaldehyde	0.0034	0.0030	**-12**
Hexane	0.0006	0.0026	**333**
Other VOCs			
Trimethylbenzenes	0.0079	0.0027	**-66**
Ethyltoluenes	0.0028	0.0011	**-61**
Dimethylphenols	0.0017	0.0099	**482**
Octane	ND	0.0024	**NA**
Other Analytes			
Ammonia*	NT	0.0100	**NA**
Carbon Dioxide	18.53	4.516	**-76**
Carbon Monoxide	ND	2.512	**NA**

ND: Non Detect; NA: Not Applicable; NT: Not Tested

Individual results constitute >95% of mass of all detected VOCs.

"Percent Change from Test FR" values in bold have a 95% probability that the differences in the average values were not from test variability.

*** See Table 3-3**

Table 3-3 Test Plan FU Detailed Ammonia Results

Analyte	FU001	FU003	FU004	FU005	FU007	FU008	FU009	Average	STDEV
Ammonia (Lb/Tn Metal)	0.0025	0.0052	0.0067	0.0121	0.0095	0.0147	0.0196	0.0100	0.0059
Ammonia (Lb/Lb Binder)	0.0002	0.0005	0.0006	0.0011	0.0009	0.0014	0.0018	0.0010	0.0006

Table 3-4 Summary of Test Plans FR and FU Average Process Parameters

Greensand PCS		
	Reference No Additions Test FR	**Shell Core FU**
Test Dates	1/15-16/04	5/24-5/27/04
Cast Weight (All Metal Inside Mold), Lbs.	111.1	110.4
Pouring Time, sec.	28	18
Pouring Temp ,°F	2632	2635
Pour Hood Process Air Temp at Start of Pour, °F	87	88
Filled Core Weight (Solid-4 core), Lbs Approximate	NA	29.0
Reported Core Binder Content, % BOS	NA	3.00
Calculated/Reported Core Binder Content, %	1.38	2.91
Total Uncoated Unfilled Core Weight in Mold, Lbs.	25.25	19.9
Total Binder Weight in Mold, Lbs.	0.347	0.580
Core LOI, %	1.26	3.38
Muller Batch Weight, Lbs.	900	900
GS Mold Sand Weight, Lbs.	620	623
Mold Compactability, %	56	55
Mold Temperature, °F	70	78
Average Green Compression , psi	11.0	16.9
GS Compactability, %	52.5	43
GS Moisture Content, %	2.27	1.92
GS MB Clay Content, %	6.02	7.31
MB Clay Reagent, ml	26.0	29.2
1800°F LOI - Mold Sand, %	0.71	1.16
900°F Volatiles , %	0.24	0.60
Overall casting appearance 1: Best, 5: Median, 9: Worst		
1		4
2		6
3		7
4	3	8
5		10
6	1	12
7		11
8		
Note : reference cores are solid 9	4	

Figure 3-1 Emission Indicators from Test Series FR and FU – Lb/Lb Binder

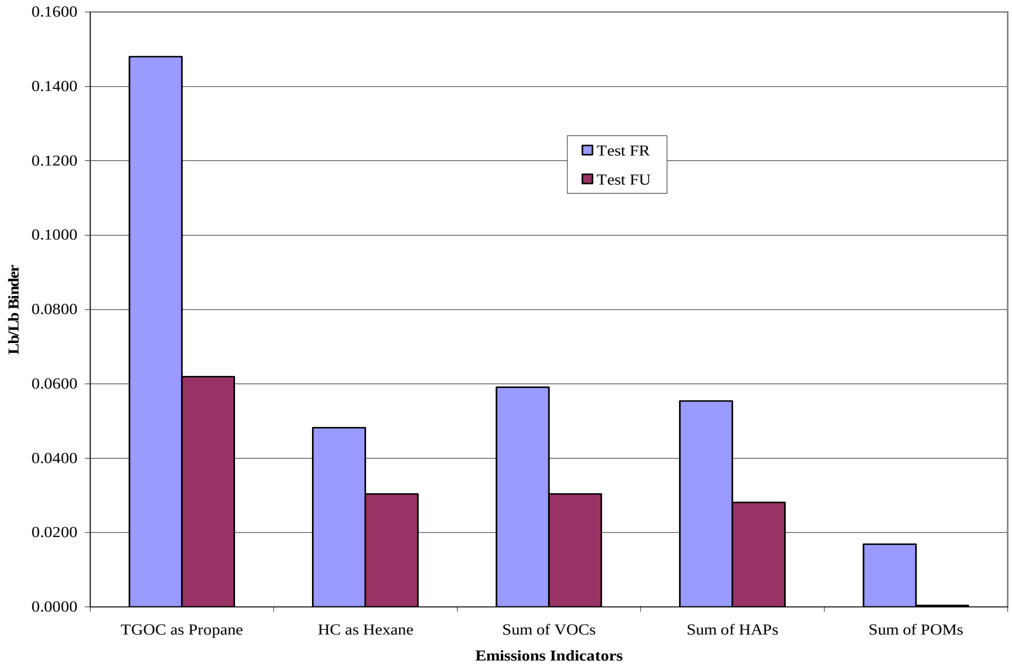


Figure 3-2 Selected HAP Emissions from Test Series FR and FU– Lb/Lb Binder

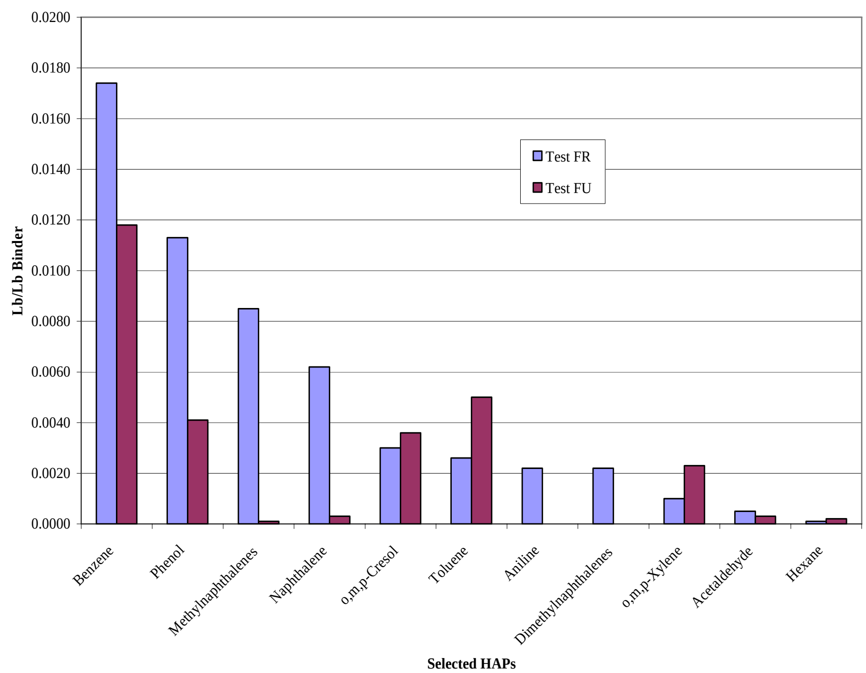


Figure 3-3 Selected VOC Emissions from Test Series FR and FU – Lb/Lb Binder

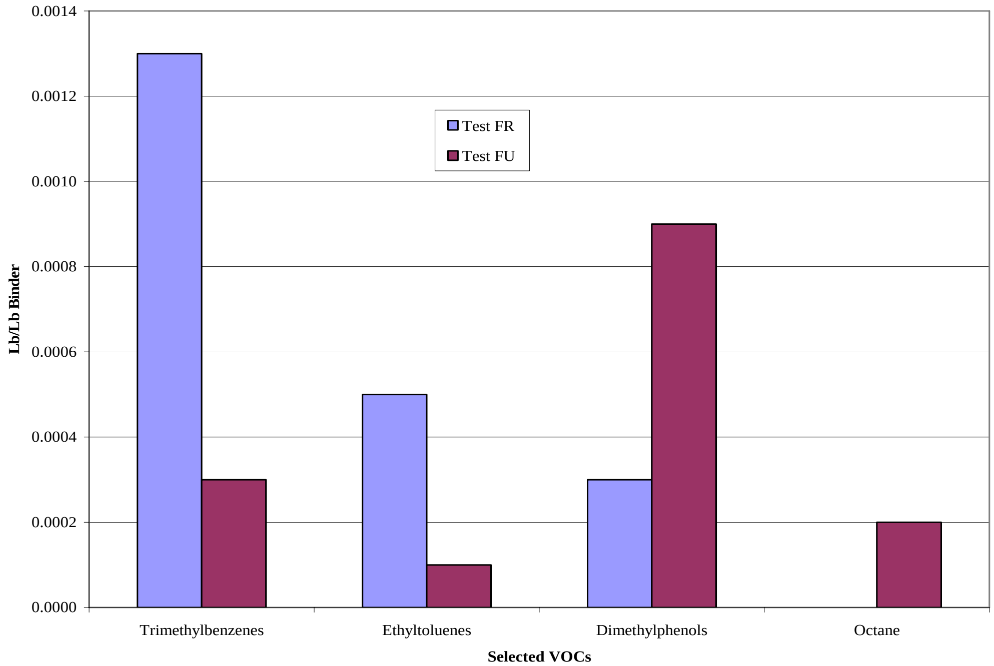


Figure 3-4 Emissions Indicators from Test Series FR and FU – Lb/Tn Metal

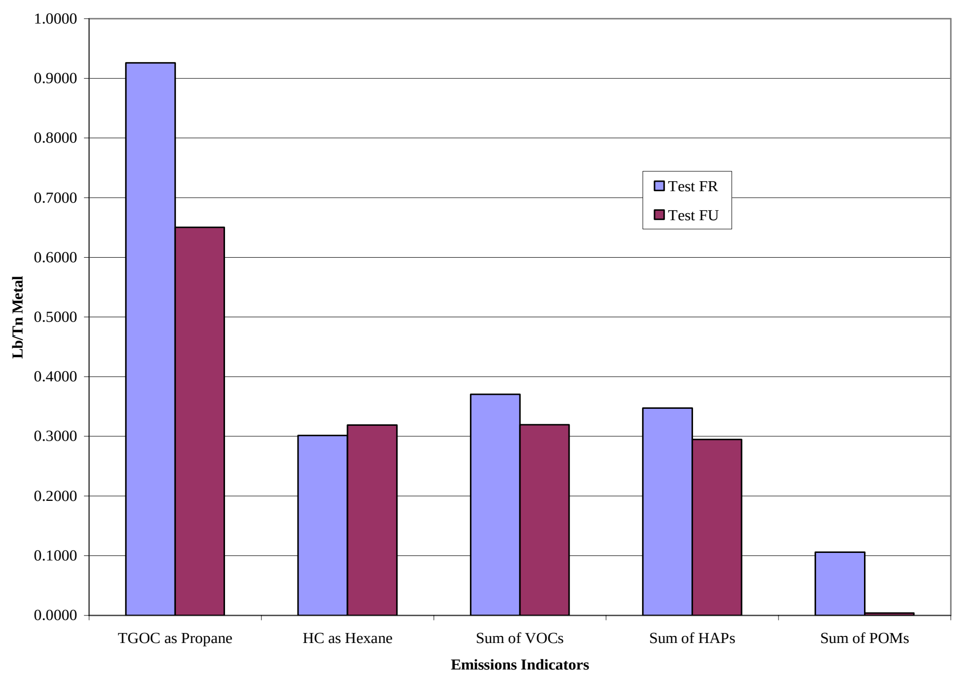


Figure 3-5 Selected HAP Emissions from Test Series FR and FU – Lb/Tn Metal

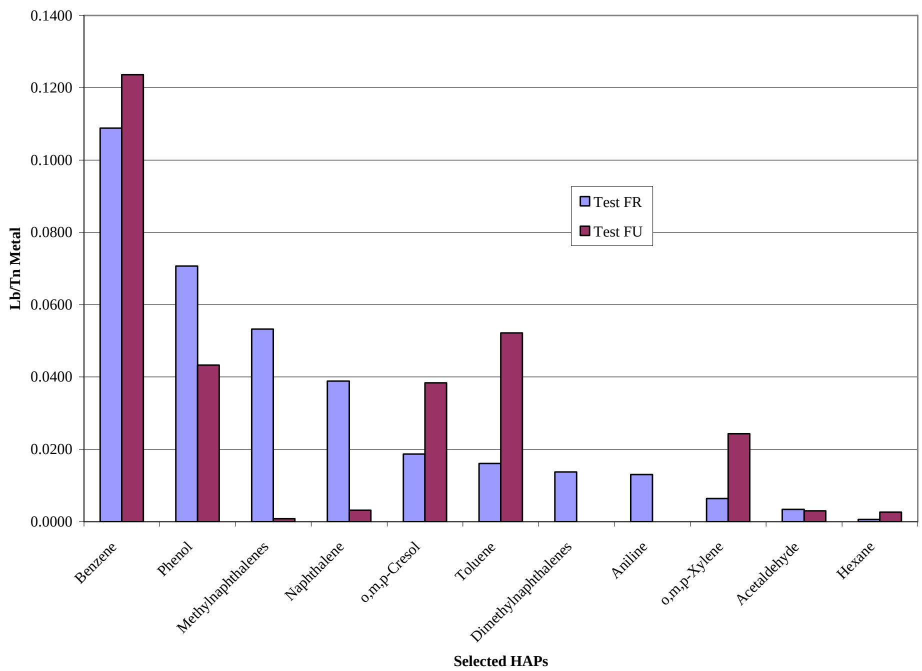
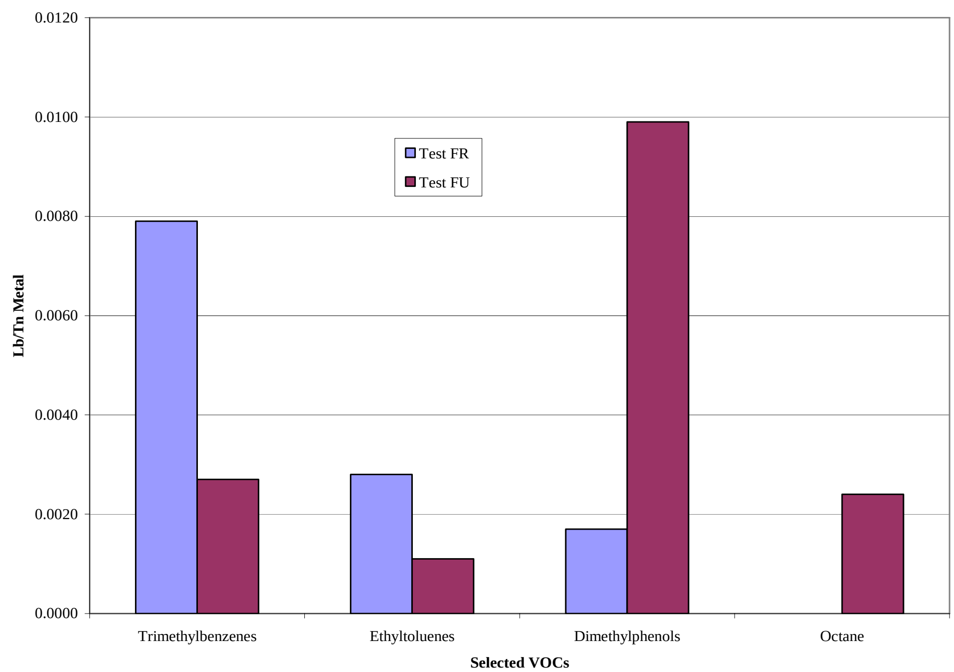


Figure 3-6 Selected VOC Emissions from Test Series FR and FU – Lb/Tn Metal



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4.0 Discussion of Results

The sampling and analytical methodologies were the same for Test Plans FR and FU except for the determination of carbon monoxide and carbon dioxide. These analytes were collected in a Tedlar bag for offsite analysis on Test FR and were determined on-line with NIST traceable monitors for Test FU. The on-line monitors provide significantly more accurate data than the bag samples.

Observation of measured process parameters indicates that the tests were run within an acceptable range. In Tables 3-1 and 3-2, the "% Change from Test FR" emissions values presented in **bold** letters have a greater than 95% probability that the differences in the average values were not the result of variability in the test protocol determined from T-Statistic calculations. Tables showing the T-Statistics calculated are found in Appendix B.

The results of the tests performed for the comparison of Test FR to Test FU show a **30%** reduction in TGOC (THC) as propane, a **6%** increase in HC as hexane, a **14%** reduction in Sum of VOCs, a **15%** reduction in Sum of HAPs, and a **96%** reduction in Sum of POMs when expressed in pounds per ton of metal. Benzene was found to be the largest contributor to the total HAPs and VOCs for both Tests FR and FU and a **14%** increase in benzene was found for Test FU compared to the baseline Test FR. When expressed in pounds per pound of binder, the "% Change from Test FR" show larger reductions overall because shell cores have a higher binder content than cold box cores. The cast weights were virtually the same between the two test series.

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

Analysis for ammonia was performed for Test FU and the average results are shown in Tables 3-1 and 3-2. Detailed results are presented in Table 3-3 as well as Appendix B. Ammonia levels were found to increase consistently over time from what was likely to have resulted from both the mold recycling process and the addition of new shell cores for each consecutive test. It appears that equilibrium had not yet been reached by the end of the twelve test pours. It is possible that due to ammonia's physical and chemical characteristics, some ammonia had been retained in the molds more strongly compared to other analytes resulting in an added effect in the ammonia levels.

Carbon dioxide and methane were detected in the ambient sample for Test FR. No samples were background corrected. Carbon dioxide and carbon monoxide were detected in the ambient samples for test FU and all samples were background corrected.

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

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

APPENDIX A APPROVED TEST PLANS AND SAMPLE PLANS FOR TEST SERIES FR AND FU

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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 mechanically-produced clay, water, coalless 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^{o}F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10^{o}F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes. Cores will be made with Amador-70 silica sand heated to 85-90^{o}F and made in an 80-90^{o}F heated enclosed core machine. No emission sampling will be done during core manufacture.

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 & CO_2 content of the runs will be monitored using instruments specific to those gasses.

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially for each subtest a 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^{o}F. The core shall be maintained at 80-90^{o}F awaiting insertion in the mold. The cores shall be stabilized for 50-120 hours when tested.

Series FR

PCS Core Product Test in Greensand with Ashland 305/904 Core Binder, Inorganic Anti-Veining Compound, & Mechanized Molding Process Instructions

A. Experiment:

1. 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.

2. The molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor.

3. 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.

4. Emissions will be compared to those from the same mold configuration containing cores with no anti-veining compound

B. Materials:

1. Mold sand:

a. Virgin mix of Wexford W450 lake sand, western and southern bentonites in the ratio of 5:2, and potable water per recipe.

2. Core:

a. 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:

a. 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:

a. Class-30 gray cast iron poured at 2630 +/- 10°F.

5. Pattern Spray:

a. 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:
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^{o}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^{o}F.
- **b.** On the main control panel turn the AUTO/MAN switch to MANUAL, turn on main disconnects and MASTER START push button.
- **c.** Fill the Part I and Part II pumps and de-air the lines.
- **d.** Calibrate the Klein mixer.
  - **(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^{o}F.
  - **(3)** Calibrate the binder pumps.
    - **(a)** Adjust the part I dispensing rate by adjusting the part I pump stroke to be 55% of 1.4 % (0.77% BOS) of the average sand batch weight dispensed in D.2.e.2).
    - **(b)** Adjust the machine's inlet air pressure to dispense the binder in about the same time as the sand is dispensed, about 10-15 seconds.
    - **(c)** Record the pressure and dispensing time, and net weight.
    - **(d)** Repeat 3 times to determine the variation in dispensing rate.
    - **(e)** Adjust the part II dispensing rate by adjusting the part II pump stroke to be 45% of 1.4% (.63% BOS) of the average sand rate dispensed in D.2.e.2).
    - **(f)** Repeat D.2.d.3).c), & d) for Part II pump.

(4) Turn off the mixer and replace the mixing bowl skirt.

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 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^{o}F core LOI test method and reported out associated with the core rack shelf it represents. Qualified cores receiving the green **Quality Checked** tag must have **LOI** values between 1.25-1.50%. Individual rows that qualify may have the

Quality Checked tag affixed. Only cores with the green Quality Tag bearing the current test series and dates and signature of the lab technician and core rack/shelf/position on shelf may be taken to the mold assembly area.

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

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^{o}F core LOI test method and reported out associated with the test mold it is to represent.

E. Sand preparation

1. 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 **FRCD7** 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. 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^{o}F at the start of the test run.

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

3. When the emission sampling is completed remove the flask with casting, and recover the sand from the hopper and surrounding floor.
- **a.** Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.
- **b.** Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

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°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.

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

Steven M. Knight
Mgr. Process Engineering

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

TECHNIKON TEST PLAN

>	**CONTRACT NUMBER:**	**1410 TASK NUMBER: 1.1.7 Series: FU**
>	**SITE:**	**Pre-production**
>	**TEST TYPE:**	**Product Test : Pouring, cooling, & shakeout of uncoated Novolac shell step cores.**
>	**METAL TYPE:**	**Class 30 gray iron**
>	**MOLD TYPE:**	**Virgin, no seacoal, greensand with 4-on step-cores, re-cycled after each pour.**
>	**NUMBER OF MOLDS:**	**3 Engineering & conditioning runs + 9 sampling runs twelve (12) runs total.**
>	**CORE TYPE: :**	**Two piece shell step core: Precoated 62 AFS 4-screen round grained silica shell sand containing 3 % (BOS) Technisand XCB630MP low emission (0.9% phenol) Novalac resin with 6%(BOR) concentrated HEXA and 0.05% (BOS) calcium stearate wax.**
>	**CORE COATING:**	**Cores shall be uncoated.**
>	**SAMPLE EVENTS:**	**Nine total runs (9).**
>	**TEST DATE:**	**START: 26 April 2004**
		FINISHED: 1 May 2004

TEST OBJECTIVES:

Measure the airborne pouring, cooling, & shakeout emissions for organic shell step cores in a mechanically-produced clay, water, 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 ^{o}F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10^{o}F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes.

BRIEF OVERVIEW:

The greensand molds will be produced on the mechanically assisted Osborne 716 molding machines for uniformity. 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 emission results will be compared to an internal baseline of uncoated step cores produced in test FT. In addition to a suite of selected emission analytes TGOC, CO, & CO_2 content of the runs will be monitored using instruments specific to those gasses. The in mold resin content may be about 30 % higher than the baseline owing to the nominal 3% content. However, this resin content is offset by the hollow core weight being about 4.5 pounds vs. 7.25 pounds for a solid core.

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. Cores will be made by the University of Northern Iowa using their two-piece step core shell core boxes with the material listed above. The shell cores will be filled with Wedron 420 silica sand and sealed with Foseco Corefix 825A sodium silicate organic free core paste to prevent metal intrusion. The cores shall be maintained at 70-80 ^{o}F awaiting insertion in the mold. The cores shall be stabile having been produced for approximately 30 days when tested. Core weights will be based on the hollow cores as received.

Series FU

PCS Core Product Test in Greensand with Technisand XCB630MP Shell binder & Mechanized Molding

Process Instructions

A. Experiment

1) Measure pouring, cooling, & shakeout emissions from uncoated filled Novolac shell cores 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 additions from test FR.

B. Materials

1) Mold sand

a) Virgin mix of Wexford W450 lake sand, western and southern bentonites in the ratio of 5:2, and potable water per recipe.

2) Core

a) Two piece shell step cores made with pre-coated 62 AFS 4-screen round grained shell sand containing nominally 3% (BOS) Technisand XCB630MP low emission (0.9% phenol) Novalac® resin with 6% (BOR) concentrated HEXA and 0.05% (BOS) calcium stearate wax.

3) Metal

a) Class 30 gray cast iron poured at 2630 +/- 10^{o}F.

4) Pattern Spray

a) 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 Preproduction operating and safety instruction manual.

D. TECHNISAND shell Step Cores:

1) Shell cores will be manufactured for us by the University of Northern Iowa.

2) The sand lab will sample, before the test is started 5 cores. Those cores will be tested for LOI using the standard 1800^{o}F core LOI test method. Qualified cores receiving the green Quality Checked tag must have LOI values between 2.8-3.50 %. If the cores qualify have the Quality Checked tag affixed, if not see the Process engineer for direction. Only cores with the green Quality Tag bearing the current test series and dates and signature of the lab technician may be taken to the mold assembly area.

3) Fill each shell core with Wedron 420 sand, seal with Foseco 825A adhesive and allow to set.

4) 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°F core LOI test method and reported out associated with the test mold it is to represent.

E. Sand preparation

1) Start up batch: make 1, FUCD1.

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°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: FUCD2

a) Add to the sand recovered from poured mold FUCD1 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: FUCD3, & FU001-FU0XX

- **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^{o}F at the start of the test run.

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

3) When the emission sampling is completed remove the flask with casting, and recover the sand from the hopper and surrounding floor.
a) Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.
b) Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

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^{o}F.

- **f)** Slag the furnace and add the balance of the alloys.
- **g)** Raise the temperature of the melt to 2700^{o}F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350^{o}F.
- **h)** Hold the furnace at 2500-2550^{o}F until near ready to tap.
- **i)** When ready to tap raise the temperature to 2700oF 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^{o}F iron into the cold ladle.
- **b)** Carefully pour the metal back to the furnace.
- **c)** Cover the ladle.
- **d)** Reheat the metal to 2780 +/- 20^{o}F.
- **e)** Tap 450 pounds of iron into the ladle while pouring inoculating alloys onto the metal stream near its base.
- **f)** Cover the ladle to conserve heat.
- **g)** Move the ladle to the pour position and wait until the metal temperature reaches 2630 +/- 10^{o}F.
- **h)** Commence pouring keeping the sprue full.
- **i)** Upon completion return the extra metal to the furnace, and cover the ladle.
- **j)** Record the pour temperature and pour time on the heat log

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 casting from mold FU001 compare it to castings from mold FU002.
- **c)** Place the better appearing casting in the first position and the lesser appearing casting in the second position.

d) Repeat this procedure with FU001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than FU001 and the next casting farther down the line is inferior.
e) Repeat this comparison to next neighbors for each casting number.
f) When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
g) Repeat this comparison until all concur with the ranking order.

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

Steven M. Knight
Mgr. Process Engineering

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/24/2004											**FU CONDITIONING - RUN 1**
FU CR-1											
THC		X									
CO, CO2		X									TOTAL

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/24/2004											**FU CONDITIONING - RUN 2**
FU CR-2											
THC		X									
CO, CO2		X									TOTAL

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/24/2004											**FU CONDITIONING - RUN 3**
FU CR-3											
THC		X									
CO, CO2		X									TOTAL

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/25/2004											
RUN 1											
THC	FU001	X									TOTAL
CO, CO2	FU001	X									TOTAL
M-18	FU00101		1						60	1	Carbopak charcoal
M-18	FU00102				1				0		Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00103		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FU00104				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00105		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FU00106				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00107		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FU00108				1				0		DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00109		1						1000	10	Acid Silica Gel (SKC 226-10-06)
NIOSH 6016	FU00110				1				0		Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/25/2004											
RUN 2											
THC	FU002	X									TOTAL
CO, CO2	FU002	X									TOTAL
M-18	FU00201		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00202		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00203		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00204		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00205		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/25/2004											
RUN 3											
THC	FU003	X									TOTAL
CO, CO2	FU003	X									TOTAL
M-18	FU00301		1						60	1	Carbopak charcoal
M-18 MS	FU00302		1						60	2	Carbopak charcoal
M-18 MS	FU00303			1					60	3	Carbopak charcoal
	Excess								60	4	Excess
NIOSH 1500	FU00304		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FU00305			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FU00306		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FU00307			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FU00308		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FU00309			1					1000	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00310		1						1000	11	Acid Silica Gel (SKC 226-10-06)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/26/2004											
RUN 4											
THC	FU004	X									TOTAL
CO, CO2	FU004	X									TOTAL
M-18	FU00401		1						60	1	Carbopak charcoal
M-18	FU00402			1					60	2	Carbopak charcoal
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00403		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00404		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00405		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00406		1						1000	10	Acid Silica Gel (SKC 226-10-06)
NIOSH 6016	FU00407			1					1000	11	Acid Silica Gel (SKC 226-10-06)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/26/2004											
RUN 5											
THC	FU005	X									TOTAL
CO, CO2	FU005	X									TOTAL
M-18	FU00501		1						60	1	Carbopak charcoal
M-18	FU00502					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00503		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00504		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00505		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00506		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/26/2004											
RUN 6											
THC	FU006	X									TOTAL
CO, CO2	FU006	X									TOTAL
M-18	FU00601		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00602		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00603		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00604		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00605		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/27/2004											
RUN 7											
THC	FU007	X									TOTAL
CO, CO2	FU007	X									TOTAL
M-18	FU00701		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00702		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00703		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00704		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00705		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/27/2004											
RUN 8											
THC	FU008	X									TOTAL
CO, CO2	FU008	X									TOTAL
M-18	FU00801		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00802		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00803		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00804		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00805		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/27/2004											
RUN 9											
THC	FU009	X									TOTAL
CO, CO2	FU009	X									TOTAL
M-18	FU00901		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
	Excess								60	4	Excess
NIOSH 1500	FU00902		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FU00903		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FU00904		1						1000	9	DNPH Silica Gel (SKC 226-119)
NIOSH 6016	FU00905		1						1000	10	Acid Silica Gel (SKC 226-10-06)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

APPENDIX B TEST SERIES FR AND FU DETAILED EMISSION RESULTS

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Test Plan FR Individual Baseline Emission Test Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		TGOC as Propane	1.55E-01	1.41E-01	1.57E-01	1.39E-01	1.48E-01	9.38E-03
		HC as Hexane	4.88E-02	5.06E-02	5.04E-02	4.30E-02	4.82E-02	3.54E-03
		Sum of VOCs	5.77E-02	5.84E-02	6.13E-02	I	5.91E-02	1.92E-03
		Sum of HAPs	5.37E-02	5.44E-02	5.82E-02	I	5.54E-02	2.44E-03
		Sum of POMs	1.47E-02	1.71E-02	1.88E-02	I	1.69E-02	2.06E-03
		Individual Organic HAPs						
x		**Benzene**	1.93E-02	1.45E-02	1.85E-02	I	1.74E-02	2.60E-03
x		**Phenol**	1.02E-02	1.25E-02	1.11E-02	I	1.13E-02	1.18E-03
x	z	**Naphthalene**	5.89E-03	6.21E-03	6.50E-03	I	6.20E-03	3.04E-04
x	z	**2-Methylnaphthalene**	4.72E-03	5.70E-03	6.26E-03	I	5.56E-03	7.77E-04
x	z	**1-Methylnaphthalene**	2.48E-03	3.02E-03	3.30E-03	I	2.94E-03	4.17E-04
x		**Toluene**	2.75E-03	2.29E-03	2.66E-03	I	2.57E-03	2.48E-04
x		**o-Cresol**	2.18E-03	2.67E-03	2.56E-03	I	2.47E-03	2.52E-04
x		**Aniline**	1.80E-03	2.26E-03	1.88E-03	2.34E-03	2.07E-03	2.73E-04
x	z	**1,3-Dimethylnaphthalene**	7.16E-04	9.11E-04	1.02E-03	I	8.84E-04	1.56E-04
x		**m,p-Xylene**	8.81E-04	7.83E-04	8.23E-04	I	8.29E-04	4.93E-05
x		**Acetaldehyde**	4.97E-04	5.86E-04	5.20E-04	5.81E-04	5.46E-04	4.43E-05
x		**m,p-Cresol**	4.20E-04	5.58E-04	5.33E-04	I	5.04E-04	7.35E-05
x	z	**1,6-Dimethylnaphthalene**	2.88E-04	3.65E-04	4.14E-04	I	3.55E-04	6.35E-05
x	z	**2,6-Dimethylnaphthalene**	2.56E-04	3.27E-04	3.72E-04	I	3.18E-04	5.86E-05
x	z	**2,7-Dimethylnaphthalene**	2.56E-04	3.27E-04	3.72E-04	I	3.18E-04	5.86E-05
x		**Styrene**	1.64E-04	4.94E-04	1.56E-04	I	2.71E-04	1.93E-04
x		**o-Xylene**	1.97E-04	1.83E-04	1.81E-04	I	1.87E-04	8.82E-06
x	z	**1,2-Dimethylnaphthalene**	1.24E-04	1.65E-04	1.84E-04	I	1.58E-04	3.04E-05
x		**Formaldehyde**	1.61E-04	1.12E-04	1.15E-04	1.10E-04	1.24E-04	2.46E-05
x	z	**2,3-Dimethylnaphthalene**	ND	5.29E-05	3.15E-04	I	1.23E-04	1.69E-04
x		**Biphenyl**	9.52E-05	1.20E-04	1.43E-04	I	1.19E-04	2.39E-05
x		**Ethylbenzene**	1.11E-04	1.27E-04	1.08E-04	I	1.15E-04	9.96E-06
x		**Hexane**	8.21E-05	9.70E-05	9.69E-05	I	9.20E-05	8.58E-06
x		**Propionaldehyde**	3.85E-05	3.63E-05	3.51E-05	3.85E-05	3.71E-05	1.73E-06
x		**2-Butanone**	3.94E-05	4.46E-05	3.45E-05	2.61E-05	3.61E-05	7.85E-06
x	z	**1,5-Dimethylnaphthalene**	ND	ND	9.79E-05	I	3.26E-05	5.65E-05
x	z	**Acenaphthalene**	ND	ND	ND	I	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	I	ND	NA
x		**Dimethylaniline**	ND	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	NA
		Other VOCs						
		1,2,4-Trimethylbenzene	1.04E-03	8.72E-04	7.74E-04	I	8.94E-04	1.33E-04
		Indene	4.72E-04	4.18E-04	4.23E-04	I	4.38E-04	2.95E-05
		Dodecane	4.12E-04	4.40E-04	2.68E-04	I	3.73E-04	9.24E-05
		1,2,3-Trimethylbenzene	4.16E-04	3.56E-04	3.17E-04	I	3.63E-04	5.03E-05
		2,4-Dimethylphenol	2.19E-04	2.95E-04	2.76E-04	I	2.64E-04	3.94E-05
		3-Ethyltoluene	2.86E-04	2.58E-04	2.22E-04	I	2.55E-04	3.22E-05

Test Plan FR Individual Baseline Emission Test Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		Other VOCs						
		1,3-Diethylbenzene	3.95E-04	3.25E-04	ND	I	2.40E-04	2.11E-04
		Undecane	1.89E-04	2.54E-04	2.08E-04	I	2.17E-04	3.34E-05
		2-Ethyltoluene	1.99E-04	1.98E-04	1.97E-04	I	1.98E-04	1.13E-06
		Propylbenzene	1.44E-04	1.85E-04	1.42E-04	I	1.57E-04	2.40E-05
		Tetradecane	1.19E-04	1.47E-04	1.74E-04	I	1.47E-04	2.79E-05
		Butyraldehyde/Methacrolein	9.17E-05	6.72E-05	5.53E-05	6.35E-05	6.94E-05	1.56E-05
		Benzaldehyde	4.86E-05	4.04E-05	3.04E-05	3.34E-05	3.82E-05	8.13E-06
		Heptane	ND	1.06E-04	ND	I	3.54E-05	6.14E-05
		Cyclohexane	ND	ND	ND	I	ND	NA
		Decane	ND	ND	ND	I	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	NA
		Indan	ND	ND	ND	I	ND	NA
		Nonane	ND	ND	ND	I	ND	NA
		Octane	ND	ND	ND	I	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	NA
		Other Analytes						
		Acetone	2.78E-04	3.43E-04	3.00E-04	2.87E-04	3.02E-04	2.87E-05
		Carbon Dioxide	2.97E+00	NA	3.13E+00	2.89E+00	3.00E+00	1.22E-01
		Methane	3.52E-03	NA	6.18E-03	5.62E-03	5.11E-03	1.40E-03
		Carbon Monoxide	ND	NA	ND	ND	ND	NA
		Ethane	ND	NA	ND	ND	ND	NA
		Propane	ND	NA	ND	ND	ND	NA
		Isobutane	ND	NA	ND	ND	ND	NA
		Butane	ND	NA	ND	ND	ND	NA
		Neopentane	ND	NA	ND	ND	ND	NA
		Isopentane	ND	NA	ND	ND	ND	NA
		Pentane	ND	NA	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

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

Test Plan FR Individual Baseline Emission Test Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		TGOC as Propane	9.52E-01	9.14E-01	9.71E-01	8.66E-01	9.26E-01	4.67E-02
		HC as Hexane	2.99E-01	3.28E-01	3.12E-01	2.68E-01	3.02E-01	2.53E-02
		Sum of VOCs	3.54E-01	3.78E-01	3.80E-01	I	3.71E-01	1.47E-02
		Sum of HAPs	3.29E-01	3.52E-01	3.61E-01	I	3.47E-01	1.65E-02
		Sum of POMs	9.03E-02	1.11E-01	1.17E-01	I	1.06E-01	1.38E-02
		Individual Organic HAPs						
x		**Benzene**	1.18E-01	9.36E-02	1.14E-01	I	1.09E-01	1.33E-02
x		**Phenol**	6.24E-02	8.11E-02	6.86E-02	I	7.07E-02	9.53E-03
x	z	**Naphthalene**	3.61E-02	4.02E-02	4.03E-02	I	3.89E-02	2.39E-03
x	z	**2-Methylnaphthalene**	2.90E-02	3.69E-02	3.88E-02	I	3.49E-02	5.22E-03
x	z	**1-Methylnaphthalene**	1.52E-02	1.95E-02	2.05E-02	I	1.84E-02	2.80E-03
x		**Toluene**	1.69E-02	1.48E-02	1.65E-02	I	1.61E-02	1.10E-03
x		**o-Cresol**	1.34E-02	1.73E-02	1.58E-02	I	1.55E-02	1.96E-03
x		**Aniline**	1.10E-02	1.47E-02	1.16E-02	1.46E-02	1.30E-02	1.93E-03
x	z	**1,3-Dimethylnaphthalene**	4.39E-03	5.90E-03	6.35E-03	I	5.55E-03	1.03E-03
x		**m,p-Xylene**	5.40E-03	5.07E-03	5.10E-03	I	5.19E-03	1.82E-04
x		**Acetaldehyde**	3.04E-03	3.79E-03	3.22E-03	3.62E-03	3.42E-03	3.46E-04
x		**m,p-Cresol**	2.58E-03	3.62E-03	3.30E-03	I	3.16E-03	5.34E-04
x	z	**1,6-Dimethylnaphthalene**	1.76E-03	2.36E-03	2.56E-03	I	2.23E-03	4.16E-04
x	z	**2,6-Dimethylnaphthalene**	1.57E-03	2.12E-03	2.30E-03	I	2.00E-03	3.83E-04
x	z	**2,7-Dimethylnaphthalene**	1.57E-03	2.12E-03	2.30E-03	I	2.00E-03	3.83E-04
x		**Styrene**	1.01E-03	3.20E-03	9.67E-04	I	1.72E-03	1.28E-03
x		**o-Xylene**	1.21E-03	1.18E-03	1.12E-03	I	1.17E-03	4.46E-05
x	z	**1,2-Dimethylnaphthalene**	7.61E-04	1.07E-03	1.14E-03	I	9.89E-04	2.01E-04
x		**Formaldehyde**	9.87E-04	7.23E-04	7.13E-04	6.84E-04	7.77E-04	1.41E-04
x	z	**2,3-Dimethylnaphthalene**	ND	3.43E-04	1.95E-03	I	7.64E-04	1.04E-03
x		**Biphenyl**	5.84E-04	7.78E-04	8.87E-04	I	7.50E-04	1.53E-04
x		**Ethylbenzene**	6.81E-04	8.20E-04	6.69E-04	I	7.23E-04	8.39E-05
x		**Hexane**	5.03E-04	6.28E-04	6.01E-04	I	5.77E-04	6.57E-05
x		**Propionaldehyde**	2.36E-04	2.35E-04	2.17E-04	2.40E-04	2.32E-04	1.01E-05
x		**2-Butanone**	2.41E-04	2.89E-04	2.13E-04	1.63E-04	2.27E-04	5.27E-05
x	z	**1,5-Dimethylnaphthalene**	ND	ND	6.06E-04	I	2.02E-04	3.50E-04
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**Acenaphthalene**	ND	ND	ND	I	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	NA
		Other VOCs						
		1,2,4-Trimethylbenzene	6.35E-03	5.65E-03	4.79E-03	I	5.60E-03	7.81E-04
		Indene	2.89E-03	2.71E-03	2.62E-03	I	2.74E-03	1.38E-04
		Dodecane	2.52E-03	2.85E-03	1.66E-03	I	2.34E-03	6.16E-04
		1,2,3-Trimethylbenzene	2.55E-03	2.31E-03	1.96E-03	I	2.27E-03	2.97E-04
		2,4-Dimethylphenol	1.34E-03	1.91E-03	1.71E-03	I	1.66E-03	2.87E-04
		3-Ethyltoluene	1.75E-03	1.67E-03	1.37E-03	I	1.60E-03	1.99E-04

Test Plan FR Individual Baseline Emission Test Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		Other VOCs						
		1,3-Diethylbenzene	2.42E-03	2.11E-03	ND	I	1.51E-03	1.32E-03
		Undecane	1.16E-03	1.64E-03	1.29E-03	I	1.36E-03	2.52E-04
		2-Ethyltoluene	1.22E-03	1.28E-03	1.22E-03	I	1.24E-03	3.66E-05
		n-Propylbenzene	8.81E-04	1.20E-03	8.81E-04	I	9.86E-04	1.81E-04
		Tetradecane	7.27E-04	9.50E-04	1.08E-03	I	9.19E-04	1.79E-04
		Butyraldehyde/Methacrolein	5.61E-04	4.35E-04	3.43E-04	3.95E-04	4.34E-04	9.31E-05
		Benzaldehyde	2.98E-04	2.62E-04	1.88E-04	2.08E-04	2.39E-04	5.01E-05
		Heptane	ND	6.89E-04	ND	I	2.30E-04	3.98E-04
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	NA
		Cyclohexane	ND	ND	ND	I	ND	NA
		Decane	ND	ND	ND	I	ND	NA
		Indan	ND	ND	ND	I	ND	NA
		Nonane	ND	ND	ND	I	ND	NA
		Octane	ND	ND	ND	I	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	NA
		Other Analytes						
		Acetone	1.70E-03	2.22E-03	1.86E-03	1.79E-03	1.89E-03	2.27E-04
		Carbon Dioxide	1.82E+01	NA	1.94E+01	1.80E+01	1.85E+01	7.38E-01
		Methane	2.16E-02	NA	3.83E-02	3.50E-02	3.16E-02	8.87E-03
		Carbon Monoxide	ND	NA	ND	ND	ND	NA
		Ethane	ND	NA	ND	ND	ND	NA
		Propane	ND	NA	ND	ND	ND	NA
		Isobutane	ND	NA	ND	ND	ND	NA
		Butane	ND	NA	ND	ND	ND	NA
		Neopentane	ND	NA	ND	ND	ND	NA
		Isopentane	ND	NA	ND	ND	ND	NA
		Pentane	ND	NA	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

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

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	5/25/04	5/25/04	5/25/04	5/26/04	5/26/04	5/26/04	5/27/04	5/27/04	5/27/04		
		TGOC as Propane	5.99E-02	I	6.38E-02	6.10E-02	6.75E-02	I	5.70E-02	6.07E-02	6.34E-02	6.19E-02	3.35E-03
		HC as Hexane	2.61E-02	I	3.18E-02	2.97E-02	3.35E-02	I	2.82E-02	3.03E-02	3.29E-02	3.04E-02	2.65E-03
		Sum of VOCs	2.92E-02	I	3.52E-02	2.90E-02	2.98E-02	I	2.87E-02	2.98E-02	3.11E-02	3.04E-02	2.26E-03
		Sum of HAPs	2.73E-02	I	3.28E-02	2.72E-02	2.71E-02	I	2.66E-02	2.73E-02	2.82E-02	2.81E-02	2.14E-03
		Sum of POMs	3.56E-04	I	4.29E-04	3.82E-04	4.19E-04	I	3.56E-04	3.64E-04	3.78E-04	3.83E-04	2.94E-05
			Individual Organic HAPs										
x		**Benzene**	1.35E-02	I	1.61E-02	1.33E-02	8.89E-03	I	1.15E-02	1.05E-02	8.82E-03	1.18E-02	2.66E-03
x		**Toluene**	4.25E-03	I	5.34E-03	4.43E-03	5.51E-03	I	4.73E-03	4.93E-03	5.59E-03	4.97E-03	5.29E-04
x		**Phenol**	3.42E-03	I	3.86E-03	3.32E-03	4.80E-03	I	3.79E-03	4.46E-03	5.18E-03	4.12E-03	7.08E-04
x		**o-Cresol**	2.47E-03	I	3.00E-03	2.34E-03	3.49E-03	I	2.50E-03	3.03E-03	3.68E-03	2.93E-03	5.22E-04
x		**m,p-Xylene**	1.71E-03	I	2.22E-03	1.81E-03	2.22E-03	I	1.94E-03	2.02E-03	2.32E-03	2.03E-03	2.27E-04
x		**m,p-Cresol**	5.32E-04	I	6.41E-04	5.26E-04	7.91E-04	I	6.01E-04	7.68E-04	9.64E-04	6.89E-04	1.60E-04
x	z	**Naphthalene**	2.92E-04	I	3.57E-04	3.09E-04	3.33E-04	I	2.76E-04	2.89E-04	3.06E-04	3.09E-04	2.79E-05
x		**Acetaldehyde**	2.65E-04	I	2.87E-04	2.70E-04	2.91E-04	I	2.98E-04	3.09E-04	3.08E-04	2.90E-04	1.72E-05
x		**o-Xylene**	2.40E-04	I	2.95E-04	2.43E-04	3.16E-04	I	2.75E-04	2.83E-04	3.15E-04	2.81E-04	3.10E-05
x		**Hexane**	2.34E-04	I	2.45E-04	2.46E-04	I	I	2.57E-04	2.44E-04	2.54E-04	2.47E-04	8.09E-06
x		**Ethylbenzene**	1.21E-04	I	1.52E-04	1.25E-04	1.66E-04	I	1.43E-04	1.47E-04	1.67E-04	1.46E-04	1.80E-05
x		**Formaldehyde**	1.05E-04	I	1.35E-04	1.13E-04	1.16E-04	I	1.29E-04	1.04E-04	1.02E-04	1.15E-04	1.27E-05
x		**Styrene**	5.12E-05	I	7.26E-05	5.13E-05	6.94E-05	I	5.62E-05	6.01E-05	6.68E-05	6.11E-05	8.69E-06
x	z	**2-Methylnaphthalene**	3.94E-05	I	4.34E-05	4.46E-05	5.33E-05	I	5.00E-05	4.74E-05	4.17E-05	4.57E-05	4.84E-06
x		**Propionaldehyde**	2.37E-05	I	3.22E-05	2.21E-05	3.27E-05	I	2.87E-05	3.22E-05	3.43E-05	2.94E-05	4.76E-06
x	z	**1-Methylnaphthalene**	2.48E-05	I	2.85E-05	2.80E-05	3.24E-05	I	3.00E-05	2.82E-05	3.02E-05	2.89E-05	2.37E-06
x		**2-Butanone**	1.12E-05	I	1.22E-05	1.47E-05	1.66E-05	I	1.40E-05	2.13E-05	2.47E-05	1.64E-05	4.93E-06
x	z	**Acenaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		**Biphenyl**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,2-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,3-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	5/25/04	5/25/04	5/25/04	5/26/04	5/26/04	5/26/04	5/27/04	5/27/04	5/27/04		
x	z	**2,7-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		**Aniline**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		**Dimethylaniline**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		**Acrolein**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
			Other VOCs										
		2,6-Dimethylphenol	5.46E-04	I	5.83E-04	ND	7.11E-04	I	5.09E-04	6.68E-04	8.16E-04	5.48E-04	2.63E-04
		2,4-Dimethylphenol	2.84E-04	I	3.50E-04	2.25E-04	4.68E-04	I	3.41E-04	5.16E-04	5.97E-04	3.97E-04	1.34E-04
		Octane	2.12E-04	I	2.33E-04	2.10E-04	2.67E-04	I	2.24E-04	2.33E-04	2.53E-04	2.33E-04	2.07E-05
		1,2,4-Trimethylbenzene	1.82E-04	I	2.40E-04	1.98E-04	2.48E-04	I	2.13E-04	2.22E-04	2.45E-04	2.21E-04	2.50E-05
		Heptane	2.00E-04	I	2.05E-04	1.87E-04	2.44E-04	I	2.00E-04	1.99E-04	2.15E-04	2.07E-04	1.82E-05
		Nonane	1.57E-04	I	1.72E-04	1.53E-04	1.96E-04	I	1.66E-04	1.67E-04	1.89E-04	1.72E-04	1.58E-05
		Decane	1.21E-04	I	1.37E-04	1.23E-04	1.53E-04	I	1.32E-04	1.32E-04	1.54E-04	1.36E-04	1.32E-05
		Dodecane	9.35E-05	I	1.17E-04	9.82E-05	1.23E-04	I	1.01E-04	1.40E-04	1.30E-04	1.15E-04	1.74E-05
		3-Ethyltoluene	I	I	6.46E-05	5.39E-05	6.59E-05	I	5.90E-05	5.90E-05	6.57E-05	6.14E-05	4.85E-06
		2-Ethyltoluene	3.95E-05	I	4.85E-05	4.29E-05	5.09E-05	I	4.95E-05	5.06E-05	5.64E-05	4.83E-05	5.57E-06
		Undecane	ND	I	ND	3.31E-04	ND	I	ND	ND	ND	4.73E-05	1.25E-04
		Butyraldehyde/Methacrolein	3.50E-05	I	4.16E-05	3.89E-05	4.49E-05	I	3.66E-05	4.62E-05	4.86E-05	4.17E-05	5.11E-06
		1,2,3-Trimethylbenzene	2.10E-05	I	2.90E-05	2.85E-05	4.24E-05	I	4.10E-05	3.64E-05	3.94E-05	3.40E-05	7.95E-06
		Benzaldehyde	I	I	3.11E-05	2.77E-05	3.30E-05	I	2.72E-05	3.07E-05	3.43E-05	3.07E-05	2.82E-06
		Indene	ND	I	9.84E-05	8.91E-05	ND	I	ND	ND	ND	2.68E-05	4.58E-05
		o,m,p-Tolualdehyde	ND	I	7.32E-05	ND	ND	I	4.18E-05	ND	ND	1.64E-05	2.95E-05
		Tetradecane	ND	I	ND	3.22E-05	ND	I	ND	ND	5.64E-05	1.27E-05	2.27E-05
		Pentanal	ND	I	ND	ND	ND	I	ND	1.19E-05	I	1.99E-06	4.87E-06
		Cyclohexane	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		1,3-Diethylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Indan	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Propylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Hexaldehyde	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	**5/25/04**	**5/25/04**	**5/25/04**	**5/26/04**	**5/26/04**	**5/26/04**	**5/27/04**	**5/27/04**	**5/27/04**		
			Other Analytes										
		Acetone	9.19E-05	I	1.03E-04	1.86E-04	1.30E-04	I	1.04E-04	1.13E-04	1.19E-04	1.21E-04	3.12E-05
		Ammonia	2.41E-04	I	5.10E-04	6.16E-04	1.14E-03	I	9.24E-04	1.39E-03	1.84E-03	9.51E-04	5.51E-04
		Carbon Dioxide	4.58E-01	I	4.48E-01	3.59E-01	3.32E-01	I	4.71E-01	4.43E-01	5.01E-01	4.30E-01	6.15E-02
		Carbon Monoxide	2.46E-01	I	2.36E-01	2.21E-01	2.44E-01	I	2.35E-01	2.33E-01	2.59E-01	2.39E-01	1.19E-02

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

All "Other Analytes" were not included in the Sum of HAPs or VOCs.

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	**5/25/04**	**5/25/04**	**5/25/04**	**5/26/04**	**5/26/04**	**5/26/04**	**5/27/04**	**5/27/04**	**5/27/04**		
		TGOC as Propane	6.22E-01	I	6.47E-01	6.62E-01	7.16E-01	I	5.86E-01	6.45E-01	6.75E-01	6.50E-01	4.09E-02
		HC as Hexane	2.71E-01	I	3.23E-01	3.22E-01	3.56E-01	I	2.90E-01	3.22E-01	3.51E-01	3.19E-01	3.03E-02
		Sum of VOCs	3.03E-01	I	3.57E-01	3.16E-01	3.16E-01	I	2.95E-01	3.16E-01	3.31E-01	3.19E-01	2.01E-02
		Sum of HAPs	2.84E-01	I	3.32E-01	2.97E-01	2.88E-01	I	2.73E-01	2.90E-01	3.00E-01	2.95E-01	1.88E-02
		Sum of POMs	3.70E-03	I	4.35E-03	4.14E-03	4.44E-03	I	3.66E-03	3.87E-03	4.02E-03	4.03E-03	3.04E-04
			Individual Organic HAPs										
x		**Benzene**	1.41E-01	I	1.63E-01	1.44E-01	9.43E-02	I	1.18E-01	1.12E-01	9.39E-02	1.24E-01	2.63E-02
x		**Toluene**	4.41E-02	I	5.41E-02	4.81E-02	5.85E-02	I	4.86E-02	5.23E-02	5.95E-02	5.22E-02	5.65E-03
x		**Phenol**	3.55E-02	I	3.91E-02	3.60E-02	5.09E-02	I	3.90E-02	4.73E-02	5.52E-02	4.33E-02	7.80E-03
x		**o-Cresol**	2.56E-02	I	3.04E-02	2.78E-02	3.70E-02	I	2.57E-02	3.22E-02	3.92E-02	3.11E-02	5.34E-03
x		**m,p-Xylene**	1.78E-02	I	2.25E-02	1.97E-02	2.35E-02	I	1.99E-02	2.14E-02	2.47E-02	2.14E-02	2.40E-03
x		**m,p-Cresol**	5.52E-03	I	6.49E-03	5.70E-03	8.40E-03	I	6.19E-03	8.15E-03	1.03E-02	7.25E-03	1.75E-03
x	z	**Naphthalene**	3.03E-03	I	3.62E-03	3.35E-03	3.53E-03	I	2.84E-03	3.07E-03	3.26E-03	3.24E-03	2.82E-04
x		**Acetaldehyde**	2.75E-03	I	2.91E-03	2.93E-03	3.09E-03	I	3.06E-03	3.28E-03	3.28E-03	3.04E-03	1.96E-04
x		**o-Xylene**	2.50E-03	I	2.99E-03	2.63E-03	3.36E-03	I	2.83E-03	3.00E-03	3.36E-03	2.95E-03	3.31E-04
x		**Hexane**	2.43E-03	I	2.49E-03	2.67E-03		I	2.64E-03	2.59E-03	2.71E-03	2.59E-03	1.08E-04
x		**Ethylbenzene**	1.25E-03	I	1.54E-03	1.35E-03	1.76E-03	I	1.47E-03	1.57E-03	1.77E-03	1.53E-03	1.93E-04
x		**Formaldehyde**	1.09E-03	I	1.37E-03	1.23E-03	1.23E-03	I	1.32E-03	1.10E-03	1.09E-03	1.20E-03	1.14E-04
x		**Styrene**	5.32E-04	I	7.36E-04	5.56E-04	7.36E-04	I	5.78E-04	6.38E-04	7.12E-04	6.41E-04	8.77E-05
x	z	**2-Methylnaphthalene**	4.09E-04	I	4.40E-04	4.84E-04	5.65E-04	I	5.14E-04	5.03E-04	4.45E-04	4.80E-04	5.31E-05
x		**Propionaldehyde**	2.46E-04	I	3.26E-04	2.40E-04	3.47E-04	I	2.95E-04	3.42E-04	3.65E-04	3.09E-04	4.97E-05
x	z	**1-Methylnaphthalene**	2.57E-04	I	2.89E-04	3.04E-04	3.44E-04	I	3.09E-04	2.99E-04	3.21E-04	3.03E-04	2.70E-05
x		**2-Butanone**	1.17E-04	I	1.24E-04	1.60E-04	1.77E-04	I	1.44E-04	2.27E-04	2.63E-04	1.73E-04	5.41E-05
x	z	**1,2-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,3-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	5/25/04	5/25/04	5/25/04	5/26/04	5/26/04	5/26/04	5/27/04	5/27/04	5/27/04		
x	z	2,7-Dimethylnaphthalene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x	z	Acenaphthalene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		Biphenyl	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		Aniline	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		N,N-Dimethylaniline	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
x		Acrolein	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
			Other VOCs										
		2,6-Dimethylphenol	5.67E-03	I	5.92E-03	0.00E+00	7.54E-03	I	5.23E-03	7.09E-03	8.69E-03	5.73E-03	2.80E-03
		2,4-Dimethylphenol	2.95E-03	I	3.54E-03	2.44E-03	4.97E-03	I	3.50E-03	5.47E-03	6.36E-03	4.18E-03	1.44E-03
		Octane	2.20E-03	I	2.36E-03	2.28E-03	2.83E-03	I	2.30E-03	2.47E-03	2.70E-03	2.45E-03	2.33E-04
		1,2,4-Trimethylbenzene	1.89E-03	I	2.44E-03	2.15E-03	2.63E-03	I	2.19E-03	2.36E-03	2.61E-03	2.32E-03	2.65E-04
		Heptane	2.08E-03	I	2.08E-03	2.02E-03	2.59E-03	I	2.06E-03	2.11E-03	2.29E-03	2.17E-03	2.01E-04
		Nonane	1.63E-03	I	1.75E-03	1.66E-03	2.08E-03	I	1.71E-03	1.78E-03	2.01E-03	1.80E-03	1.75E-04
		Decane	1.25E-03	I	1.39E-03	1.34E-03	1.62E-03	I	1.35E-03	1.40E-03	1.64E-03	1.43E-03	1.47E-04
		Dodecane	9.71E-04	I	1.19E-03	1.07E-03	1.30E-03	I	1.04E-03	1.48E-03	1.38E-03	1.20E-03	1.91E-04
		3-Ethyltoluene	I	I	6.55E-04	5.85E-04	7.00E-04	I	6.07E-04	6.26E-04	7.00E-04	6.45E-04	4.80E-05
		2-Ethyltoluene	4.10E-04	I	4.92E-04	4.65E-04	5.40E-04	I	5.09E-04	5.37E-04	6.01E-04	5.08E-04	6.08E-05
		Butyraldehyde/Methacrolien	3.64E-04	I	4.22E-04	4.22E-04	4.77E-04	I	3.76E-04	4.90E-04	5.17E-04	4.38E-04	5.83E-05
		Undecane	ND	I	ND	2.78E-03	ND	I	ND	ND	ND	3.98E-04	1.05E-03
		1,2,3-Trimethylbenzene	2.18E-04	I	2.94E-04	3.09E-04	4.50E-04	I	4.21E-04	3.87E-04	4.20E-04	3.57E-04	8.49E-05
		Benzaldehyde	I	I	3.16E-04	3.00E-04	3.50E-04	I	2.80E-04	3.25E-04	3.65E-04	3.23E-04	3.16E-05
		Indene	ND	I	9.97E-04	9.66E-04	ND	I	ND	ND	ND	2.81E-04	4.79E-04
		o,m,p-Tolualdehyde	ND	I	7.42E-04	ND	ND	I	4.30E-04	ND	ND	1.67E-04	3.00E-04
		Tetradecane	ND	I	ND	3.49E-04	ND	I	ND	ND	6.01E-04	1.36E-04	2.43E-04
		Pentanal	ND	I	ND	ND	ND	I	ND	1.27E-04	I	2.11E-05	5.17E-05
		1,3,5-Trimethylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		1,3-Diethylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Cyclohexane	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Indan	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		n-Propylbenzene	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA
		Hexaldehyde	ND	I	ND	ND	ND	I	ND	ND	ND	ND	NA

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

HAPs	VOCs	COMPOUND / SAMPLE NUMBER	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	Average	STDEV
		Test Dates	5/25/04	5/25/04	5/25/04	5/26/04	5/26/04	5/26/04	5/27/04	5/27/04	5/27/04		
			Other Analytes										
		Acetone	9.54E-04	I	1.05E-03	I	1.38E-03	I	1.07E-03	1.20E-03	1.27E-03	1.15E-03	1.58E-04
		Ammonia	2.50E-03	I	5.17E-03	6.68E-03	1.21E-02	I	9.51E-03	1.47E-02	1.96E-02	1.00E-02	5.90E-03
		Carbon Dioxide	4.76E+00	I	4.54E+00	3.89E+00	3.53E+00	I	4.84E+00	4.71E+00	5.34E+00	4.52E+00	6.12E-01
		Carbon Monoxide	2.55E+00	I	2.39E+00	2.40E+00	2.59E+00	I	2.42E+00	2.47E+00	2.76E+00	2.51E+00	1.33E-01

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

All "Other Analytes" were not included in the Sum of HAPs or VOCs.

Test FR Quantitation Limits – 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
Acetone	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 FR Quantitation Limits – 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
Acetone	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 FU Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	1.13E-05
1,2,4-Trimethylbenzene	1.13E-05
1,3,5-Trimethylbenzene	1.13E-05
1,3-Dimethylnaphthalene	1.13E-05
1-Methylnaphthalene	1.13E-05
2-Ethyltoluene	1.13E-05
2-Methylnaphthalene	1.13E-05
Benzene	1.13E-05
Ethylbenzene	1.13E-05
Hexane	1.13E-05
m,p-Xylene	1.13E-05
Naphthalene	1.13E-05
o-Xylene	1.13E-05
Styrene	1.13E-05
Toluene	1.13E-05
Undecane	1.13E-05
1,2-Dimethylnaphthalene	5.64E-05
1,3-Diethylbenzene	5.64E-05
1,5-Dimethylnaphthalene	5.64E-05
1,6-Dimethylnaphthalene	5.64E-05

Analytes	Lb/Lb Binder
1,8-Dimethylnaphthalene	5.64E-05
2,3,5-Trimethylnaphthalene	5.64E-05
2,3-Dimethylnaphthalene	5.64E-05
2,4-Dimethylphenol	5.64E-05
2,6-Dimethylnaphthalene	5.64E-05
2,6-Dimethylphenol	5.64E-05
2,7- Dimethylnaphthalene	5.64E-05
3-Ethyltoluene	5.64E-05
Acenaphthalene	5.64E-05
Biphenyl	5.64E-05
Cyclohexane	5.64E-05
Decane	5.64E-05
Dodecane	5.64E-05
Heptane	5.64E-05
Indan	5.64E-05
Indene	5.64E-05
m,p-Cresol	5.64E-05
Nonane	5.64E-05
o-Cresol	5.64E-05
Octane	5.64E-05

Analytes	Lb/Lb Binder
Phenol	5.64E-05
Propylbenzene	5.64E-05
Tetradecane	5.64E-05
HC as Hexane	2.90E-04
2-Butanone (MEK)	1.03E-05
Acetaldehyde	1.03E-05
Acetone	1.03E-05
Acrolein	1.03E-05
Benzaldehyde	1.03E-05
Butyraldehyde	1.03E-05
Crotonaldehyde	1.03E-05
Formaldehyde	1.03E-05
Hexaldehyde	1.03E-05
Butyraldehyde/Methacrolein	1.72E-05
o,m,p-Tolualdehyde	2.75E-05
Pentanal (Valeraldehyde)	1.03E-05
Propionaldehyde (Propanal)	1.03E-05
Carbon Monoxide	2.69E-03
Carbon Dioxide	4.23E-03

Test FU Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.19E-04
1,2,4-Trimethylbenzene	1.19E-04
1,3,5-Trimethylbenzene	1.19E-04
1,3-Dimethylnaphthalene	1.19E-04
1-Methylnaphthalene	1.19E-04
2-Ethyltoluene	1.19E-04
2-Methylnaphthalene	1.19E-04
Benzene	1.19E-04
Ethylbenzene	1.19E-04
Hexane	1.19E-04
m,p-Xylene	1.19E-04
Naphthalene	1.19E-04
o-Xylene	1.19E-04
Styrene	1.19E-04
Toluene	1.19E-04
Undecane	1.19E-04
1,2-Dimethylnaphthalene	5.93E-04
1,3-Diethylbenzene	5.93E-04
1,5-Dimethylnaphthalene	5.93E-04
1,6-Dimethylnaphthalene	5.93E-04

Analytes	Lb/Tn Metal
1,8-Dimethylnaphthalene	5.93E-04
2,3,5-Trimethylnaphthalene	5.93E-04
2,3-Dimethylnaphthalene	5.93E-04
2,4-Dimethylphenol	5.93E-04
2,6-Dimethylnaphthalene	5.93E-04
2,6-Dimethylphenol	5.93E-04
2,7- Dimethylnaphthalene	5.93E-04
3-Ethyltoluene	5.93E-04
Acenaphthalene	5.93E-04
Biphenyl	5.93E-04
Cyclohexane	5.93E-04
Decane	5.93E-04
Dodecane	5.93E-04
Heptane	5.93E-04
Indan	5.93E-04
Indene	5.93E-04
m,p-Cresol	5.93E-04
Nonane	5.93E-04
o-Cresol	5.93E-04
Octane	5.93E-04

Analytes	Lb/Tn Metal
Phenol	5.93E-04
Propylbenzene	5.93E-04
Tetradecane	5.93E-04
HC as Hexane	3.05E-03
2-Butanone (MEK)	1.08E-04
Acetaldehyde	1.08E-04
Acetone	1.08E-04
Acrolein	1.08E-04
Benzaldehyde	1.08E-04
Butyraldehyde	1.08E-04
Crotonaldehyde	1.08E-04
Formaldehyde	1.08E-04
Hexaldehyde	1.08E-04
Butyraldehyde/Methacrolein	1.81E-04
o,m,p-Tolualdehyde	2.89E-04
Pentanal (Valeraldehyde)	1.08E-04
Propionaldehyde (Propanal)	1.08E-04
Carbon Monoxide	2.83E-02
Carbon Dioxide	4.44E-02

Test Plan FR and FU T-Statistics – Lb/Lb Binder

Analytes	Test FR (Lb/Lb Binder)	Test FU (Lb/Lb Binder)	T-Statistic
TGOC as Propane	0.1480	0.0619	17.7
HC as Hexane	0.0482	0.0304	8.9
Sum of VOCs	0.0591	0.0304	22.3
Sum of HAPs	0.0554	0.0281	19.0
Sum of POMs	0.0169	0.0004	15.7
Individual Organic HAPs			
Benzene	0.0174	0.0118	3.4
Phenol	0.0113	0.0041	11.0
Methylnaphthalenes	0.0085	0.0001	14.0
Naphthalene	0.0062	0.0003	39.3
o,m,p-Cresol	0.0030	0.0036	-2.0
Toluene	0.0026	0.0050	-11.2
Aniline	0.0022	ND	14.0
Dimethylnaphthalenes	0.0022	ND	7.3
o,m,p-Xylene	0.0010	0.0023	-10.5
Acetaldehyde	0.0005	0.0003	NA
Hexane	0.0001	0.0002	NA
Other VOCs			
Trimethylbenzenes	0.0013	0.0003	10.0
Ethyltoluenes	0.0005	0.0001	NA
Dimethylphenols	0.0003	0.0009	-4.0
Octane	ND	0.0002	NA
Other Analytes			
Ammonia*	NT	0.0010	NA
Carbon Dioxide	2.996	0.4305	39.4
Carbon Monoxide	ND	0.2391	-53.2

ND: Non Detect; NA: Not Applicable

Individual results constitute >95% of mass of all detected VOCs.

***See Table 3-3**

Test Plan FR and FU T-Statistics – Lb/Tn Metal

Analytes	Test FR (Lb/Tn Metal)	Test FU (Lb/Tn Metal)	T-Statistic
TGOC as Propane	0.9259	0.6504	9.8
HC as Hexane	0.3016	0.3190	-1.0
Sum of VOCs	0.3705	0.3193	4.8
Sum of HAPs	0.3474	0.2949	4.8
Sum of POMs	0.1059	0.0040	14.8
Individual Organic HAPs			
Benzene	0.1088	0.1236	-1.2
Phenol	0.0707	0.0433	4.9
Methylnaphthalenes	0.0533	0.0008	13.1
Naphthalene	0.0389	0.0032	29.6
o,m,p-Cresol	0.0187	0.0384	-6.7
Toluene	0.0161	0.0522	-16.5
Dimethylnaphthalenes	0.0137	ND	7.6
Aniline	0.0130	ND	13.7
o,m,p-Xylene	0.0064	0.0243	-17.5
Acetaldehyde	0.0034	0.0030	2.4
Hexane	0.0006	0.0026	-31.9
Other VOCs			
Trimethylbenzenes	0.0079	0.0027	9.3
Ethyltoluenes	0.0028	0.0011	11.2
Dimethylphenols	0.0017	0.0099	-5.3
Octane	ND	0.0024	-31.7
Other Analytes			
Ammonia*	NT	0.0100	NA
Carbon Dioxide	18.53	4.516	32.2
Carbon Monoxide	ND	2.512	-49.9

ND: Non Detect; NA: Not Applicable

Individual results constitute >95% of mass of all detected VOCs.

***See Table 3-3**

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APPENDIX C TEST SERIES FR AND FU DETAILED PROCESS DATA

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Test FR Detailed Process Data

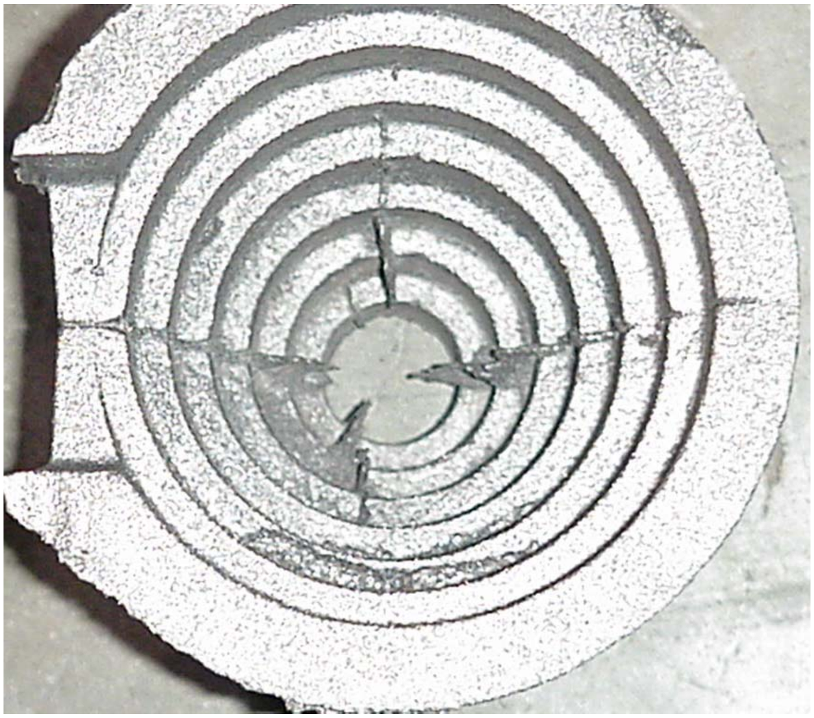
Greensand PCS															
Test Dates	1/15/2004	1/15/2004	1/16/2004	1/16/2004	Averages	1/21/2004	1/21/2004	1/22/2004	1/22/2004	Averages	1/28/2004	1/28/2004	1/29/2004	1/29/2004	Averages
Emissions Sample # / Production Sample #	FR 01	FR 02	FR 03	FR 04		FR 05	FR 06	FR 07	FR 08 A		FR 09	FR 10	FR 11	FR 12	
Core Additive	Reference w/o Additive					1 % Red Iron Oxide					2 % Black Iron Oxide				
Cast Weight (all metal inside mold), Lbs.	110.95	108.35	112.35	112.60	**111.1**	112.80	113.65	110.25	109.15	**111.5**	110.55	111.45	108.20	106.85	**109.3**
Pouring Time, sec.	36	26	24	24	**28**	23	25	22	27	**24**	19	20	23	22	**21**
Pouring Temp ,°F	2636	2632	2630	2631	**2632**	2621	2639	2628	2633	**2630**	2624	2635	2635	2627	**2630**
Pour Hood Process Air Temp at Start of Pour, °F	88	89	85	87	**87**	85	89	87	87	**87**	87	86	86	88	**87**
Mixer auto dispensed batch weight, Lbs	45.35	45.35	45.35	45.35	**45.35**	42.90	42.90	42.90	42.90	**42.90**	45.67	45.67	45.67	45.67	**45.67**
Calibrated auto dispensed binder weight, Lbs	0.633	0.633	0.633	0.633	**0.633**	0.600	0.600	0.600	0.600	**0.600**	0.634	0.634	0.634	0.634	**0.634**
Core binder calibrated weight, %BOS	1.39	1.39	1.39	1.39	**1.39**	1.40	1.40	1.40	1.40	**1.40**	1.39	1.39	1.39	1.39	**1.39**
Core binder calibrated weight, %	1.38	1.38	1.38	1.38	**1.38**	1.38	1.38	1.38	1.38	**1.38**	1.37	1.37	1.37	1.37	**1.37**
Total uncoated core weight in mold, Lbs.	24.70	25.50	25.30	25.50	**25.25**	24.50	24.50	24.65	24.55	**24.55**	25.65	25.80	25.35	25.85	**25.66**
Total binder weight in mold, Lbs.	0.340	0.351	0.348	0.351	**0.347**	0.338	0.338	0.340	0.339	**0.339**	0.351	0.353	0.347	0.354	**0.351**
Core LOI, %	1.19	1.25	1.37	1.23	**1.26**	1.33	1.34	1.35	1.32	**1.34**	1.39	1.36	1.36	1.41	**1.38**
Core dogbone tensile, psi	39.5	39.5	39.5	39.5	**39.5**	ND	ND	ND	ND	**NA**	50.20	50.20	50.20	50.20	**50.2**
Core age, hrs.	41	55	73	76	**61**	44	57	68	74	**61**	46	49	81	73	**62**
Muller Batch Weight, Lbs.	900	900	900	900	**900**	900	900	900	900	**900**	900	900	900	900	**900**
GS Mold Sand Weight, Lbs.	613	622	619	626	**620**	615	616	600	616	**612**	588	604	599	597	**597**
Mold compactability, %	55	54	57	57	**56**	56	55	55	53	**55**	58	57	58	56	**57**
Mold Temperature, °F	72	70	67	69	**70**	64	67	70	67	**67**	63	69	67	69	**67**
Average Green Compression , psi	11.30	12.16	10.44	10.08	**11.00**	13.11	12.95	15.28	14.60	**13.99**	17.28	17.80	18.33	15.90	**17.33**
GS Compactability, %	53	47	55	55	**53**	54	52	50	48	**51**	52	51	48	48	**50**
GS Moisture Content, %	1.86	2.28	2.36	2.56	**2.27**	2.27	2.29	2.41	2.24	**2.30**	2.67	2.34	2.60	2.03	**2.41**
GS MB Clay Content, %	5.58	6.20	6.20	6.08	**6.02**	6.20	6.08	6.08	5.73	**6.02**	7.37	7.37	7.49	7.14	**7.34**
MB Clay reagent, ml	25.0	26.5	26.5	26.0	**26.0**	26.5	26.0	26.0	24.5	**25.8**	31.5	31.5	32.0	30.5	**31.38**
1800°F LOI - Mold Sand, %	0.71	0.68	0.74	0.72	**0.71**	0.78	0.80	0.86	0.78	**0.81**	0.78	0.78	0.82	1.05	**0.86**
900°F Volatiles , %	0.20	0.24	0.30	0.20	0.24	0.16	0.34	0.30	0.30	**0.28**	0.22	0.26	0.26	0.26	**0.25**
Appearance within group B:best, M:median, W: worst	M		B	W		M	W	B				M	B	W	
Overall appearance ranking: 1 = best, 9 = worst	6		4	9		3	5	1				7	2	8	

Test FU Detailed Process Data

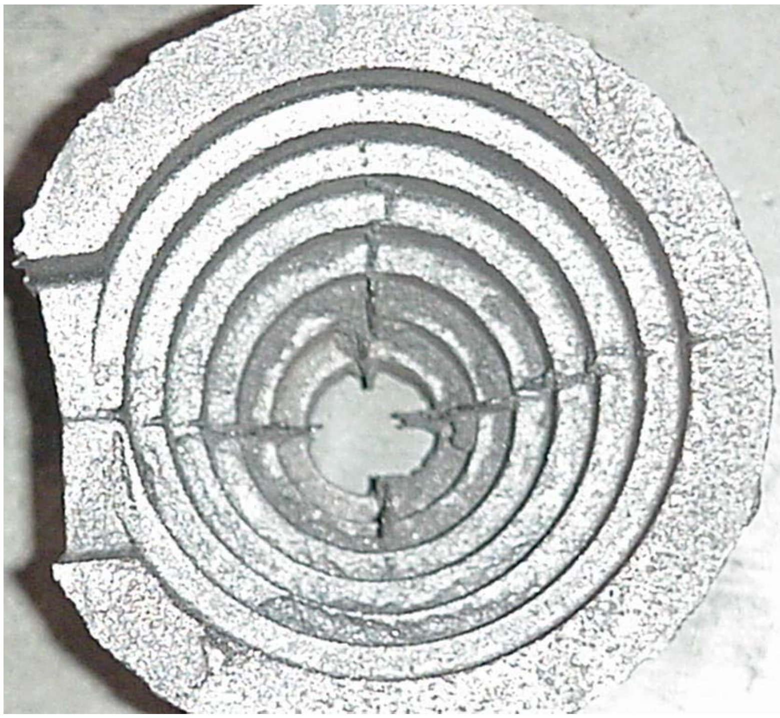
Greensand PCS	Conditioning			Emission Sampling									
Test Dates	5/24/04	5/24/04	5/24/04	5/25/04	5/25/04	5/25/04	5/26/04	5/26/04	5/26/04	5/27/04	5/27/04	5/27/04	Averages
Emissions Sample #	FU CR01	FUCR02	FUCR03	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	
Production Sample #	FU001	FU002	FU003	FU004	FU005	FU006	FU007	FU008	FU009	FU010	FU011	FU012	
Cast Weight (All Metal Inside Mold), Lbs.	111.20	107.95	108.65	109.40	47.85	112.65	107.85	108.75	43.40	112.20	110.40	111.35	**110.4**
Pouring Time, sec.	17	20	21	16	18	18	24	17	20	18	18	16	**18**
Pouring Temp ,°F	2633	2637	2639	2624	2638	2637	2639	2634	2641	2636	2634	2641	**2635**
Pour Hood Process Air Temp at Start of Pour, °F	86	88	86	87	87	88	86	86	89	92	89	86	**88**
Filled Core Weight (Solid-4 core), Lbs Approximate	29	29	29	29	29	29	29	29	29	29	29	29	**29**
Reported Core Binder Content, % BOS	3	3	3	3	3	3	3	3	3	3	3	3	**3**
Calculated/Reported Core Binder Content, %	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	**2.9**
Total Uncoated Unfilled Core Weight in Mold, Lbs.	19.37	19.85	20.21	19.49	20.51	19.62	20.10	19.82	19.92	19.82	20.13	20.35	**19.90**
Total Binder Weight in Mold, Lbs.	0.564	0.578	0.589	0.568	0.597	0.571	0.585	0.577	0.580	0.577	0.586	0.593	**0.580**
Core LOI, %	2.83	3.24	3.34	3.37	3.38	3.39	3.36	3.36	3.40	3.40	3.39	3.39	**3.38**
Muller Batch Weight, Lbs.	1301	900	900	900	900	900	900	900	900	900	900	900	**900**
GS Mold Sand Weight, Lbs.	657	623	619	615	625	616	616	628	625	635	631	619	**623**
Mold Compactability, %	50	54	52	55	51	57	54	54	55	52	54	56	**55**
Mold Temperature, °F	69	73	80	73	76	81	81	79	82	74	78	81	**78**
Average Green Compression , psi	13.97	14.40	16.60	14.18	15.41	17.71	17.27	17.10	17.36	16.82	17.73	17.57	**16.91**
GS Compactability, %	43	48	41	42	37	35	47	45	37	37	45	48	**43**
GS Moisture Content, %	1.94	2.16	1.60	2.04	1.61	1.59	1.76	1.50	1.70	1.95	2.36	2.23	**1.92**
GS MB Clay Content, %	7.00	7.25	7.13	7.38	7.13	7.13	7.38	7.25	7.38	7.38	7.25	7.38	**7.31**
MB Clay Reagent, ml	28.0	29.0	28.5	29.5	28.5	28.5	29.5	29.0	29.5	29.5	29.0	29.5	**29.2**
1800°F LOI - Mold Sand, %	1.26	0.95	1.05	0.88	1.22	1.12	1.25	1.23	1.39	1.35	0.97	1.31	**1.16**
900°F Volatiles , %	0.62	0.38	0.54	0.28	0.84	0.66	0.72	0.62	0.78	0.82	0.38	0.70	**0.60**
Appearance within group B:best, M:median, W: worst		Best					Median				Worst		
Overall appearance ranking: 1 = best, 9 = worst	3	1	4	2		5	6	7		8	10	9	

Molds FU005 and FU009 ranout. Do not use in summary

Best Appearing Casting from Mold FR 003 - Baseline

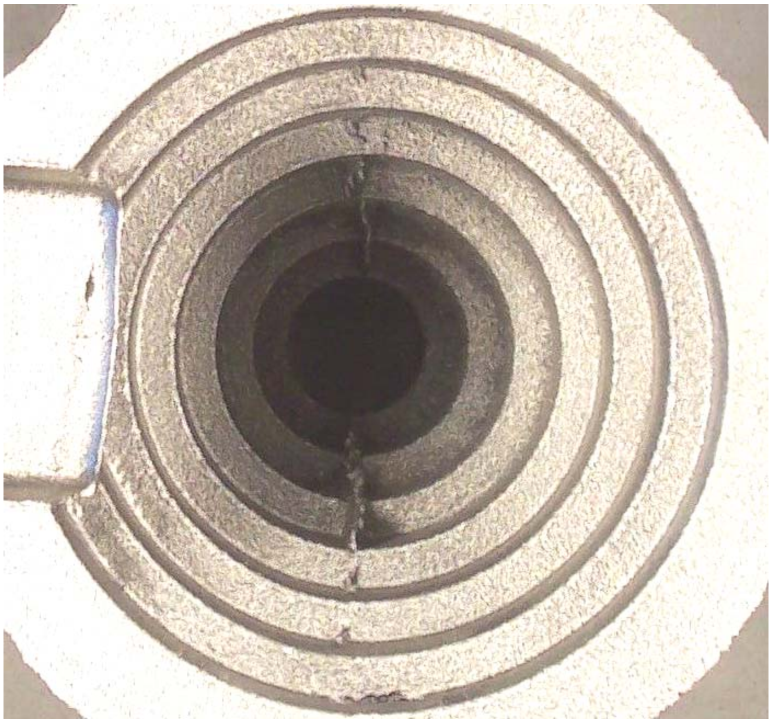


Median Appearing Casting from Mold FR 001 – Baseline



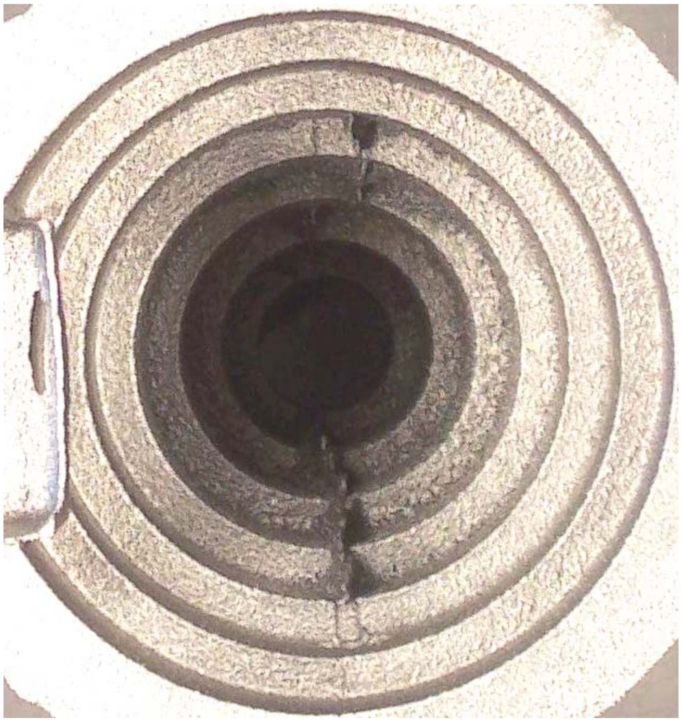
Worst Appearing Casting from Mold FR 004 – Baseline

Best Appearing Casting from Mold FU 002 – Shell Core



Median Appearing Casting from Mold FU 007 – Shell Core

Worst Appearing Casting from Mold FU 011 – Shell Core



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APPENDIX D METHOD 25A CHARTS

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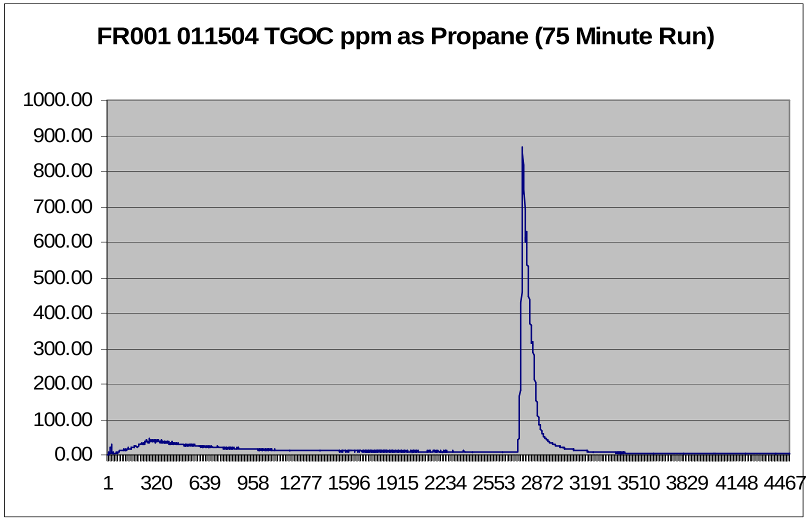
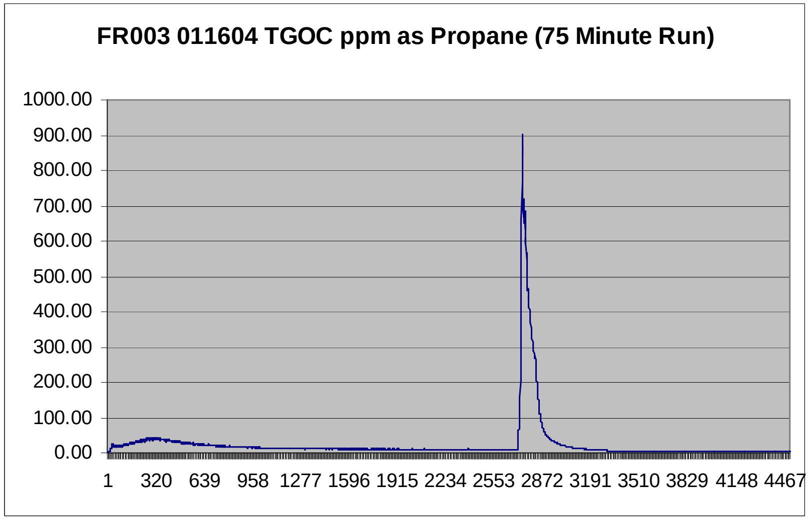
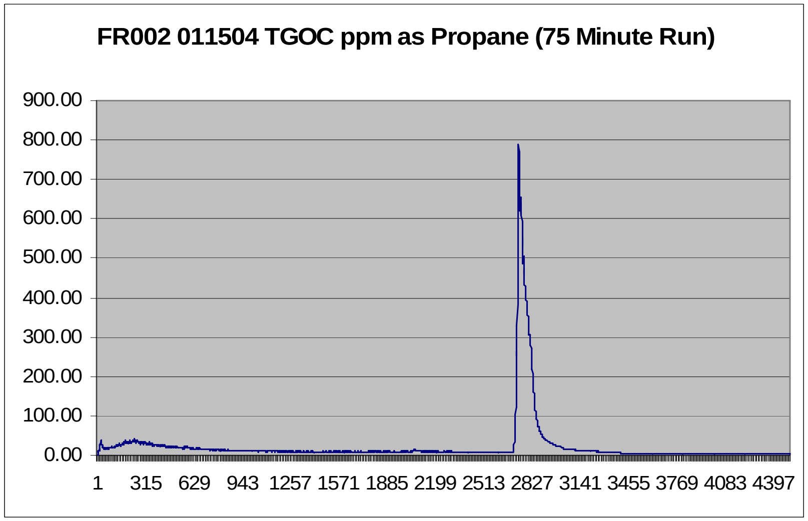
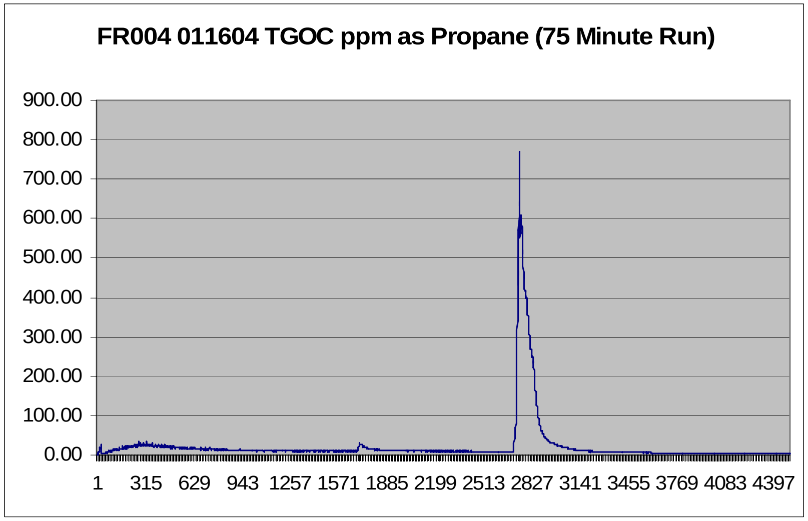
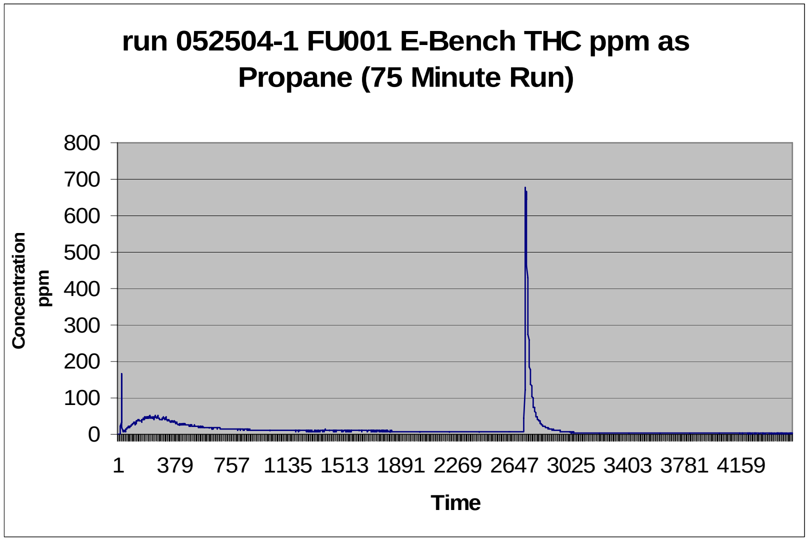
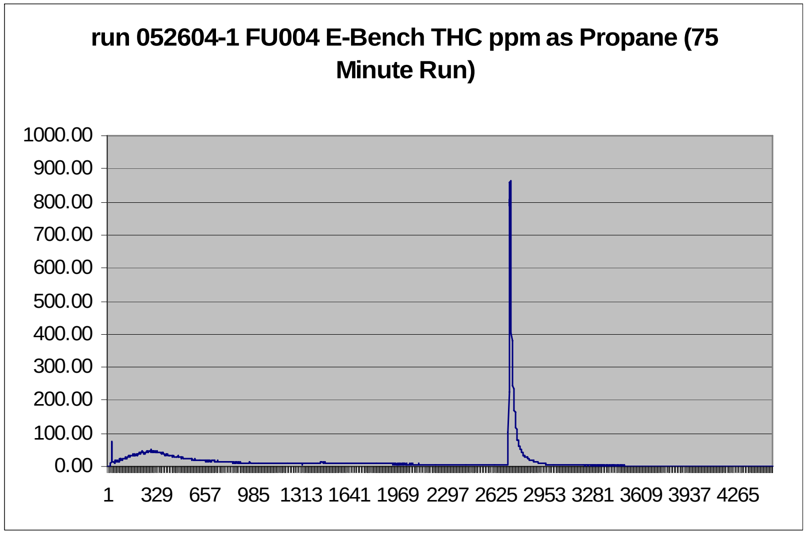

FR001 011504 TGOC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467

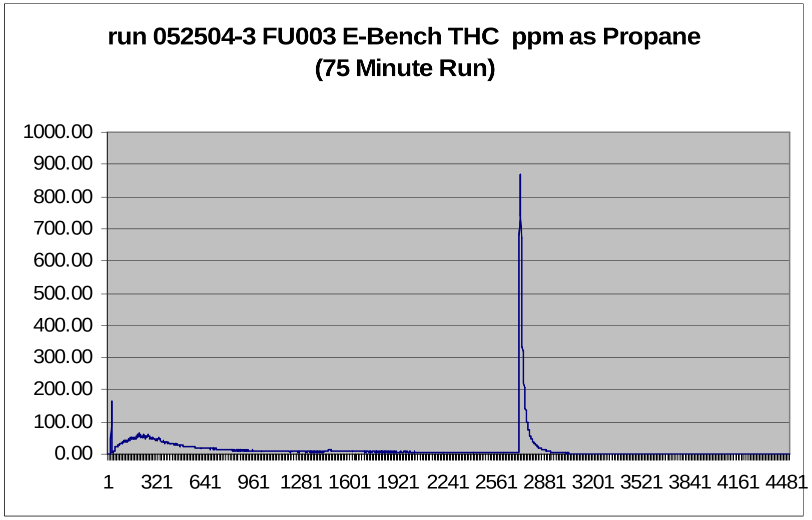

FR003 011604 TGOC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467

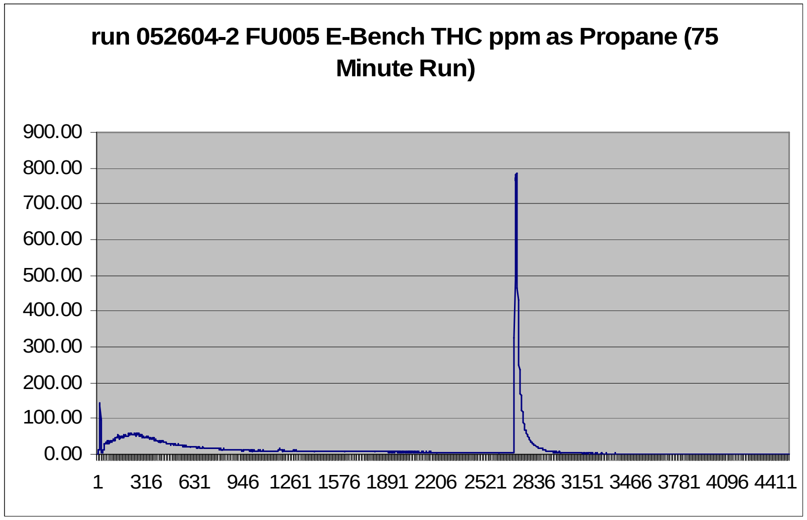

FR002 011504 TGOC ppm as Propane (75 Minute Run)
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397

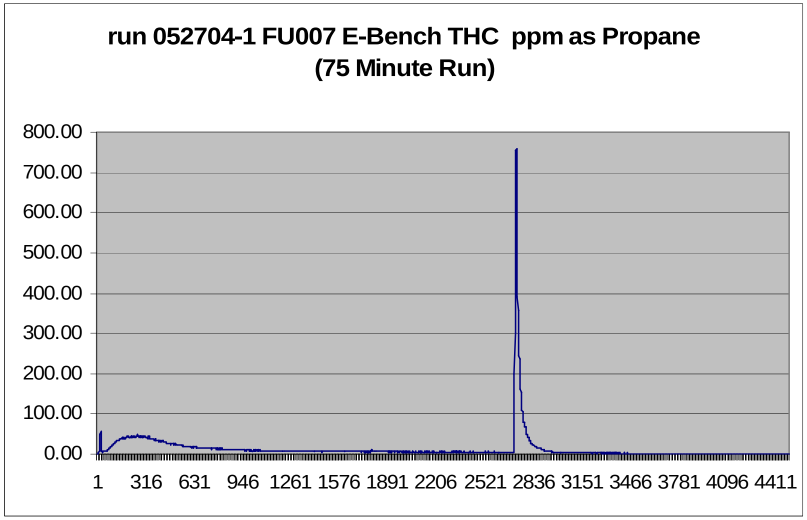

FR004 011604 TGOC ppm as Propane (75 Minute Run)
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397

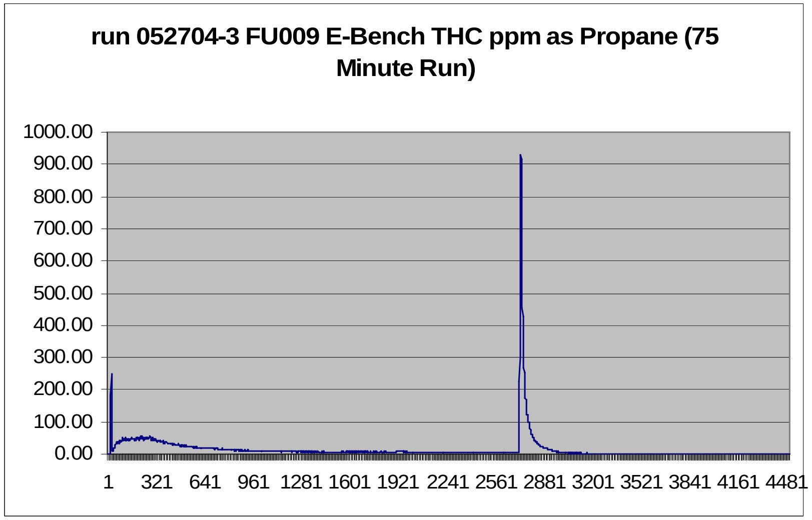

run 052504-1 FU001 E-Bench THC ppm as Propane (75 Minute Run)
Concentration ppm
800
700
600
500
400
300
200
100
0
1 379 757 1135 1513 1891 2269 2647 3025 3403 3781 4159
Time

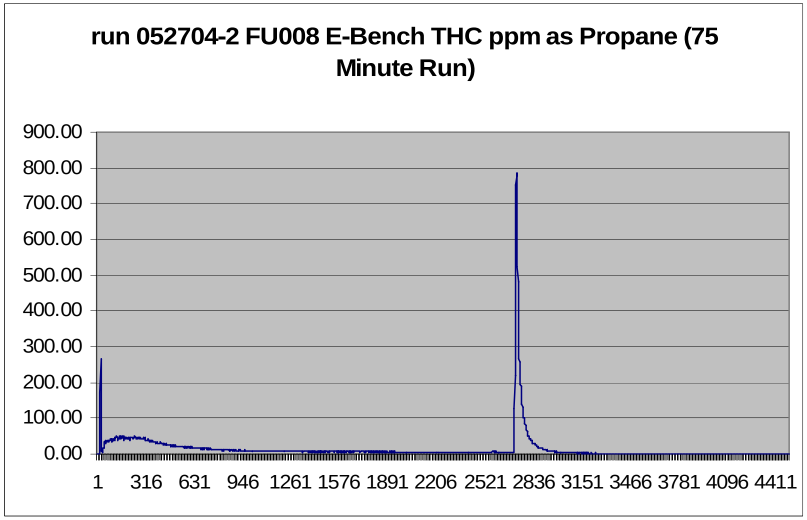

run 052604-1 FU004 E-Bench THC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 329 657 985 1313 1641 1969 2297 2625 2953 3281 3609 3937 4265


run 052504-3 FU003 E-Bench THC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 052604-2 FU005 E-Bench THC ppm as Propane (75 Minute Run)
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 316 631 946 1261 1576 1891 2206 2521 2836 3151 3466 3781 4096 4411


run 052704-1 FU007 E-Bench THC ppm as Propane (75 Minute Run)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 316 631 946 1261 1576 1891 2206 2521 2836 3151 3466 3781 4096 4411


run 052704-3 FU009 E-Bench THC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 052704-2 FU008 E-Bench THC ppm as Propane (75 Minute Run)
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 316 631 946 1261 1576 1891 2206 2521 2836 3151 3466 3781 4096 4411

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APPENDIX E GLOSSARY

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Glossary

BO	Based on ( ).
BOS	Based on Sand.
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	Data rejected based on data validation considerations
NA	Not Applicable
ND	Non-Detect
NT	Lab testing was not done
PCS	Pouring, Cooling, Shakeout
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.
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