CERP

Casting Emission Reduction Program

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US Army Task N256

Production Foundry, [redacted] Comparative Airborne Emissions

Technikon # RV 200104 DI

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Production Foundry, [redacted] Comparative Airborne Emissions

Test Plan # RV 2 00104 DI

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 against a standardized baseline process profile. You may not obtain the same results in your facility. Data was not collected to assess casting quality, cost, or producibility.

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Executive Summary

This report contains the results of testing conducted at the Casting Emission Reduction Program (CERP) Production Foundry according to Production Baseline Test Plan DD and Production Test Plan DI. The testing was conducted by CERP, a cooperative initiative between the Department of Defense (US Army Industrial Ecology Center) and the United States Council for Automotive Research (US CAR). CERP's purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions from foundries and/or improve the efficiency of casting processes. Other technical partners directly supporting the CERP project include: the American Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US EPA), and the California Air Resources Board (CARB).

The specific objective of this test was to determine reductions, if any, in levels of Hazardous Air Pollutant (HAP) and Volatile Organic Compound (VOC) emissions produced by a greensand mold using [redacted] as a seacoal replacement under CERP Production Foundry conditions. The resultant emissions from Test DI, expressed as pounds of emission per ton of iron (lb/ton), are then used for comparison to the Production Baseline Test DD. Both the baseline test (DD) and the subject test (DI) started with a virgin sand system that experienced approximately ten (10) turns prior to the beginning of emission testing.

The CERP Production Foundry is a basic greensand foundry similar to existing mechanized commercial foundries. It emulates an automotive foundry in the type and size of equipment, materials, and processes used. A single cavity automotive I-4 engine block is used as the test mold pattern. The Production Foundry is used to evaluate materials, equipment, and processes in a continuous real-world production-like environment. It is instrumented to provide emission measurements, according to methods based on US EPA air testing protocols, of the sand system, and combined pouring, cooling, and shakeout processes. The Production Foundry is also instrumented so that process data on all activities of the metal casting process can be simultaneously and continuously collected in order to complete an economic impact evaluation of the prospective emission reducing strategy.

The testing performed in the Production Foundry involves the continuous collection of air samples over six (6) sixty (60) minute periods at each of two (2) different sampling points. The sampling points are located in the sand system exhaust duct and the combined pouring/cooling/shakeout exhaust duct. Process and stack parameters measured during the test include: the weight of the casting, mold, seacoal and clay additions, and core; % Loss on Ignition (LOI) and % volatiles values for the mold sand; % LOI for the core; % clay content of the mold sand; %

compactability of the mold sand; pouring temperatures; metallurgical data; and stack temperature, pressure, volumetric flow rate, and moisture content. The process parameters and the stack flow rates are maintained within prescribed ranges in order to ensure the repeatability of the tests.

Samples were collected and analyzed for over seventy (70) target compounds using procedures based on US EPA Method 18. Continuous monitoring of the Total Gaseous Organic Content (TGOC), formerly Total Hydrocarbon Concentration (THC), of the emissions was conducted according to US EPA Method 25A. Finally, the "condensable" organic material in the emissions was determined using a Technikon developed procedure. The "condensables" represent the "back half" catch from US EPA Method 5.

The mass emission rate of each parameter or target compound was calculated, in pounds per ton of metal, using the Method 25A data or the laboratory analytical results, the measured source data, and the weight of castings processed each hour. Results for structural isomers have been grouped and reported as a single entity. For example, ortho, meta, and paraxylene are the three (3) structural isomers of dimethylbenzene and are reported as o,m,p-xylene though separate results are available in Appendix B of this report. Several "emissions indicators," in addition to the TGOC (THC) 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 subgroups of this measure. The "Sum of VOCs" is based on the sum of the individual target Volatile Organic Compounds (VOCs) measured and includes the Hazardous Air Pollutants (HAPs) and 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 POMs. Finally, the "Sum of POMs" is the sum of all of the polycyclic organic material measured.

The results of the baseline, product, or process testing conducted in the CERP foundries are not suitable for use as general emission factors. The specific materials used (grey iron from an electric melt furnace, greensand with seacoal, a relatively heavy core weight, and a cold box core produced with a relatively old resin binding system); the specific casting produced (an I-4 automotive engine block); the specific production processes employed (an impact mold line); and the specific testing conditions (relatively low production rate, high capture efficiencies, and combined emissions from pouring, cooling and shakeout processes at the Production Foundry) produce emission results unique to the materials, castings, casting processes and measurement conditions used. The data produced are intended to demonstrate the <u>relative</u> emission reductions from the use of alternative materials, equipment and processes, and not the absolute emission levels that would be experienced in commercial foundries. A number of process parameters such as casting surface area, sand to metal ratios, pouring temperatures, stack flow rates, LOI levels, seacoal and resin contents, and the type of foundry (Cope & Drag versus Disa for example) can have a significant impact on actual emission levels. CERP does plan to evaluate, and if possible, quantify the impacts of several of these parameters to assist the foundry industry as well as regulatory agencies in their understanding of the importance of these parameters on air emission levels.

Table 1 Summary Test Results - Test Plan DI and Baseline Test DD Sand System and Combined Pouring/Cooling/Shakeout

Analyte	Baseline DD (lbs/tn)	Test DI (lbs/tn)	Percent Change from Test DD
TGOC (THC) as Propane	3.96	N/A	N/A
HC as Hexane	1.80	1.83	2%
Sum of VOCs	1.14	0.917	**-20%**
Sum of HAPs	0.973	0.822	**-15%**
Sum of POMs	0.102	0.147	**44%**
Benzene	0.326	0.329	1%
Aniline	0.122	0.024	**-80%**
Phenol	0.102	0.069	**-32%**
Toluene	0.097	0.094	-3%
N,N-Dimethylaniline	0.077	0.030	**-61%**
o,m,p-Xylene	0.058	0.055	-6%
Methylnaphthalenes	0.051	0.093	**80%**
Naphthalene	0.044	0.043	1%
o,m,p-Cresol	0.043	0.020	**-52%**
Hexane	0.020	0.013	**-33%**
2-Butanone	0.011	0.018	**61%**
Ethylbenzene	0.010	0.008	**-24%**
Acetaldehyde	0.009	0.015	**62%**
Trimethylbenzenes	0.092	0.047	**-48%**
Octane	0.019	0.009	**-54%**
Ethyltoluenes	0.015	0.017	11%
Heptane	0.009	0.006	**-31%**
Undecane	0.008	0.009	**19%**
Dodecane	0.007	ND	**-100%**
Condensables	2.40	2.21	-8%
Carbon Monoxide	ND	5.29	N/A
Methane	ND	1.09	N/A
Carbon Dioxide	147	121	-17%

Individual results shown constitute > 95% of mass of all detected VOCs.
I: Test results rejected due to data validation considerations
ND: Non Detect
“Percent change from Test DD” values in **bold** indicate a 95% probability that the difference in the average values were not from test variability.

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1.0 Introduction

1.1 Background

The Casting Emission Reduction Program (CERP) is a cooperative initiative between the Department of Defense (US Army Industrial Ecology Center) and the United States Council for Automotive Research (USCAR). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions from foundries and/or improve the efficiency of casting processes. Other technical partners directly supporting the project include: the American Foundrymen's Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (USEPA), and the California Air Resources Board (CARB). Each of these partners is represented on a Steering Committee that has oversight for the testing conducted at the CERP facility.

1.2 CERP Objectives

The primary objective of CERP is to evaluate the impact of new materials, equipment, and processes on airborne emissions from the production of metal castings. Specifically, the CERP facility has been created to evaluate alternate materials and production processes designed to achieve significant airborne emission reductions, especially for organic Hazardous Air Pollutants (HAPs). HAP emissions reduction from the alternative materials, equipment and production processes is expressed as a comparison to similar emissions from a baseline test. 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 specifically designed to facilitate the collection and evaluation of airborne emissions, and associated process data. Candidate materials and/or processes are screened for emission reductions in the Pre-production Foundry and then further evaluated in the Production Foundry. The data collected during the various testing projects are evaluated to determine the impact of the alternate materials and/or processes on airborne emissions as well as on the quality and economics of casting and core manufacture. These alternate materials, equipment, and processes may need to be further adapted and defined so that they will integrate into current commercial green sand casting facilities smoothly and with minimal capital expenditure.

Pre-production testing is conducted in order to evaluate the impact on air emissions from a proposed alternative material, equipment or process. The CERP Pre-Production Foundry is a simple, general-purpose manual foundry, which was adapted and instrumented to allow the collection of detailed emission measurements, using methods based on US EPA air testing protocols.

Measurements are taken during pouring, casting cooling, and shakeout processes performed on discrete mold and core packages under tightly controlled conditions not feasible in a commercial foundry. The Pre-production foundry uses an eight-on, bottom-feed AFS step block as its test mold pattern. A report entitled Baseline Testing Emission Results – Pre-Production Foundry provides details of the baseline testing done in the Pre-Production Foundry. This report can be obtained from the CERP web site at www.technikonllc.com.

Alternative materials, equipment and processes that, during their testing in the Pre-Production Foundry, demonstrate significant air emission reduction potential and preserve casting quality parameters are further evaluated in the Production Foundry. The Production Foundry's design as a basic green sand foundry was deliberately chosen so that whatever is tested in this facility could be easily converted for use in existing mechanized commercial foundries. The Production Foundry emulates an automotive foundry in the type and size of equipment, materials, and processes used. A single cavity automotive I-4 engine block mold is used to further evaluate materials, equipment, and processes in a continuous real-world production-like environment. The Production Foundry provides simultaneous, detailed, individual emission measurements, according to methods based on US EPA air testing protocols, of the melting, pouring, sand preparation, mold making, and core making processes. The Production Foundry is instrumented so that process data on all activities of the metal casting process can be simultaneously and continuously collected in order to complete an economic impact evaluation of the prospective emission reducing strategy. Castings are randomly selected to evaluate the impact of the alternate material, equipment, or process on the quality of the casting.

Test results for a particular process or product may not be the same from both foundries due to differences in the testing process. The Pre-production Foundry is designed to screen new products, processes, or equipment, whereas the Production Foundry is designed to test the effect of the product, process, or equipment in a continuous production-like environment.

The results of the testing conducted at both the Production and Pre-production Foundries are not suitable for use as general emission factors. The specific materials used (grey iron from an electric melt furnace, greensand with seacoal, a relatively heavy core weight, and a cold box core with a relatively old resin binding system); the specific castings produced (an eight-on step block in the Pre-production Foundry and an I-4 automotive block in the Production Foundry); the specific production processes employed (a stationary hand poured mold in the Pre-production Foundry and an impact mold line in the Production Foundry); and the specific testing conditions (relatively low stack velocity, long sampling times, high capture rates, and combined emissions from pouring, cooling and shakeout processes at the Production Foundry) produce emission results unique to the materials, castings, casting processes and measurement conditions used. The data produced are intended to demonstrate the relative emission reductions from the use of alternative materials, equipment and processes, and not the absolute emission levels that would be experienced in commercial foundries. A number of process parameters such as casting surface area, sand to metal ratios, pouring temperatures, stack flow rates, LOI levels, seacoal and resin contents, and the type of foundry (Cope & Drag versus Disa for example) can have a significant impact on actual emission levels. CERP does plan to evaluate and, if possible, quantify the impacts of several of these parameters to assist the foundry industry as well as regulatory agencies in their understanding of the importance of these parameters on air emission levels.

1.3 Report Organization

This report has been designed to document the methodology used and the results obtained during product testing in the Production Foundry. Section 1 presents a general overview of the testing, while Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, quality assurance, quality control (QA/QC) procedures, and data management and reduction methods. Process data and emissions measurement results are presented in Section 3 of this report, with detailed emissions data included in Appendix B. Section 4 of the report contains a discussion of the results of this test including conclusions drawn from the interpretation of the results.

The raw data, as well as the data validation and reduction steps used for the test presented in this report are included in the test series data binders, which are maintained at the CERP facility. There are also several support documents, which provide details regarding the testing and analytical procedures used. Appendix E contains a listing of these documents.

1.4 Preliminary Testing

The testing presented in this report was performed according to the CERP Production Testing Protocols. These protocols were established by CERP, following the performance of a series of preliminary tests. It has been determined by CERP that six to nine replicate tests will provide a statistically significant sample for the purpose of evaluating the emission reductions from alternative materials, equipment and processes. The results of the testing conducted in support of this conclusion are included in the document CERP Production Testing Protocols.

1.5 Specific Test Plan and Objectives

This report contains the results of testing performed to assess HAP and VOC airborne emissions from Test Plan DI, and compare them to Baseline Test DD, in the CERP Production Foundry. Table 2 provides a summary of Baseline Test DD and Test Plan DI. The approved test plans are included in Appendix A.

Table 2 Baseline Test DD and Test Plan DI Summary

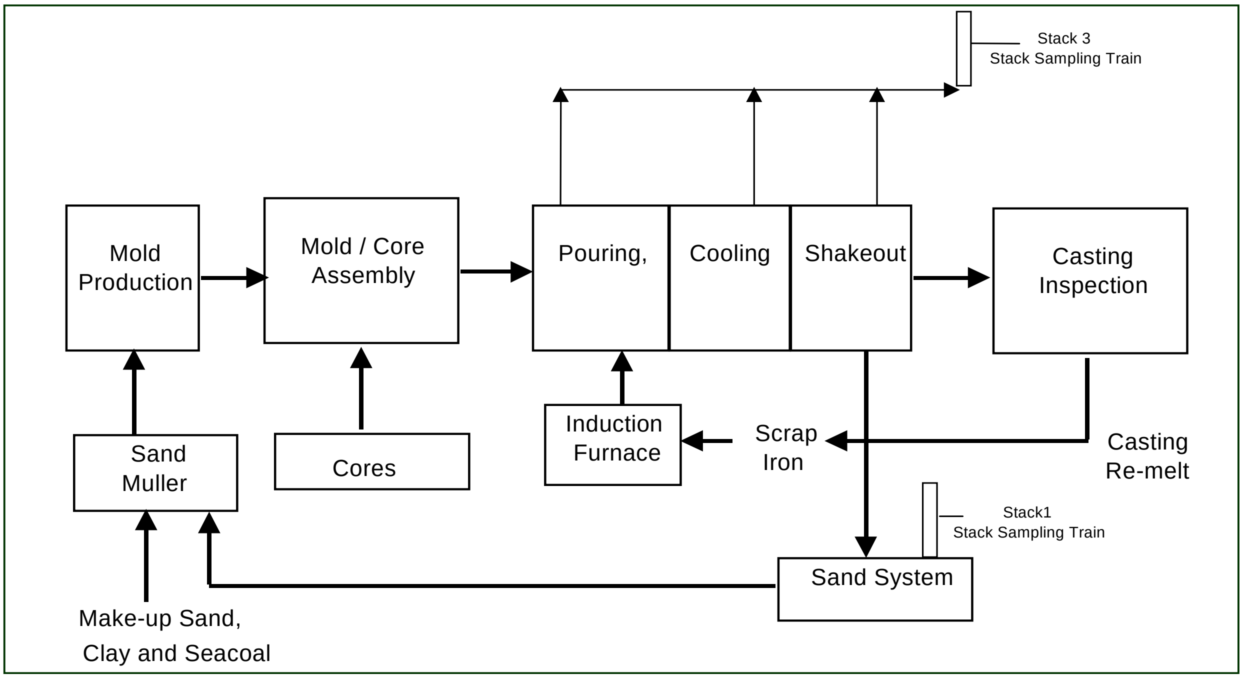
Test Series	DD	DI
Test Dates	November 21, 2000	February 21, 2001
Number of Test Runs	Seven (7) one-hour tests	Six (6) one-hour tests
Sampling Points	Two (2) sampling points: sand system and combined pouring/cooling/shakeout.	Two (2) sampling points: sand system and combined pouring/cooling/shakeout.
Mold Type	Greensand with H&G HGLS090181 Premix	Greensand with a 50:50 Mix of [redacted] and Seacoal
Core Type	ISOCURE® 305/904 Resin	ISOCURE® 305/904 Resin
Casting Type	Single cavity automotive I-4 engine block	Single cavity automotive I-4 engine block
Emissions Measured	70 organic HAPs and VOCs	70 organic HAPs and VOCs
Process and Stack Parameters Measured	Casting, Mold and Core Weights, Molds processed, Metallurgical data, Mold and Core Component Weights, % LOI (mold and core), % volatiles, % Clay, % Moisture, Stack Temperature, Stack Moisture Content, Stack Pressure, and Stack Volumetric Flow Rate	Casting, Mold and Core Weights, Molds processed, Metallurgical data, Mold and Core Component Weights, % LOI (mold and core), % volatiles, % Clay, % Moisture, Stack Temperature, Stack Moisture Content, Stack Pressure, and Stack Volumetric Flow Rate

2.0 Test Methodology

2.1 Description of Process and Testing Equipment

Figure 1 is a flow diagram of the Production Foundry process.

Figure 1 Production Foundry Process Flowchart



2.2 Description of Testing Program

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

1. **Mold, Core and Metal Preparation:** Molds were produced on an impact mold line. Cores were prepared to a specified composition by the CERP testing team using a cold box core machine. Iron was melted in two electric induction melt furnaces with a total capacity of 5 tons/hour. 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 provided on a metal composition worksheet.

2. **Individual Sampling Events:** Sampling of each of the sampling points (sand system and combined pouring/cooling/shakeout) was conducted over eight (8) individual one-hour test runs. Each mold/core package was placed in a flask that was assigned a number and tracked by time and position throughout the process. The number of poured mold/core packages en-

tering each process step (sand system and combined pouring/cooling/shakeout) for each test hour was determined from the tracking data for each mold/core package. Air samples were collected continuously during each one-hour test run at each of the sampling points. The average casting weight and mold/core package counts were used to determine the total metal weight processed at each point during each test hour in order to correlate the emissions measurements with the metal weight processed.

Emissions Sampling

Emissions samples were drawn from sampling ports located in conformance with US EPA Method 1 at each of the sampling points. The tip of the probe was located at the centroid of the duct in accordance with US EPA Method 18. The samples were collected at a constant rate in adsorption tubes and the flow rate through each of the sample tubes was controlled using critical orifices.

3. **Process Parameter Measurements:** The finished castings were cleaned and quality checks of the castings were performed. Average mold and core weights were determined from weights of the various materials required to assemble the prescribed test mold configuration. The % LOI, % clays and % compactability of the mold were determined from periodic samples of the mold sand. The % LOI of the cores was determined from representative testing of the cores. Pouring temperatures were also recorded periodically during the testing to determine the average pour temperature. Table 3 lists the process parameters that were monitored during each test. The analytical equipment and methods used are also listed.

Table 3 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Core Weight	Mettler PJ8000 Digital Scale (Gravimetric)
Mold Weight	Standard Weight (Gravimetric)
Casting Weight	Standard Weight (Gravimetric)
Seacoal Weight	Simpson Technology (Calibrated Volumetric)
Resin Weight	Mettler PJ8000 Digital Scale (Gravimetric)
LOI% at mold	Denver Instruments XE-100 Analytical Scale (AFS procedure 212-87-S)
Core LOI%	Denver Instruments XE-100 Analytical Scale (AFS procedure 321-87-S)
Clay, % at mold	Dietert 535A MB Clay Tester (AFS Procedure 210-87-S)
Metallurgical Parameters	
Pouring temperature	Electro-Nite DT 260 (T/C immersion pyrometer)
Carbon/Silica	Electro-Nite Datacast 2000 (Thermal Arrest) and Baird Foundry Mass Spectrometer
Alloy Weights	Ohaus DS10 (Gravimetric)
Mold Compactability	Dietert 319A Sand Squeezer (AFS procedure 221-87-S)

4. Air Emissions Analysis: The specific sampling and analytical methods used in the Production Foundry tests were based on the US EPA reference methods shown in Table 4. The details of the specific testing procedures and their variance from the reference methods are included in the CERP Standard Operating Procedures. Appendix F contains a list of the entire target analytes tested for along with their respective detection limits.

Table 4 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 2002*
VOCs concentration	EPA Method 18, 25A, TO11, NIOSH 2002*
Condensables	Technikon Method **

* These methods were specifically modified to meet the testing objectives of the CERP Program.
**The Technikon condensables method is intended to provide a measure of the EPA Method 5 “back-half” determination.

5. 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 using the measured stack pressure, temperature, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of metal determined from the average casting weight and the count of mold/core packages processed for the specific emission point and test hour. The results are calculated as pounds of analyte per ton of metal processed. The specific calculation formulas are included in the CERP Emissions Testing and Analytical Testing Operating Procedures.

The results of validated duplicate samples for individual sampling events (one-hour test runs) were averaged to provide the result for each analyte for each of the sampling events. The results for each analyte from the six sampling events were then averaged to provide the analyte’s average emission rate for the entire series. The averaged results of each of the sampling events and the corresponding series averages are included in Section 3 of this report.

6. 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, 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 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

Table 1 presents a summary of the total emissions generated at the sand system and combined pouring, cooling, shakeout sampling points, for Test Plan DI, and Baseline Test DD.

Table 2 presents a summary of the test parameters for both of these test plans.

Table 3 presents the test equipment and methodologies used to measure the process parameters for Test Plan DI.

Table 4 presents a summary of the sampling and analytical methodologies utilized for Test Plan DI.

Table 5a and 5b present Test Plans DD and DI process data, respectively.

Table 6a and 6b present the stack data and calculated flow rates for Test Plans DD and DI, respectively.

A summary of the airborne emission results for the baseline (Test DD), and this test plan, (Test DI), in pounds of analyte per ton of metal poured, is presented in Table 7a and 7b, respectively. The data represents the individual and combined emissions from the sand system and pouring, cooling, and shakeout. The results include five emission indicators, as well as the organic HAP compounds and non-HAP VOCs, which together comprise at least 95% of the mass of the VOCs measured during the test.

Figures 2, 3, and 4 present comparisons of the total (sand system plus combined pouring / cooling / shakeout) emissions measured during Test DI and Production Baseline Test DD, based on results shown in Table 7a and 7b.

Figures 5, 6 and 7 present similar charts of the sand system results shown in Table 7a and 7b, and Figures 8, 9, and 10 show the combined pouring/cooling/shakeout results from Table 7a and 7b.

Appendix B contains tables presenting the results for all analytes measured during Test DI and Production Baseline Test DD. The results presented in this report are not blank corrected.

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Table 5a Production Foundry Test DD Process Data

Average Casting Weight, lbs./mold	151.74
Average Mold Sand Weight lbs./mold	1261
Average Core Sand Weight, lbs./mold	55.21
Average Resin Weight, lbs./mold	0.947

Process Parameter	**# of Samples**	**Minimum**	**Maximum**		**Average**	**Std Dev.**
Compactability, %	22	36	45		40	2.266
LOI, % (at mold), (1800˚F)	22	4.36	4.92		4.62	0.124
Clays, % (at mold),	22	8.27	9.56		8.83	0.466
Core LOI, % , (1400˚F)	14	1.38	1.64		1.51	0.068
Pouring Temperature, °F	19	2598	2646		2628	14.029

Mold Count								
Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**Averages**
Test Number	DD001	DD002	DD003	DD004	DD005	DD006	DD006	
Number of Molds at Sand System	26	22	25	25	26	26	24	25
Test Number	DD021	DD022	DD023	DD024	DD025	DD026	DD027	
Number of Molds at Combined Pouring/Cooling/Shakeout	26	21	26	25	26	26	24	25

Table 5b Production Foundry Test DI Process Data

Average Casting Weight, lbs./mold	151.74
Average Mold Sand Weight lbs./mold	1261
Average Core Sand Weight, lbs./mold	55.21
Average Resin Weight, lbs./mold	0.947

Process Parameter	# of Samples	Minimum	Maximum		Average	Std Dev.
Compactability, %	17	31	39		36	2.340
LOI, % (at mold)	17	4.33	5.37		4.70	0.320
Clays, % (at mold)	18	8.91	10.84		9.90	0.544
Core LOI, % 1400ºF	8	1.70	1.97		1.87	0.088
Pouring Temperature, ºF	19	2577	2647		2625	16.694

Mold Count								
Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		**Average molds/hr**
Test Number	DI001	DI002	DI003	DI004	DI005	DI006		
Number of Molds at Sand System	20	21	24	20	22	24		22
Test Number	DI021	DI022	DI023	DI024	DI025	DI026		
Number of Molds at Combined Pouring/Cooling/Shakeout	21	22	25	20	21	23		22

NOTE: The inclusion of lignite in the material recipe impacted the clay determination test causing values to read high by an estimated 1.25% clay, compared to an equivalently processed sand with seacoal only.

Table 6a Production Foundry Test DD Stack Data and Calculated Flow Rates

	Test Run Number	1	2	3	4	5	6	7	Average
Sand System	Average Stack Temperature, ºF	61	64	65	65	65	65	66	64
	Total Moisture Content, %	1.18	1.22	1.27	1.49	1.04	1.55	1.50	1.32
	Avg. Stack Pressure, in. Hg Abs.	29.66	29.68	29.68	29.67	29.68	29.68	29.66	29.67
	Average Stack Velocity, ft./sec.	47.2	47.0	46.0	46.0	46.5	46.0	46.6	46.5
	Stack Flow Rate, scfm	35,317	35,018	34,013	34,039	34,595	34,029	34,445	34,494
PCS Combined	Average Stack Temperature, ºF	65.0	67.0	70.0	70.0	70.0	70.0	71.0	69.0
	Total Moisture Content, %	0.9	0.9	0.9	1.1	1.1	1.1	1.2	1.0
	Avg. Stack Pressure, in. Hg Abs.	29.60	29.61	29.61	29.60	29.61	29.61	29.59	29.60
	Average Stack Velocity, ft./sec.	71.3	70.6	70.4	70.1	70.9	70.5	70.1	70.56
	Stack Flow Rate, scfm	52,915	52,274	51,877	51,513	52,045	51,773	51,439	51,977

Table 6b Production Foundry Test DI Stack Data and Calculated Flow Rates

	Test Run Number	1	2	3	4	5	6	Average
Sand System	Average Stack Temperature, ºF	65	65	67	67	68	70	67
	Total Moisture Content, %	1.55	1.63	1.65	1.73	1.77	1.69	1.67
	Avg. Stack Pressure, in. Hg Abs.	29.76	29.76	29.87	29.77	29.71	29.69	29.76
	Average Stack Velocity, ft./sec.	45.9	45.3	45.4	45.4	45.5	45.6	45.5
	Stack Flow Rate, scfm	34,090	33,631	33,617	33,545	33,471	33,429	33,631
PCS Combined	Average Stack Temperature, ºF	61.0	60.0	61.0	62.0	63.0	63.0	61.7
	Total Moisture Content, %	1.26	1.29	1.32	1.37	1.39	1.39	1.34
	Avg. Stack Pressure, in. Hg Abs.	29.74	29.74	29.75	29.75	29.69	29.67	29.72
	Average Stack Velocity, ft./sec.	66.2	67.4	67.4	67.5	67.3	66.8	67.1
	Stack Flow Rate, scfm	49,713	50,599	50,554	50,472	50,072	49,791	50,200

* Moisture is based on Relative Humidity and Atmospheric Temperature

Table 7a Production Test Plan DD Average Test Results Sand System and Combined Pouring/Cooling/Shakeout

COMPOUND / SAMPLE NUMBER	SAND SYSTEM AVERAGE	COMBINED PCS AVERAGE	TOTAL
TGOC (THC) as Propane	0.990	2.97	3.96
HC as Hexane	0.626	1.17	1.80
Sum of VOCs	0.405	0.735	1.14
Sum of HAPs	0.330	0.643	0.973
Sum of POMs	0.048	0.054	0.102
Individual Organic HAPs			
Benzene	0.075	0.251	0.326
Aniline	0.049	0.073	0.122
Phenol	0.042	0.060	0.102
Toluene	0.032	0.065	0.097
N,N-Dimethylaniline	0.035	0.042	0.077
o,m,p-Xylene	0.024	0.035	0.058
Methylnaphthalenes	0.023	0.028	0.051
Naphthalene	0.023	0.021	0.044
o,m,p-Cresol	0.016	0.026	0.043
Hexane	0.004	0.016	0.020
2-Butanone	0.007	0.005	0.011
Ethylbenzene	0.004	0.006	0.010
Acetaldehyde	0.004	0.005	0.009
Other VOCs			
Trimethylbenzenes	0.050	0.042	0.092
Octane	0.004	0.015	0.019
Ethyltoluenes	0.007	0.008	0.015
Heptane	ND	0.009	0.009
Dodecane	0.004	0.003	0.007
Other Analytes			
Acetone	0.014	0.011	0.026
Carbon Monoxide	ND	ND	ND
Methane	ND	ND	ND
Carbon Dioxide	52.8	93.9	146.7
Condensibles	0.936	1.47	2.40

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

I: Data was rejected based on data validation considerations.

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

NT: Not Tested; **N/A:** Not Applicable

Table 7b Production Test Plan DI - Average Test Results -Sand System and Combined Pouring/Cooling/Shakeout

COMPOUND / SAMPLE NUMBER	SAND SYSTEM AVERAGE	COMBINED PCS AVERAGE	TOTAL
TGOC (THC) as Propane	I	I	I
HC as Hexane	0.524	1.31	1.83
Sum of VOCs	0.284	0.633	0.917
Sum of HAPs	0.241	0.581	0.822
Sum of POMs	0.053	0.094	0.147
Individual Organic HAPs			
Benzene	0.080	0.249	0.329
Methylnaphthalenes	0.034	0.068	0.101
Toluene	0.028	0.060	0.089
Phenol	0.025	0.041	0.066
N,N-Dimethylaniline	0.024	0.036	0.060
o,m,p-Xylene	0.023	0.032	0.055
Aniline	0.009	0.024	0.033
Naphthalene	0.008	0.021	0.029
o,m,p-Cresol	0.007	0.013	0.020
Hexane	0.005	0.012	0.017
Acetaldehyde	0.004	0.010	0.015
2-Butanone	0.009	0.009	0.018
Ethylbenzene	0.001	0.005	0.006
Formaldehyde	ND	0.003	0.003
Styrene	ND	0.002	0.002
Other VOCs			
Trimethylbenzenes	0.022	0.024	0.046
Octane	0.004	0.009	0.013
Ethyltoluenes	0.003	0.008	0.010
Heptane	0.002	0.006	0.008
Dimethylnaphthalenes	0.002	0.005	0.007
Undecane	ND	0.005	0.005
Benzaldehyde	ND	0.002	0.002
Other Analytes			
Acetone	0.014	0.019	0.033
Carbon Monoxide	ND	6.35	6.35
Methane	ND	1.30	1.30
Carbon Dioxide	52.3	93.4	145.8
Condensables	0.521	2.03	2.55

I: Data was rejected based on data validation considerations.
ND: Not Detected
All **"Other Analytes"** are not included in the sum of HAPs or VOCs.

Figure 2 Comparison of Emission Indicators for Production Baseline DD and Test DI Sand System and Combined PCS

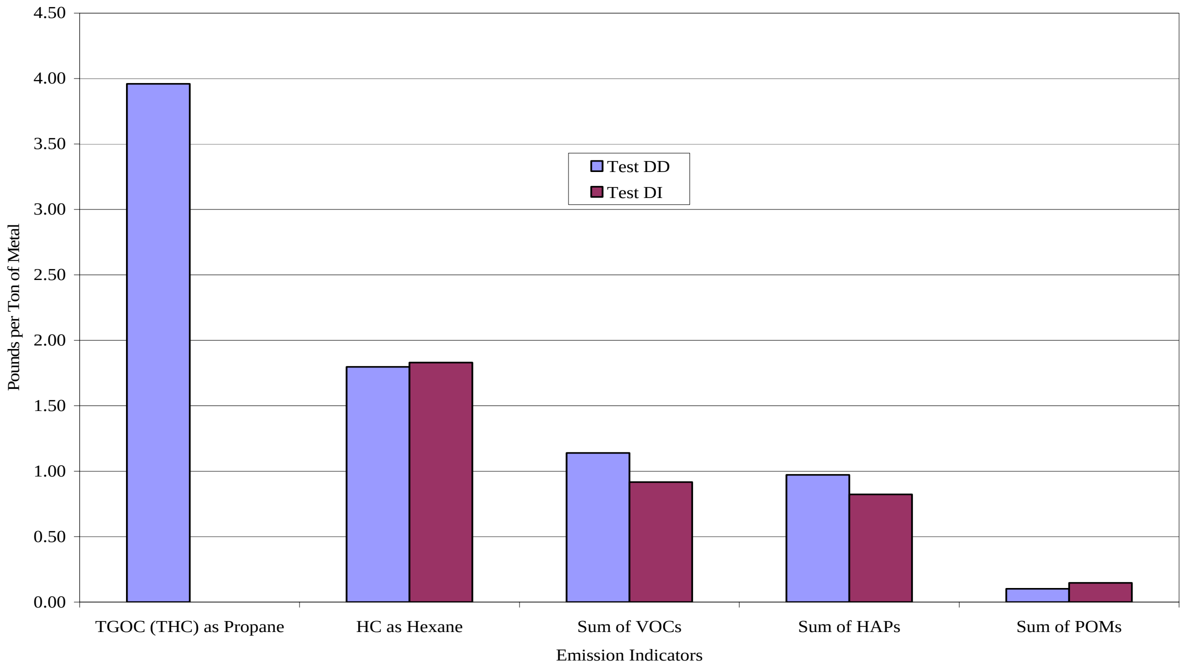


Figure 3 Comparison of Selected HAPs for Production Baseline DD and Test DI Sand System and Combined PCS

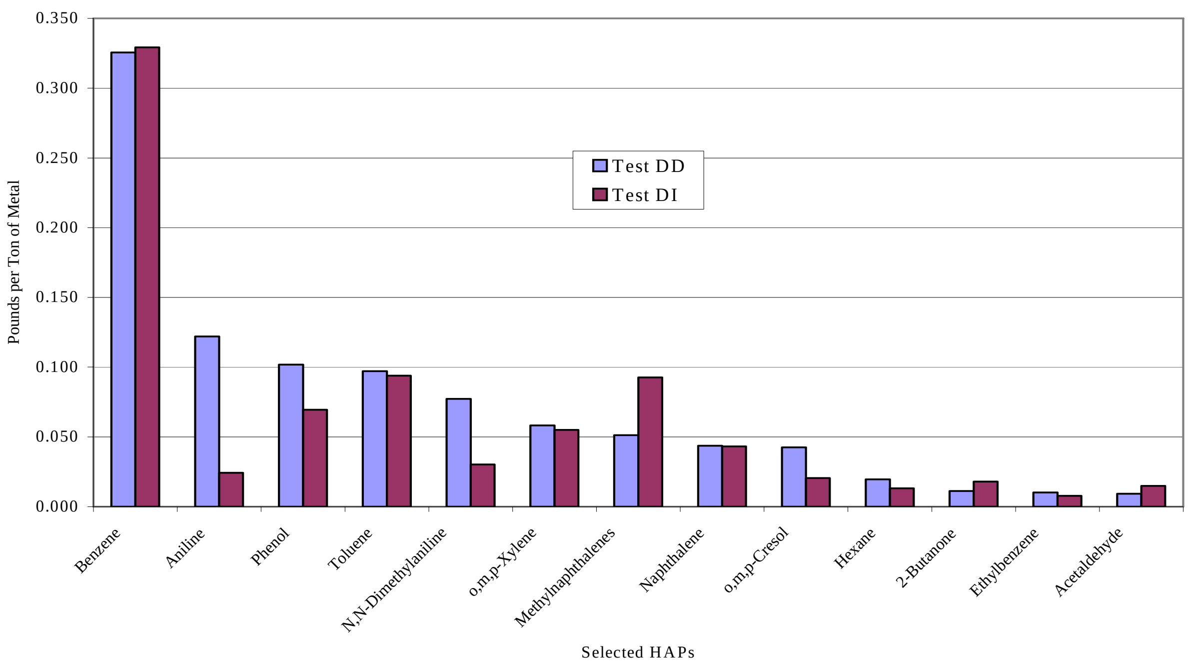


Figure 4 Comparison of Selected VOCs for Production Baseline DD and Test DI Sand System and Combined PCS

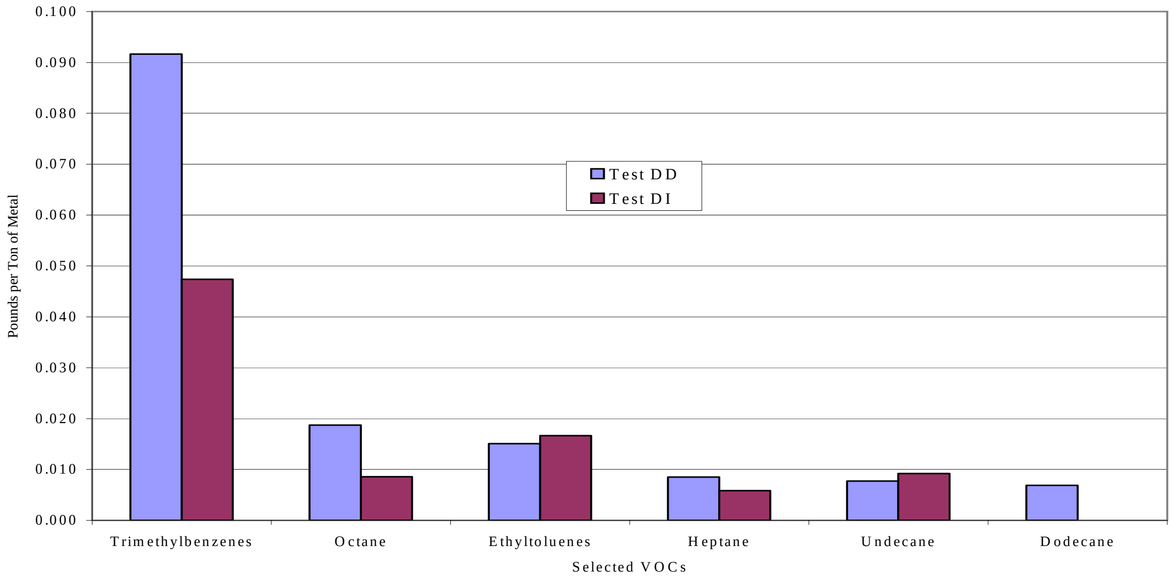


Figure 5 Comparison of Emission Indicators for Production Baseline DD and Test DI Sand System

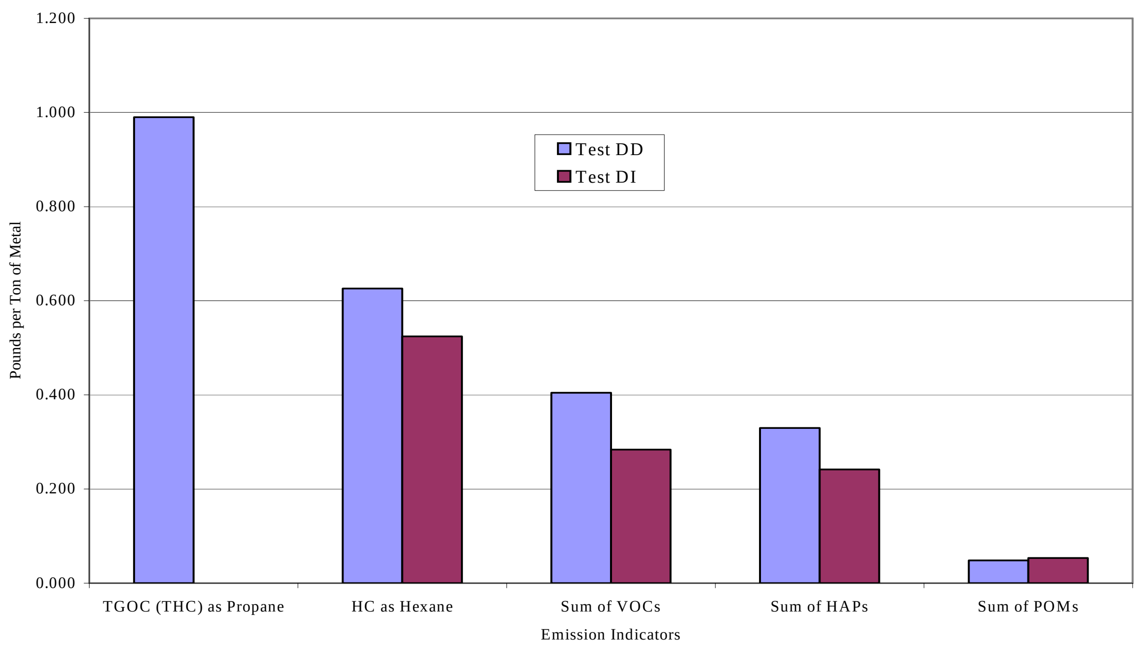


Figure 6 Comparison of Selected HAPs for Production Baseline DD and Test DI Sand System

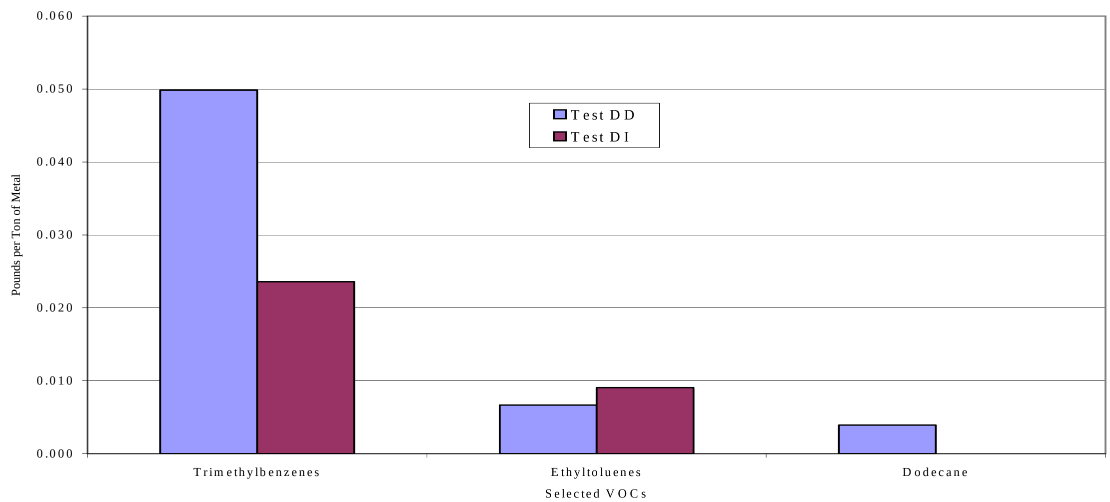


Figure 7 Comparison of Selected VOCs for Production Baseline DD and Test DI Sand System

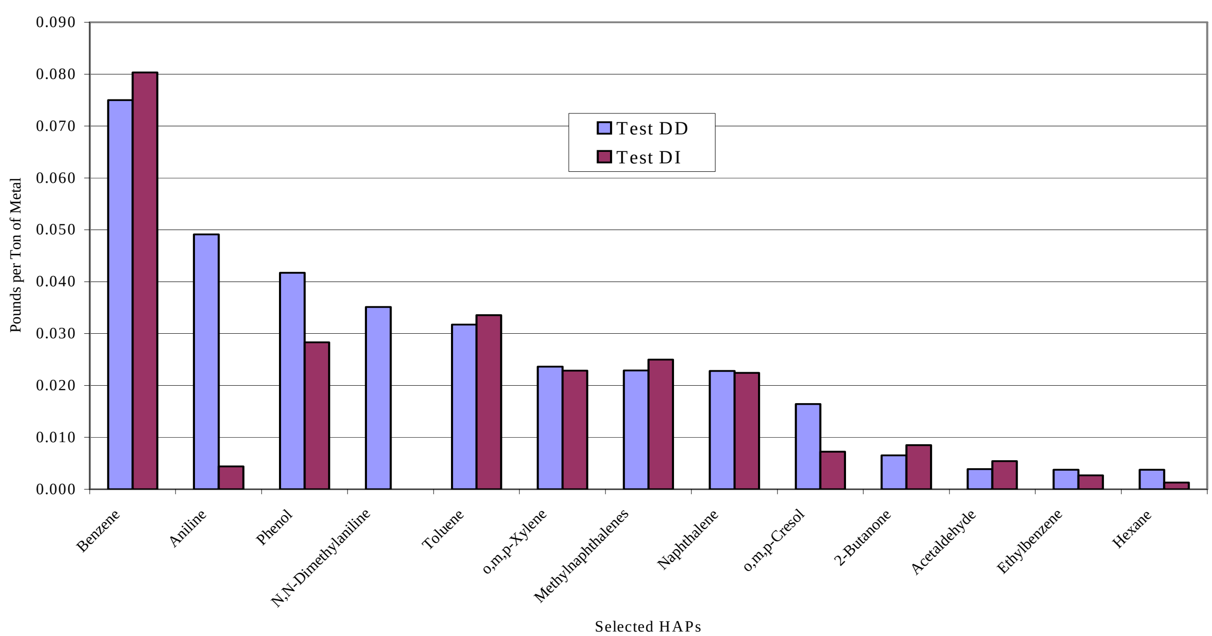


Figure 8 Comparison of Selected Emission Indicators for Production Baseline DD and Test DI - Combined PCS

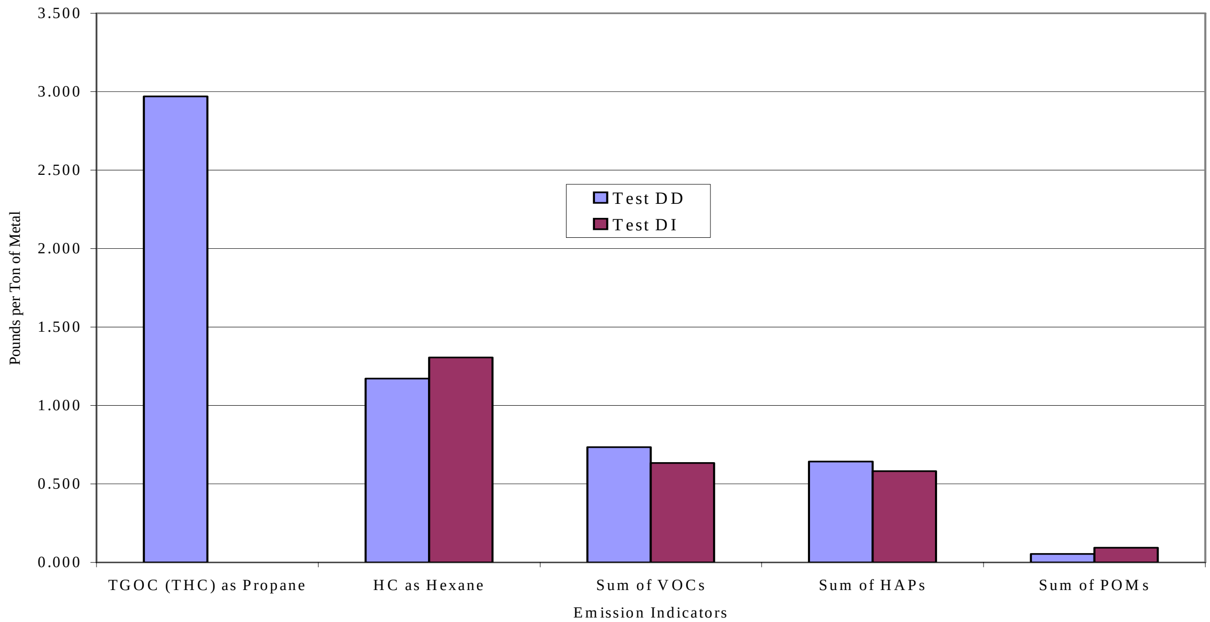


Figure 9 Comparison of Selected HAPs for Production Baseline DD and Test DI Combined PCS

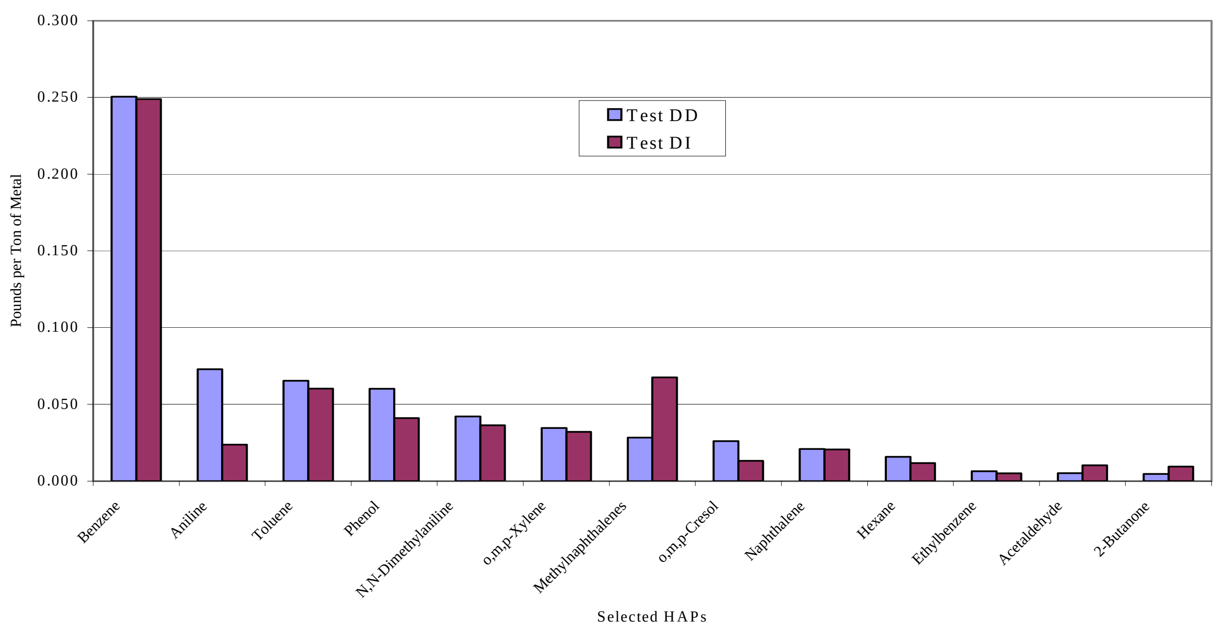
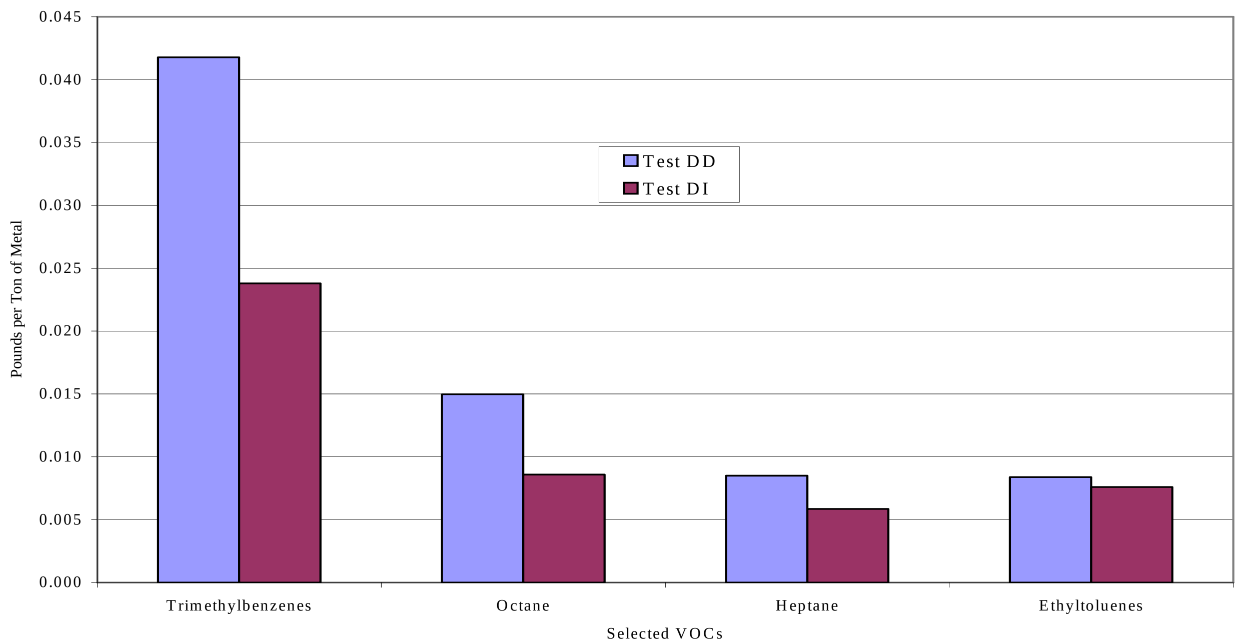


Figure 10 Comparison of Selected VOCs for Production Baseline DD and Test DI - Combined PCS



4.0 Discussion of Results

Protocols used for the core production, greensand preparation, collection of process parameters, sampling, and analysis for this test series DI were consistent with those used for previous Production Foundry baseline testing (DD). In addition, samples were collected in Tedlar bags, and analyzed for carbon monoxide, carbon dioxide, methane, and volatile hydrocarbons in the range of C2 to C5. Three samples were collected from the sand system and one from pouring/cooling/shakeout.

Emission indicators including TGOC (THC) as propane, HC as hexane, and the sums of measured VOCs (volatile organic compounds), HAPs (hazardous air pollutants), and POMs (polycyclic organic materials), are shown in Table 7. Two methods were employed to measure undifferentiated hydrocarbon emissions in Baseline Test DD, TGOC (THC) as Propane, performed in accordance with EPA Method 25A, and HC as Hexane by NIOSH Method 1500. Distinct differences in methodologies are present in each method that would be expected to produce dissimilar results. 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 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).

Results for Baseline Test DD show that hydrocarbon emissions from pouring/cooling/shakeout, measured as TGOC (THC) as Propane, comprised approximately 75% of the total TGOC emissions measured from both stacks, and sand system TGOC emissions comprised 25% of the total.

Results for TGOC (THC) as Propane are not available for Test Series DI. The data was rejected due to data validation considerations because the analyzer used to collect the data exhibited extreme instability over the course of the test series. Therefore the comparison with Baseline Test DD could not accurately be made. Charts showing TCOC (THC) results for Test Series DI are included in Appendix B of this report.

When reported as HC as hexane, measurements from Baseline Test DD showed that pouring/cooling/shakeout emissions comprised 65% of the total from both stacks, and sand system HC (hexane) emissions comprised 35% of the total. For Test Series DI, HC as hexane measurements showed that pouring/cooling/shakeout emissions comprised 71% of the total from both stacks, and sand system HC (hexane) emissions comprised 29% of the total.

In terms of individual HAPs, benzene is found to be the most abundant in both the sand system and in pouring/cooling/shakeout. This was true for both the Baseline Test (DD), and for the current Test Series (DI). In the Baseline Test (DD), approximately 20% of the total amount of benzene was measured in the sand system exhaust and 80% was measured in the combined pouring/cooling/shakeout exhaust. In Test Series DI, approximately 24% of the total amount of benzene was measured in the sand system exhaust and 76% was measured in the combined pouring/cooling/shakeout exhaust.

The process data indicates that the process was operated within acceptable ranges. See Appendix A for test plans and Appendix C for process data. The MB Clay values, however, were high with no supportive reason for the occurrence. One possible explanation is that the [redacted] influences the standard MB Clay test.

APPENDIX A APPROVED TEST PLAN FOR TEST SERIES DD AND DI

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TECHNIKON/CERP TEST PLAN

- **CONTRACT NUMBER:** 1256 **TASK NUMBER:** 120
- **CONTROL NUMBER:** RE 2 00099
- **SAMPLE FAMILY:** DD
- **SAMPLING EVENT:** 001 thru 006 Stack 1 (Total Sand System & Re-claimed Sand from Pits)
- **SAMPLING EVENT:** 021 thru 026 Stack 3 (Combined Pouring, Cooling, & Shakeout)
- **SITE:** ____**PRE-PRODUCTION(243)**__X__ **PRODUCTION(238)**
- **TEST TYPE:** Production Foundry Quality Baseline
- **MOLD TYPE: New** Greensand with H&G Seacoal
- **NUMBER OF MOLDS POURED:** 250
- **CORE TYPE:** Ashland Cores with Standard 1.75 ISOCURE® 305/904 Resin
- **TEST DATES:** **START:** 11/21/2000
  FINISH: 11/21/2000

TEST OBJECTIVES:

Primary: To measure the emissions from this new greensand mixture under the dynamic conditions of the Production foundry.
Secondary: Evaluate the casting quality of the I-4 engine block produced by this method.
Tertiary: Establish the protocol to create new production foundry sand systems to be used in establishing the production foundry baseline and future tests to be compared to this baseline.

VARIABLES:
All molds will be made using all new sand system materials consisting of Wexford W450 Lake Sand, 8.0-8.5% Western & Southern Bentonites in a 5:2 ratio and H&G seacoal to make 5% LOI. Pouring temperature shall be nominally 2630ºF. The cores are made with Wexford Lake Sand and 1.75% ISOCURE® resin (based on sand) in the proportion 55% Part I (LF305) and 45% Part II (904GR).

BRIEF OVERVIEW: This test must simultaneously establish an emission profile and a casting surface quality characteristic. It is known in the industry that to establish an acceptable green sand casting surface quality level the sand system must have a degree of maturity to allow the sand and organic material distributions to stabilize and fill interstitial voids. This happens as a consequence of the casting process itself. It is not practical to frequently do this and cleanly change materials for different tests. We will therefore establish a protocol to reproducibly create new sand systems with a standard degree of maturation which produces a standard casting quality, less than a mature sand system would produce. All subsequent material tests would be done in new sand systems, containing the test material, assembled to the standard protocol established herein.

SPECIAL CONDITIONS: The new materials: sand, western bentonite, southern bentonite, and seacoal will be blended in a single pass through the muller. Excess clays will be added to the original mixture to allow subsequent casting cycles to degrade them without further additions to form interstitial fines. The assembled sand system shall undergo two additional mulling-only passes to homogenize and pulverize the materials and develop much of the clay's potential. The sand system shall be subjected to 100 molds (approximately 1-1/4 turns) of star castings to promote the thermal aging without the influence of new core sand dilution and organic input. Finally the sand system shall be subjected to 100 molds of I-4 engine block castings (approximately 1-1/4 turns). This point will be the standard start point for the baseline and all comparative tests.

Original Signed	11/15/00
Manager Process Engineering (Technikon)	**Date**
Original Signed	11/15/00
V.P. Measurement Technologies (Technikon)	**Date**
Original Signed	11/15/00
V.P. Operations (Technikon)	**Date**
Original Signed	12/5/00
Emissions Team (USCAR)	**Date**
Original Signed	12/5/00
Process and Facilities Team (USCAR)	**Date**
Original Signed	2/12/00
Project Manager (CTC)	**Date**

Series DD

Pilot Foundry Casting Quality Baseline

Process Instructions

A. Introduction: The surface quality of an iron casting made in green sand is established predominantly by the effective size of open pores between the grains of the molding media usually sand. The smaller the interstitial sand grain opening the greater is the resistance to hydrostatic penetration between the sand grains by the liquid metal. A variety of methods can be employed to reduce the effective pore size including methods that enhance mechanical compaction or densification, engineering the mold materials to be composed of several intertwined size gradations, exercising engineering controls over sand preparation, or limiting the metallo-static pressure by limiting the depth of the liquid metal. When all these things are done the very casting process itself causes the materials to fracture and fill in pores in an evolutionary manner. Because there are so many different methods, each with its own set of unintended consequences, a standard protocol which includes all the above methods and the time evolution of the sand must be established to create a standard finish against which castings made with emission reducing materials can be compared. The time requirement to mature a sand system to achieve a good surface finish is at odds with the need to quickly and economically replace the whole sand system when different materials are to be tested. Of necessity, therefore, a standard protocol is to be established where an immature sand system can be assembled to achieve a standard acceptable surface finish against which castings from other experiments can be compared.

B. Experiment: Establish a greensand baseline in the production foundry from new materials assembled and matured to a standard protocol to which subsequent mold material replacements and alternative a processing can be compared.

C. Materials: Wexford W450 Lake sand, major brand Western and Southern Bentonite, Hill and Griffith D-4 grind Seacoal (bituminous coal), and tap water.

D. Equipment preparation:

Note: Start and operate the production foundry equipment only according to the Production Foundry Operating and Safety Manual.

1. Start the sand system baghouse and visually verify the air flow control dampers are in the standard position established in November 2000.

   a) Report the survey results.
   b) Correct any deviations.

2. Start the sand system equipment.

a) Start the mold line with at least 2 cooling lines operative.

E. SAND PREPARATION DURING PRE-CONDITIONING.

1. Transfer stored sand out of the main sand hopper to be used for the pending test.
2. Clean the areas of the sand system that tend of accumulate sand e.g. elevators, cooler, muller, storage hoppers, and pits.
3. Feed 50 tons of new Lake Sand to the emptied cleaned sand storage tower.
4. Stop the cooler surge hopper discharge conveyor belt to prevent blended mold sand from mixing with raw lake sand.
5. Set the muller batch size to 4400 pounds for the Wexford W450 Lake sand only.
6. Add sand, western & southern bentonite and seacoal to the production muller according to the following table:

a) Feed Wexford W450 Lake sand via the muller weigh hopper ....4400 Lbs.
b) Manually add Western bentonite (5-50 Lb. bags) ....250 Lbs.
c) Manually add Southern bentonite (2-50 Lb. bags) ....100 Lbs.
d) Manually add H&G D-4 grind Seacoal (5-50 Lb. Bags).........................250 Lbs.
e) Total batch weight...5000 Lbs.

Note: This recipe should yield about 10 % MB clay and 5% LOI. The final start target is 8.25 +/- 0.5% MB clay and 5 +/- 0.3% LOI. The excess clay is deliberate to generate interstitial inert fines from decomposition of the clays with heat without adding any more virgin clays until the test starts. New organics will have to be added during the conditioning as these do not “develop” from mechanical work beyond the raw materials as clays do.

7. Add three (3) gallons of water to suppress dust and damp mull the sand for 3 minutes.

a) Temper the sand, while continuing to mull, with sufficient tap water to achieve 32-38% compactability. Total mull time about 5 minutes.

Note: Observe the muller power meter so as to not overload the muller motor.
Note: It will take about 23 muller batches to process the 50 tons of raw sand into about 57 tons of molding sand.

8. Grab a bag of sand from one of the first 5 muller batches, seal it, and take it immediately to the sand lab for analysis. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.
9. The sand lab is to immediately, upon receipt, perform the following green property sand tests:

a) Sand temperature.
b) Moisture.
c) Compactability.

- **d)** 2 by 2 sample weight.
- **e)** Green compression strength on a 2 by 2 standard test sample.

10. The following sand tests should be started upon completion of the above tests:
- **a)** MB clay.
- **b)** Mold LOI.
- **c)** AFS clay wash.
- **d)** GFN analysis

11. Begin making molds without cores. Engine blocks without cores may mold and break up more easily in the shakeout than stars considering that no iron will have been poured in them.

Note: It is expected that for each mold made 1300 pounds will be retained in the mold and 600 pounds will return to the 40000 pound capacity cooler surge hopper where it must be captured. The cooler surge hopper should hold tempered sand from about 55 molds.

12. Process all the raw sand before returning the blended sand to the main storage hopper.

Note: When the raw sand is exhausted turn on the cooler surge hopper discharge conveyor belt.

13. Empty the mold line to the return sand system**.**

Note: There will probably be substantial green sand lumps coming off the shakeout which will have to be dealt with at the shakeout.

14. Re-set the muller batch size to 5000 pounds.
15. Re-mull the system sand for two (2) additional turnovers of the sand system, about 50 muller batches, with the standard 3 minute door-to-door mulling cycle. Make re-bond additions as directed by the process engineer, none are expected.
16. Grab bags of sand for the sand lab once near the end of each turnover, 25 muller batches. Record the batch cycle number when the sand sample was taken.
17. The sand lab will repeat the sand test series described in E.8-E.9.

F. SAND PREPARATION DURING THERMAL CONDITIONING

1. The process engineer will provide a re-bond recipe at startup based on the last sand sample from the pre-conditioning cycle.
2. The sand moisture content shall be adjusted so that a compactability of 36-40% is achieved.
3. Begin sand sampling shortly after hot sand comes back to the muller and every 25-30 muller batches thereafter to the end of the test. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.

4. Sample the sand from the last muller cycle. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.
5. The sand lab will repeat the sand test series described in E.8-E.9.
6. From time to time the process engineer will change the re-bond recipe to reflect current values and maintain the system within the prescribed targets.
7. Return all the sand to the main sand bin.
8. This point will be considered the standard sand system for comparative production foundry tests.

G. SAND PREPARATION DURING TESTING

1. The process engineer will provide a re-bond recipe at startup based on the last sand sample from the thermal conditioning cycle.
2. The sand moisture content shall be adjusted so that a compactability of 36-40% is achieved.
3. The standard sand sampling frequency shall be once each 25-30 muller batches. (1.1-1.3 turnovers of the sand system)
4. From time to time the process engineer will change the re-bond recipe to reflect current values and maintain the system within the prescribed targets.

Note: Until we establish the process capability of the sand system the sand sampling frequency shall be once each 5 batches during official test periods. (5 times per sand system turnover)

Note: The sand tests and timing of running the sand tests remains the same as in E.8 & E.9 above. The supplemental tests may be deferred to a strategically convenient time excepting there from the green property test of E.8 which must be done when the samples are fresh.

H. CORE MANUFACTURE

1. Standard uncoated banded Isocure® I-4 engine block cores shall be used.
2. Mix the core sand using Wexford W-450 Lake sand with 1.75% total resin BOS. The resin shall be Ashland Isocure® LF305 Part I (55%) and 904GR Part II (45%).
3. Manufacture 250 sets of cores on the Georg Fisher core machine.
4. Use the Core Process Machine Parameters- George Fischer Core Machine, effectivity date 1 Jan 2000, to setup the core machine.
5. 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 50 shall be marked with a hold tag until they can be 100% scratch hardness tested to re-qualify. Scrap all cores with values less than 50.
6. The Laboratory shall run core LOI on the core batches. Qualified cores shall be QUALITY CHECK tagged before being sent to the production floor.
7. Until we are able to establish the capability of the new sand delivery a sample of the raw Wexford W450 sand shall be taken each 5-7 mixer batches (once per half hour). A 1400^{o} LOI and a screen analysis shall be preformed on each.

I. MOLD MAKING DURING THERMAL CYCLING

1. The mold line will operate at 25 molds per hour down a single cooling line, either lines 1 or 2.

Note: Only one line can be used or the sand system would run out of sand in the main storage hoppers before the sand returns from the molds.

2. Make and pour 75 molds with the star pattern. (1.3 turnovers of the sand system)
3. Make and pour 75 molds of the I-4 engine block with cores. The baseline will use standard Isocure® cores. Other tests may use other core materials. (1.3 turnovers of the sand system)

Note: The inclusion of engine block molds with their cargo of Isocure® core is to impart to the system sand a standard amount of core originated condensable material.

J. Mold making during the Casting Quality baseline test.

1. The mold line will operate at 25 molds per hour down a single cooling line, either lines 1 or 2.
2. Warm up the sand system with one turn over using Isocure® bonded engine block cores. Use the change in the temperature of the return sand as evidence of compliance.
3. Operate sufficient time to gather six 1-hour samples in a single day while the cooling line is full of molds of similar age.
4. The emission sampling team shall qualify each sample period based on acceptance criteria in the sample plan.

K. MELTING

1. One melt furnace will be used.
2. Furnace charges shall conform to the generic Startup Charge (effectivity date 9 Mar 1999) and Back Charge (effectivity date 9 Apr 1999) recipes.
3. Pour the engines at 2630 +/- 30^{o}F.
4. The molds shall be poured full.
5. A record shall be kept for the melt furnace and pouring furnace operation. Where double tapping and charging are employed the record shall reflect the aggregate charge additions but separate tap events.
6. Each melt heat shall have a Data Cast test and a spectrometer lug poured. Where double tapping and charging are employed only one test need be performed for the pair.
7. The pour furnace operator shall pour and submit a spectrometer lug after the initial filling and each hour thereafter until cessation of pouring.
8. It is imperative that the pouring be continuous during each of the 6-1 hr emission tests
9. The emission testing shall not begin until hot castings continuously come out of the shake out.
10. The Metallurgical lab will do spectrochemical analysis on all spectro lugs.

L. CASTING SAMPLING

1. Thirty-two castings shall be sampled randomly throughout the test period, isolated and hand brushed and ranked by 5 persons in descending order of appearance base on a defined set of criteria. The criteria shall be set out in a supplemental document but shall include: casting general appearance, surface roughness in flat vertical surfaces, mechanical penetration in corners, swells, and expansion defects.
2. Thirty-six (36) castings in groups of 4 shall be sampled randomly though out the test period, isolated and shot blast cleaned to various cleaning times ranging from 4 minutes to 20 minutes in 2 minute increments and ranked by 5 persons in descending order of appearance base on a defined set of criteria. The criteria shall be set out in a supplemental document but shall include: casting general appearance, surface roughness in flat vertical surfaces, mechanical penetration in corners, swells, and expansion defects to establish a shot blast cleaning standard
3. Thirty-two castings shall be sampled randomly throughout the test period, isolated and shot blast cleaned to the pre-established standard and ranked by persons in descending order of appearance base on a defined set of criteria. The criteria shall be set out in a supplemental document but shall include: casting general appearance, surface roughness in flat vertical surfaces, mechanical penetration in corners, swells, and expansion defects.

M. SHAKEOUT

1. Hang 68 engine blocks on the casting cooling conveyor for shot blast cleaning.
2. Set aside 32 castings for hand brush cleaning.

N. CASTING CLEANING

1. Shot blast clean 9 groups of 4 castings for increasing periods of time beginning at 4 minutes and increasing to 20 minutes in 2 minute increments.

   a) Lay the groups on the floor in order and determine the best cleaning time.

2. Shot blast 32 castings for the time determined in N.1.a.

   a) Lay these on the floor side by side ranked in order of quality as defined in section L.
   b) Permanently mark the ranking order on the castings and store them safely in a readily accessible location. These casting will have to be laid out against future test castings as the quality reference for shot blast castings.

3. Hand brush 32 castings to remove loose sand.

   a) Lay these on the floor side by side ranked in order of quality as defined in section L.
   b) Permanently mark the ranking order on the castings and store them safely in a readily accessible location. These casting will have to be laid out against future test castings as the quality reference for hand-brush cleaned castings.

Steve Knight
Mgr. Process Engineering

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 1											Train: CERP # 2
Airsense											
THC	DD00102	X									M-25a
M-18 by MS	DD00103		1						25	1	M-18 by MS - Low Volume
M-18 by MS	DD00104				1				0		QC M-18 by MS - Low Volume Blank
M-18	DD00105		1						25	2	FID - M-18
M-18	DD00106				1				0		QC M-18 FID Blank
M-18	DD00107		1						60	3	M18 FID
M-18	DD00108				1				0		QC M-18 FID Blank
M-18 by MS	DD00109		1						60	4	M-18 MS
M-18 by MS	DD00110				1				0		QC - M-18 MS Blank
Niosh 1500	DD00111		1						500	5	Orbo 32L
Niosh 1500	DD00112			1					500	6	Orbo 32L, Duplicate (2 Runs only #1 & #4)
Niosh 1500	DD00113				1				0		Orbo 32L
TO11	DD00114		1						500	7	
TO11	DD00115			1					500	8	Duplicate (2 Runs only #1 & #4)
TO11	DD00116				1				0		QC
GAS,CO + CO2	DD00117		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD00118		1						750	10	(SKC 226-15)
NIOSH 2002	DD00119			1					750	11	SKC226-15, Duplicate (2 Runs only #1 & #4)
NIOSH 2002	DD00120				1				0		QC,(SKC 226-15)
Moisture									500	12	
Excess									5000	13	
PUF	DD00121										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 2											Train: CERP # 2
Airsense											
THC	DD00202	X									M-25a
M-18 by MS	DD00203		1						25	1	M18-MS Low Volume
M-18 by MS	DD00204					1			25	1	Low Volume (Breakthrough)
M-18	DD00205		1						25	2	M-18 Low Volume
M-18	DD00206					1			25	2	Low Volume (Breakthrough)
M-18	DD00207		1						60	3	M-18
M-18	DD00208					1			60	3	M-18 (Breakthrough)
M-18 by MS	DD00209		1						60	4	M-18 MS
M-18 by MS	DD00210					1			60	4	M-18 MS (Breakthrough)
Niosh 1500	DD00211		1						500	5	Orbo 32L
Excess									500	6	Excess
TO11	DD00212		1						500	7	
TO11	DD00213					1			500	7	TO11 (Breakthrough)
Excess									500	8	Excess
GAS,CO + CO2	DD00214		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD00215			1					750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD00216										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 2
Airsense											
THC	DD00302	X									M-25a
M-18 by MS	DD00303		1						25	1	M-18 MS Low Volume
M-18	DD00304		1						25	2	M-18 Low Volume
M-18	DD00305		1						60	3	M-18
M-18 by MS	DD00306		1						60	4	M-18 MS
Niosh 1500	DD00307		1						500	5	Orbo 32L
Excess									500	6	Excess
TO11	DD00308		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD00309		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD00310		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD00311										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 2
Airsense											
THC	DD00402	X									M-25a
M-18 by MS	DD00403		1						25	1	M-18 MS Low Volume
M-18	DD00404		1						25	2	M-18 Low Volume
M-18	DD00405		1						60	3	M-18
M-18 by MS	DD00406		1						60	4	M-18 MS
Niosh 1500	DD00407		1						500	5	Orbo 32L
Niosh 1500	DD00408			1					500	6	Orbo 32L, Duplicate (2 Runs only #1 & #4)
TO11	DD00409		1						500	7	
TO11	DD00410			1					500	8	Duplicate (2 Runs only #1 & #4)
GAS,CO + CO2	DD00411		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD00412		1						750	10	(SKC 226-15)
NIOSH 2002	DD00413			1					750	11	SKC226-15, Duplicate (2 Runs only #1 & #4)
Moisture									500	12	
Excess									5000	13	
PUF	DD00414										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 2
Airsense											
THC	DD00502	X									M-25a
M-18 by MS	DD00503		1						25	1	M-18 MS Low Volume
M-18	DD00504		1						25	2	M-18 Low Volume
M-18	DD00505		1						60	3	M-18
M-18 by MS	DD00506		1						60	4	M-18 MS
Niosh 1500	DD00507		1						500	5	Orbo 32L
Excess									500	6	Excess
TO11	DD00508		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD00411		1						25	9	BAG Sample used from test DD004.
NIOSH 2002	DD00510		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD00511										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 6											Train: CERP # 2
Airsense											
THC	DD00602	X									M-25a
M-18 by MS	DD00603		1						25	1	M-18 MS Low Volume
M-18	DD00604		1						25	2	M-18 Low Volume
M-18	DD00605		1						60	3	M-18
M-18 by MS	DD00606		1						60	4	M-18 MS
Niosh 1500	DD00607		1						500	5	Orbo 32L
Excess									500	6	Excess
TO11	DD00608		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD00411		1						25	9	BAG Sample used from test DD004.
NIOSH 2002	DD00610		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD00611										

FOUNDRY QUALITY BASELINE - SAND SYSTEM (STACK 1) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 7											Train: CERP # 2
Airsense											
THC	DD00702	X									M-25a
M-18 by MS	DD00703		1						25	1	M-18 MS Low Volume
M-18	DD00704		1						25	2	M-18 Low Volume
M-18	DD00705		1						60	3	M-18
M-18 by MS	DD00706		1						60	4	M-18 MS
Niosh 1500	DD00707		1						500	5	Orbo 32L
Excess									500	6	Excess
TO11	DD00708		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD00411		1						25	9	BAG Sample used from test DD004.
NIOSH 2002	DD00710		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD00711										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 1											Train: CERP # 1
Airsense											
THC	DD02102	X									M-25a
M-18 by MS	DD02103		1						25	1	M-18 by MS - Low Volume
M-18 by MS	DD02104				1				0		QC M-18 by MS - Low Volume Blank
M-18	DD02105		1						25	2	FID - M-18
M-18	DD02106				1				0		QC M-18 FID Blank
M-18	DD02107		1						60	3	M18 FID
M-18	DD02108				1				0		QC M-18 FID Blank
M-18 by MS	DD02109		1						60	4	M-18 MS
M-18 by MS	DD02110				1				0		QC - M-18 MS Blank
Niosh 1500	DD02111		1						250	5	Orbo 32L
Niosh 1500	DD02112			1					250	6	Orbo 32L, Duplicate (2 Runs only #1 & #4)
Niosh 1500	DD02113				1				0		Orbo 32L
TO11	DD02114		1						500	7	
TO11	DD02115			1					500	8	Duplicate (2 Runs only #1 & #4)
TO11	DD02116				1				0		QC
GAS,CO + CO2	DD02117		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD02118		1						750	10	(SKC 226-15)
NIOSH 2002	DD02119			1					750	11	SKC226-15, Duplicate (2 Runs only #1 & #4)
NIOSH 2002	DD02120				1				0		QC,(SKC 226-15)
Moisture									500	12	
Excess									5000	13	
PUF	DD02121										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 2											Train: CERP # 1
Airsense											
THC	DD02202	X									M-25a
M-18 by MS	DD02203		1						25	1	M18-MS Low Volume
M-18 by MS	DD02204					1			25	1	Low Volume (Breakthrough)
M-18	DD02205		1						25	2	M-18 Low Volume
M-18	DD02206					1			25	2	Low Volume (Breakthrough)
M-18	DD02207		1						60	3	M-18
M-18	DD02208					1			60	3	M-18 (Breakthrough)
M-18 by MS	DD02209		1						60	4	M-18 MS
M-18 by MS	DD02210					1			60	4	M-18 MS (Breakthrough)
Niosh 1500	DD02211		1						250	5	Orbo 32L
Excess									250	6	Excess
TO11	DD02212		1						500	7	
TO11	DD02213					1			500	7	TO11 (Breakthrough)
Excess									500	8	Excess
GAS,CO + CO2	DD02214		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD02215		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD02216										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 1
Airsense											
THC	DD02302	X									M-25a
M-18 by MS	DD02303		1						25	1	M-18 MS Low Volume
M-18	DD02304		1						25	2	M-18 Low Volume
M-18	DD02305		1						60	3	M-18
M-18 by MS	DD02306		1						60	4	M-18 MS
Niosh 1500	DD02307		1						250	5	Orbo 32L
Excess									250	6	Excess
TO11	DD02308		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD02309		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD02310		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD02311										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 1
Airsense											
THC	DD02402	X									M-25a
M-18 by MS	DD02403		1						25	1	M-18 MS Low Volume
M-18	DD02404		1						25	2	M-18 Low Volume
M-18	DD02405		1						60	3	M-18
M-18 by MS	DD02406		1						60	4	M-18 MS
Niosh 1500	DD02407		1						250	5	Orbo 32L
Niosh 1500	DD02408			1					250	6	Orbo 32L, Duplicate (2 Runs only #1 & #4)
TO11	DD02409		1						500	7	
TO11	DD02410			1					500	8	Duplicate (2 Runs only #1 & #4)
GAS,CO + CO2	DD02411		1						25	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DD02412		1						750	10	(SKC 226-15)
NIOSH 2002	DD02413			1					750	11	SKC226-15, Duplicate (2 Runs only #1 & #4)
Moisture									500	12	
Excess									5000	13	
PUF	DD02414										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)		Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 1
Airsense											
THC	DD02502	X									M-25a
M-18 by MS	DD02503		1						25	1	M-18 MS Low Volume
M-18	DD02504		1						25	2	M-18 Low Volume
M-18	DD02505		1						60	3	M-18
M-18 by MS	DD02506		1						60	4	M-18 MS
Niosh 1500	DD02507		1						250	5	Orbo 32L
Excess									250	6	Excess
TO11	DD02508		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD02411		1						25	9	BAG Sample reused from Test DD024.
NIOSH 2002	DD02510		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD02511										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 6											Train: CERP # 1
Airsense											
THC	DD02602	X									M-25a
M-18 by MS	DD02603		1						25	1	M-18 MS Low Volume
M-18	DD02604		1						25	2	M-18 Low Volume
M-18	DD02605		1						60	3	M-18
M-18 by MS	DD02606		1						60	4	M-18 MS
Niosh 1500	DD02607		1						250	5	Orbo 32L
Excess									250	6	Excess
TO11	DD02608		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD02411		1						25	9	BAG Sample reused from Test DD024.
NIOSH 2002	DD02610		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD02611										

FOUNDRY QUALITY BASELINE - TOTAL PCS (STACK 3) DD SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
11/21/00											SAMPLES TO CLAYTON LAB
TEST 7											Train: CERP # 1
Airsense											
THC	DD02702	X									M-25a
M-18 by MS	DD02703		1						25	1	M-18 MS Low Volume
M-18	DD02704		1						25	2	M-18 Low Volume
M-18	DD02705		1						60	3	M-18
M-18 by MS	DD02706		1						60	4	M-18 MS
Niosh 1500	DD02707		1						250	5	Orbo 32L
Excess									250	6	Excess
TO11	DD02708		1						500	7	
Excess									500	8	Excess
GAS,CO + CO2	DD02411		1						25	9	BAG Sample reused from Test DD024.
NIOSH 2002	DD02710		1						750	10	(SKC 226-15)
Excess									750	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DD02711										
M-18	DD02712						X		60		BOTTLE - Mix 1A
M-18	DD02713						X		60		BOTTLE- Mix 1A
TO11	DD02714						X		500		BOTTLE - Mix 2
TO11	DD02715						X		500		BOTTLE- Mix 2

TECHNIKON/CERP TEST PLAN

- **CONTRACT NUMBER:** 1256 **TASK NUMBER:** 110
- **CONTROL NUMBER:** RV 2 00104
- **SAMPLE FAMILY**: DI
- **SAMPLING EVENT:** 001 thru 006 Stack 1 (Sand System & Re-claimed Sand from Pits)
- **SAMPLING EVENT:** 021 thru 026 Stack 3 (Combined Pouring, Cooling,& Shakeout)
- **SITE: ____PRE-PRODUCTION(243)__X__ PRODUCTION(238)**
- **TEST TYPE:** Production Foundry [redacted]
- **MOLD TYPE:** New Greensand with [redacted]
- **NUMBER OF MOLDS POURED:** 250
- **CORE TYPE:** Ashland Cores with Standard 1.75 ISOCURE® 305/904 Resin
- **TEST DATES:** **START:** 21 Feb 2001
  FINISH: 21 Feb 2001

TEST OBJECTIVES:

Primary: To measure the emissions from this seacoal replacement mixture under the dynamic conditions of the Production foundry. This test to follow the methods of test Casting Quality Baseline DD. The strategy is to use a seacoal replacement that reduces LOI but is expected to maintain the casting surface finish.

Secondary: Compare the casting quality of the I-4 engine block produced by this method to those produced in test DD.

VARIABLES:
All molds will be made using all new sand system materials consisting of Wexford W450 Lake Sand, 8.0-8.5% Western & Southern Bentonites in a 5:2 ratio and [redacted] in a 50:50 mixture with H&G seacoal to make 4.7% LOI. Pouring temperature shall be nominally 2630ºF.
The cores are made with Wexford Lake Sand and 1.75% ISOCURE® resin (based on sand) in the proportion 55% Part I (LF305) and 45% Part II (904GR).

BRIEF OVERVIEW: This test must simultaneously establish an emission profile and a casting surface quality characteristic. It is known in the industry that to establish an acceptable green sand casting surface quality level the sand system must have a degree of maturity to allow the sand and organic material distributions to stabilize and fill interstitial voids. This happens as a consequence of the casting process itself. It is not practical to frequently do this and cleanly change materials for different tests. We will therefore follow a protocol to reproducibly create new sand systems with a "standard degree" of maturation which produces a "standard casting quality", less than a mature sand system would produce.

SPECIAL CONDITIONS: The new materials: sand, western bentonite, southern bentonite, [redacted] and H&G seacoal will be blended in a single pass through the muller. Excess clays will be added to the original mixture to allow subsequent casting cycles to degrade them without further additions to form interstitial fines. The assembled sand system shall undergo two additional mulling-only passes to homogenize and pulverize the materials and develop much of the clay's potential. The sand system shall be subjected to 2 turns (approximately 100 molds) of star castings to promote the thermal aging without the influence of new core sand dilution and organic input. Finally the sand system shall be subjected to 2 turns (approximately 100 molds) of I-4 engine block castings. This point will be the standard start point for the baseline and all comparative tests.

Original Signed	2/20/01
Manager Process Engineering (Technikon)	**Date**
Original Signed	2/20/01
V.P. Measurement Technologies (Technikon)	**Date**
Original Signed	2/20/01
V.P. Operations (Technikon)	**Date**
Original Signed	2/20/01
Emissions Team (USCAR)	**Date**
Original Signed	2/20/01
Process and Facilities Team (USCAR)	**Date**
Original Signed	4/25/01
Project Manager (CTC)	**Date**

Series DI

Pilot Foundry [redacted]

PROCESS INSTRUCTIONS

A. EXPERIMENT:

1. Measure the dynamic emission from a greensand having half of its seacoal replaced by [redacted], [redacted].
2. Determine the casting quality resulting from these materials applied in the standard manner relative to the standard casting quality.

B. INTRODUCTION:

1. The strategy in this experiment is to replace the seacoal with a 50/50 mixture of seacoal and [redacted] who's LOI and emissions are less than seacoal but which will not create significant deleterious casting finish.
2. The time requirement to mature a sand system to achieve a good surface finish is at odds with the need to quickly and economically replace the whole sand system when different materials are to be tested. Because there are so many different methods, each with its own set of unintended consequences, a protocol has been established in test DD, Casting Quality Baseline, with standard methods and time evolution of the sand to create a standard finish against which castings made with emission reducing materials are to be compared.

C. Materials: Wexford W450 Lake sand, major brand Western and Southern Bentonite, Hill and Griffith D-4 grind Seacoal (bituminous coal), [redacted], and tap water.

D. EQUIPMENT PREPARATION:

Note: Start and operate the production foundry equipment only according to the Production Foundry Operating and Safety Manual.

1. Start the sand system baghouse and visually verify the air flow control slide gates are in the standard position and the make-up air rings are adjusted to give the same flow rates in the various branch lines established in November 2000.

   a) REPORT THE SURVEY RESULTS.
   b) Correct any deviations.
   c) Start the sand system equipment.
   d) Start the mold line with at least 2 cooling lines operative.

2. **SAND PREPARATION DURING PRE-CONDITIONING.**

   a) Transfer stored sand out of the main sand hopper to be used for the pending test.

b) Clean the areas of the sand system that tend to\accumulate sand e.g. elevators, cooler, muller, storage hoppers, and pits.

c) Feed 50 tons of new Lake Sand to the emptied cleaned sand storage tower.

d) Stop the cooler surge hopper discharge conveyor belt to prevent blended mold sand from mixing with raw lake sand.

e) Set the muller batch size to 5000 pounds for the Wexford W450 Lake sand plus additives.

f) Manually run the residual sand from the elevator into the muller, record the batch number and weight.

g) Manually add western & southern bentonite and seacoal to the production muller via the north sand bin transfer belt according to the following table:

1)	Western bentonite (5-50 Lb. bags)	250 Lbs.
2)	Southern bentonite (2-50 Lb. bags)	100 Lbs.
3)	[redacted] (2.5-50Lb. Bags)	125 Lbs.
4)	H & G D-4 seacoal (2.5-50 Lb. Bags)	125 Lbs.

h) Record the accumulative weight with all the additives.

Note: The difference is the additive weight. Total additives weight should be 600 +/- 10 pounds. Contact the process engineer if this precision can not be maintained.

i) Add raw lake sand until the total batch weight is 5000 +/- 20 pounds. All the mold additives must be in the muller batch hopper before the balance of the lake sand is added.

Note: This recipe should initially yield about 9% MB clay and 5% LOI based on test BD where 7% clay addition yielded 8.6% MB clay initially and 5.44% of a 50/50 mixture of seacoal and [redacted] yielded a 4.73% LOI. The final start target after conditioning is 8.25 +/- 0.5% MB clay and 4.7 +/- 0.3% LOI. The excess clay is deliberate to generate interstitial inert fines from decomposition of the clays with heat without adding any more virgin clays until the test starts. New organics will have to be added during the conditioning as these do not "develop" from mechanical work beyond the raw materials as the clays do. The LOI will be maintained at the initial value =/- 0.3%. The THC output will be important in defining the real emission output.

j) Add three (3) gallons of water to suppress dust and damp mull the sand for 3 minutes. Temper the sand, while continuing to mull, with sufficient tap water to achieve 32-38% compactability. Total mull time about 5 minutes.

Note: Observe the muller power meter so as to not overload the muller motor.
Note: It will take about 23 muller batches to process the 50 tons of raw sand into about 57 tons of molding sand.

k) Grab a bag of sand from one of the first 5 muller batches, seal it, and take it immediately to the sand lab for analysis. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.

3. The sand lab is to immediately, upon receipt, perform the following green property sand tests:

   a) Sand temperature.
   b) Moisture.
   c) Compactability.
   d) 2 by 2 sample weight.
   e) Green compression strength on a 2 by 2 standard test sample.

4. The following sand tests should be started upon completion of the above tests:

   a) MB clay.
   b) Mold LOI.
   c) AFS clay wash.
   d) GFN analysis

5. Begin making molds without cores. Engine blocks without cores may mold and break up more easily in the shakeout than stars considering that no iron will have been poured in them.

Note: It is expected that for each mold made 1300 pounds will be retained in the mold and 600 pounds will return to the 40000 pound capacity cooler surge hopper where it must be captured. The cooler surge hopper should hold tempered sand from about 55 molds.

6. Process all the raw sand before returning the blended sand to the main storage hopper.

Note: When the raw sand is exhausted turn on the cooler surge hopper discharge conveyor belt.

7. Empty the mold line to the return sand system.

Note: There will probably be substantial green sand lumps coming off the shakeout which will have to be dealt with at the shakeout.

8. Re-set the muller batch size to 5000 pounds.
9. Re-mull the system sand for two (2) additional turnovers of the sand system, about 50 muller batches, with the standard 3 minute door-to-door mulling cycle. Make re-bond additions as directed by the process engineer, none are expected.
10. Grab bags of sand for the sand lab once near the end of each turnover, 25 muller batches. Record the batch cycle number when the sand sample was taken.
11. The sand lab will repeat the sand test series described in D.3 – D4.

E. SAND PREPARATION DURING THERMAL CONDITIONING

1. The process engineer will provide a re-bond recipe at startup based on the last sand sample from the pre-conditioning cycle.
2. The sand moisture content shall be adjusted so that a compactability of 36-40% is achieved. Begin sand sampling shortly after hot sand comes back to the muller and every 25-30 muller batches thereafter to the end of the test. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.
3. Sample the sand from the last muller cycle. Record the date, time, and batch cycle number counted from the beginning of the creation of the current system sand at each sampling.
4. The sand lab will repeat the sand test series described in D.3-D4.
5. From time to time the process engineer will change the re-bond recipe to reflect current values and maintain the system within the prescribed targets.
6. Return all the sand to the main sand bin.
7. This point will be considered the standard sand system for comparative production foundry tests.

F. SAND PREPARATION DURING TESTING

1. The process engineer will provide a re-bond recipe at startup based on the last sand sample from the thermal conditioning cycle.
2. The sand moisture content shall be adjusted so that a compactability of 36-40% is achieved.
3. The standard sand sampling frequency shall be once each 25-30 muller batches. (1.1-1.3 turnovers of the sand system)
4. From time to time the process engineer will change the re-bond recipe to reflect current values and maintain the system within the prescribed targets.

Note: Until we establish the process capability of the sand system the sand sampling frequency shall be once each 5 batches during official test periods. (5 times per sand system turnover)
Note: The sand tests and timing of running the sand tests remains the same as in D.3 & D.4 above. The supplemental tests may be deferred to a strategically convenient time excepting there from the green property test of D.3 which must be done when the samples are fresh.

G. Core manufacture

1. Standard uncoated banded Isocure® I-4 engine block cores shall be used.
2. Mix the core sand using Wexford W-450 Lake sand with 1.75% total resin BOS. The resin shall be Ashland Isocure® LF305 Part I (55%) and 904GR Part II (45%).
3. Manufacture 500 sets of cores on the Georg Fisher core machine.
4. Use the Core Process Machine Parameters- George Fischer Core Machine, effectivity date 1 Jan 2000, to setup the core machine.

5. 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 50 shall be marked with a hold tag until they can be 100% scratch hardness tested to re-qualify. Scrap all cores with values less than 50.
6. The Laboratory shall run core LOI on the core batches. Qualified cores shall be QUALITY CHECK tagged before being sent to the production floor.

Note: Until we are able to establish the capability of the new sand delivery a sample of the raw Wexford W450 sand shall be taken each 5-7 mixer batches (once per half hour). A 1050 degree LOI and a screen analysis shall be preformed on each.

H. MOLD MAKING DURING THERMAL CYCLING

1. The mold line will operate at 25 molds per hour down a single cooling line, either lines 1 or 2.

Note: Only one line can be used or the sand system would run out of sand in the main storage hoppers before the sand returns from the molds.

2. Make and pour 75 molds with the star pattern. (1.3 turnovers of the sand system)
3. Make and pour 75 molds of the I-4 engine block with cores. The baseline will use standard Isocure® cores. Other tests may use other core materials. (1.3 turnovers of the sand system)

Note: The inclusion of engine block molds with their cargo of Isocure® core is to impart to the system sand a standard amount of core originated condensable material.

4. During this thermal processing period collect a representative piece of core from those being set in the mold, bag it, marking with date and time, and send to the sand lab for 1050°F LOI analysis.

I. MOLD MAKING DURING THE VENDOR TEST.

1. The mold line will operate at 25 molds per hour down a single cooling line, either lines 1 or 2.
2. Warm up the sand system with one turn over using Isocure® bonded engine block cores. Use the change in the temperature of the return sand as evidence of compliance.
3. Operate sufficient time to gather six 1-hour samples in a single day while the cooling line is full of molds of similar age.
4. The emission sampling team shall qualify each sample period based on acceptance criteria in the sample plan.
5. During this vendor test period collect one representative piece of core from those being set in the mold each half hour, bag it, marking with date and time, and send to the sand lab for 1050°F LOI analysis.

J. MELTING

1. One melt furnace will be used.
2. Furnace charges shall conform to the generic Startup Charge (effectivity date 9 Mar 1999) and Back Charge (effectivity date 9 Apr 1999) recipes.
3. Pour the engines at 2630 +/- 30°F.
4. The molds shall be poured full.
5. A record shall be kept for the melt furnace and pouring furnace operation. Where double tapping and charging are employed the record shall reflect the aggregate charge additions but separate tap events.
6. Each melt heat shall have a Data Cast test and a spectrometer lug poured. Where double tapping and charging are employed only one test need be performed for the pair.
7. The pour furnace operator shall pour and submit a spectrometer lug after the initial filling and each hour thereafter until cessation of pouring.
8. It is imperative that the pouring be continuous during each of the 6-1 hr emission tests
9. The emission testing shall not begin until hot castings continuously come out of the shake out.
10. The Metallurgical lab will do spectrochemical analysis on all spectro lugs.

K. CASTING SAMPLING

1. Thirty (30) castings, 5 from each test period, shall be sampled randomly though out the test period, isolated and hand brushed and ranked by 5 persons in descending order of appearance base on a defined set of criteria. The criteria shall be set out in a supplemental document but shall include: casting general appearance, surface roughness in flat vertical surfaces, mechanical penetration in corners, swells, and expansion defects.
2. Thirty (30) castings in groups of 4 shall be sampled randomly though out the test period, isolated and shot blast cleaned for 8 minutes and ranked by 5 persons in descending order of appearance base on a defined set of criteria. The criteria shall be set out in a supplemental document but shall include: casting general appearance, surface roughness in flat vertical surfaces, mechanical penetration in corners, swells, and expansion defects to establish a shot blast cleaning standard

L. SHAKEOUT

1. Hang 30 engine blocks on the casting cooling conveyor for shot blast cleaning.
2. Set aside 30 castings for hand brush cleaning.

M. CASTING CLEANING

1. Shot blast 30 castings for 8 minutes.

   a) Retrieve the reference castings from the Casting Quality baseline
   b) DD and lay them on the floor in rank order.
   c) Have 5 persons rank these new shot blasted castings. Lay the shot blast castings, ranked in order of quality as defined in section L, on the floor beside the reference castings.

d) Rank the new castings relative to the reference castings.
e) Permanently mark the ranking order on the new castings. Restore both sets of castings.
f) Repeat N.1.a-d for the hand brushed castings.

Steve Knight
Manager Process Engineering

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 1											Train: CERP # 2
THC	DI00101	X									M-25a
M-18 by MS	DI00102		1						25	1	M-18 MS
M-18 by MS	DI00103				1				0	1	QC M-18 MS Blank
M-18 by MS	DI00104			1					25	2	M-18 MS Duplicate
M-18 by MS	DI00105				1				0	2	QC M-18 MS Blank
M-18	DI00106		1						60	3	FID - M-18
M-18	DI00107				1				0	3	QC M-18 FID Blank
M-18	DI00108			1					60	4	FID - M-18 Duplicate
M-18	DI00109				1				0	4	QC M-18 FID Blank
GAS,CO + CO2	DI00110		1						60	5	BAG Sample to Airtoxics Lab.
Niosh 1500	DI00111		1						500	6	Orbo 32S
Niosh 1500	DI00112			1					500	7	Orbo 32S, Duplicate
Niosh 1500	DI00113				1				0	7	Orbo 32S
TO11	DI00114		1						750	8	
TO11	DI00115			1					750	9	Duplicate
TO11	DI00116				1				0	9	QC Blank
NIOSH 2002	DI00117		1						1000	10	SKC 226-15
NIOSH 2002	DI00118			1					1000	11	SKC226-15, Duplicate
NIOSH 2002	DI00119				1				0	11	QC Blank - SKC 226-15
Moisture									500	12	
Excess									5000	13	
PUF	DI001		1								

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 2											Train: CERP # 2
THC	DI00201	X									M-25a
M-18 by MS	DI00202		1						25	1	M-18 MS
M-18 by MS	DI00203					1			25	1	M-18 MS Breakthrough
M-18 by MS	DI00204			1					25	2	M-18 MS Duplicate
M-18 by MS	DI00205					1			25	2	M-18 MS Breakthrough
M-18	DI00206		1						60	3	FID - M-18
M-18	DI00207					1			60	3	M-18 FID Breakthrough
M-18	DI00208			1					60	4	FID - M-18 Duplicate
M-18	DI00209					1			60	4	M-18 FID Breakthrough
GAS,CO + CO2	DI00210		1						60	5	BAG Sample to Airtoxics Lab.
Niosh 1500	DI00211		1						500	6	Orbo 32S
Excess									500	7	Excess
TO11	DI00213		1						750	8	
TO11	DI00214					1			750	8	Breakthrough
Excess									750	9	Excess
NIOSH 2002	DI00215		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	
PUF	DI002		1								

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 2
THC	DI00301	X									M-25a
M-18 by MS	DI00302		1						25	1	M-18 MS
M-18 by MS	DI00303			1					25	2	M-18 MS Duplicate
M-18	DI00304		1						60	3	M-18 FID
M-18	DI00305			1					60	4	M-18 FID Duplicate
Excess									60	5	Excess
Niosh 1500	DI00307		1						500	6	Orbo 32S
GAS,CO + CO2	DI00306		1						500	7	BAG Sample to Airtoxics Lab.
TO11	DI00308		1						750	8	
Excess									750	9	Excess
NIOSH 2002	DI00309		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI003		1								

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 2
THC	DI00401	X									M-25a
M-18 by MS	DI00402		1						25	1	M-18 MS
M-18 by MS	DI00403			1					25	2	M-18 MS Duplicate
M-18	DI00404		1						60	3	M-18 FID
M-18	DI00405			1					60	4	M-18 FID Duplicate
Excess									60	5	Excess
Niosh 1500	DI00407		1						500	6	Orbo 32S
Niosh 1500	DI00408			1					500	7	Orbo 32S Duplicate
TO11	DI00409		1						750	8	
GAS,CO + CO2	DI00406		1						750	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DI00411		1						1000	10	SKC 226-15
NIOSH 2002	DI00412			1					1000	11	SKC 226-15 Duplicate
Moisture	DI00413								500	12	
Excess									5000	13	Excess
PUF	DI004		1								

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 2
THC	DI00501	X									M-25a
M-18 by MS	DI00502		1						25	1	M-18 MS
M-18 by MS	DI00503			1					25	2	M-18 MS Duplicate
M-18	DI00504		1						60	3	M-18 FID
M-18	DI00505			1					60	4	M-18 FID Duplicate
Excess									60	5	Excess
Niosh 1500	DI00507		1						500	6	Orbo 32S
GAS,CO + CO2	DI00506		1						500	7	BAG Sample to Airtoxics Lab.
TO11	DI00508		1						750	8	
TO11	DI00510			1					750	9	
NIOSH 2002	DI00509		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI005		1								

VENDOR SEACOAL REPLACEMENT - SAND SYSTEM (STACK 1) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 6											Train: CERP # 2
THC	DI00601	X									M-25a
M-18 by MS	DI00602		1						25	1	M-18 MS
M-18 by MS	DI00603			1					25	2	M-18 MS Duplicate
M-18	DI00604		1						60	3	M-18 FID
M-18	DI00605			1					60	4	M-18 FID Duplicate
Excess									60	5	Excess
Niosh 1500	DI00607		1						500	6	Orbo 32S
GAS,CO + CO2	DI00606		1						500	7	BAG Sample to Airtoxics Lab.
TO11	DI00608		1						750	8	
Excess									750	9	
NIOSH 2002	DI00609		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI006		1								

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 1											Train: CERP # 1
THC	DI02101	X									M-25a
M-18 by MS	DI02102		1						25	1	M-18 MS
M-18 by MS	DI02103				1				0	1	QC M-18 MS Blank
M-18 by MS	DI02104			1					25	2	M-18 MS Duplicate
M-18 by MS	DI02105				1				0	2	QC M-18 MS Blank
M-18	DI02106		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02107				1				0	3	QC M-18 FID Blank
M-18	DI02108			1					40	4	FID - M-18 Duplicate **(RUBY)**
M-18	DI02109				1				0	4	QC M-18 FID Blank
GAS,CO + CO2	DI02110		1						60	5	BAG Sample to Airtoxics Lab.
Niosh 1500	DI02111		1						500	6	Orbo 32S
Niosh 1500	DI02112			1					500	7	Orbo 32S, Duplicate
Niosh 1500	DI02113				1				0	7	Orbo 32S
TO11	DI02114		1						750	8	
TO11	DI02115			1					750	9	Duplicate
TO11	DI02116				1				0	9	QC Blank
NIOSH 2002	DI02117		1						1000	10	SKC 226-15
NIOSH 2002	DI02118			1					1000	11	SKC226-15, Duplicate
NIOSH 2002	DI02119				1				0	11	QC Blank - SKC 226-15
Moisture									500	12	
Excess									5000	13	
PUF	DI021		1								

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 2											Train: CERP # 1
THC	DI02201	X									M-25a
M-18 by MS	DI02202		1						25	1	M-18 MS
M-18 by MS	DI02203					1			25	1	M-18 MS Breakthrough
M-18 by MS	DI02204			1					25	2	M-18 MS Duplicate
M-18 by MS	DI02205					1			25	2	M-18 MS Breakthrough
M-18	DI02206		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02207					1			40	3	M-18 FID Breakthrough
M-18	DI02208			1					40	4	FID - M-18 Duplicate **(RUBY)**
M-18	DI02209					1			40	4	M-18 FID Breakthrough
GAS,CO + CO2	DI02210		1						60	5	BAG Sample to Airtoxics Lab.
Niosh 1500	DI02211		1						500	6	Orbo 32S
Excess									500	7	Excess
TO11	DI02213		1						750	8	
TO11	DI02214					1			750	8	Breakthrough
Excess									750	9	Excess
NIOSH 2002	DI02215		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	
PUF	DI022		1								

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 1
THC	DI02301	X									M-25a
M-18 by MS	DI02302		1						25	1	M-18 MS
M-18 by MS	DI02303			1					25	2	M-18 MS Duplicate
M-18	DI02304		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02305			1					40	4	FID - M-18 Duplicate **(RUBY)**
Excess									60	5	Excess
Niosh 1500	DI02307		1						500	6	Orbo 32S
GAS,CO + CO2	DI02306		1						500	7	BAG Sample to Airtoxics Lab.
TO11	DI02308		1						750	8	
Excess									750	9	Excess
NIOSH 2002	DI02309		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI023										

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 1
THC	DI02401	X									M-25a
M-18 by MS	DI02402		1						25	1	M-18 MS
M-18 by MS	DI02403			1					25	2	M-18 MS Duplicate
M-18	DI02404		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02405			1					40	4	FID - M-18 Duplicate **(RUBY)**
Excess									60	5	Excess
Niosh 1500	DI02407		1						500	6	Orbo 32S
Niosh 1500	DI02408			1					500	7	Orbo 32S Duplicate
TO11	DI02409		1						750	8	
GAS,CO + CO2	DI02406		1						750	9	BAG Sample to Airtoxics Lab.
NIOSH 2002	DI02411		1						1000	10	SKC 226-15
NIOSH 2002	DI02412			1					1000	11	SKC 226-15 Duplicate
Moisture	DI02413								500	12	
Excess									5000	13	Excess
PUF	DI024		1								

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)		Comments
2/21/01											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 1
THC	DI02501	X									M-25a
M-18 by MS	DI02502		1						25	1	M-18 MS
M-18 by MS	DI02503			1					25	2	M-18 MS Duplicate
M-18	DI02504		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02505			1					40	4	FID - M-18 Duplicate **(RUBY)**
Excess									60	5	Excess
Niosh 1500	DI02507		1						500	6	Orbo 32S
GAS,CO + CO2	DI02506		1						500	7	BAG Sample to Airtoxics Lab.
Excess									500	7	Excess
TO11	DI02508		1						750	8	
TO11	DI02510			1					750	9	
NIOSH 2002	DI02509		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI025		1								

VENDOR SEACOAL REPLACEMENT - P/C/S SYSTEM (STACK 3) DI SERIES

Method	**Sample #**	**Data**	**Sample**	**Duplicate**	**Blank**	**Breakthrough**	**Spike**	**Spike Amount**	**Flow (ml/min)**	**Train Channel**	**Comments**
2/21/01											SAMPLES TO CLAYTON LAB
TEST 6											Train: CERP # 1
THC	DI02601	X									M-25a
M-18 by MS	DI02602		1						25	1	M-18 MS
M-18 by MS	DI02603			1					25	2	M-18 MS Duplicate
M-18	DI02604		1						40	3	FID - M-18 **(RUBY)**
M-18	DI02605			1					40	4	FID - M-18 Duplicate **(RUBY)**
Excess									60	5	Excess
Niosh 1500	DI02607		1						500	6	Orbo 32S
GAS,CO + CO2	DI02606		1						500	7	BAG Sample to Airtoxics Lab.
TO11	DI02608		1						750	8	
Excess									750	9	
NIOSH 2002	DI02609		1						1000	10	SKC 226-15
Excess									1000	11	Excess
Moisture									500	12	
Excess									5000	13	Excess
PUF	DI026		1								

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APPENDIX B TEST SERIES DD AND DI EMISSION TEST RESULTS

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Test DD Sand System Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD001	DD002	DD003	DD004	DD005	DD006	DD007	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
		TGOC (THC) as Propane	8.93E-01	8.69E-01	1.03E+00	1.05E+00	1.08E+00	1.10E+00	9.08E-01	9.90E-01	9.70E-02
		HC as Hexane	5.82E-01	7.33E-01	6.27E-01	6.42E-01	7.17E-01	5.86E-01	4.94E-01	6.26E-01	8.26E-02
		Sum of VOCs	3.07E-01	3.69E-01	4.30E-01	4.59E-01	4.58E-01	4.61E-01	3.49E-01	4.05E-01	6.27E-02
		Sum of HAPs	2.79E-01	3.27E-01	3.38E-01	3.61E-01	3.54E-01	3.67E-01	2.82E-01	3.30E-01	3.65E-02
		Sum of POMs	2.53E-02	3.64E-02	4.65E-02	5.21E-02	5.55E-02	6.07E-02	6.24E-02	4.84E-02	1.35E-02
	Individual HAPs and VOCs										
	z	Benzene	7.53E-02	7.47E-02	7.45E-02	7.64E-02	7.39E-02	7.52E-02	I	7.50E-02	8.51E-04
	z	Aniline	4.84E-02	5.21E-02	4.72E-02	5.22E-02	4.87E-02	4.77E-02	4.74E-02	4.91E-02	2.15E-03
	z	Phenol	3.01E-02	3.52E-02	4.31E-02	4.57E-02	4.16E-02	4.76E-02	4.89E-02	4.17E-02	6.86E-03
	z	N,N-Dimethylaniline	2.30E-02	3.60E-02	3.40E-02	3.90E-02	3.75E-02	3.95E-02	3.70E-02	3.51E-02	5.65E-03
	z	Toluene	3.00E-02	3.47E-02	3.19E-02	3.33E-02	3.26E-02	3.23E-02	2.73E-02	3.17E-02	2.42E-03
x	z	Naphthalene	1.23E-02	1.80E-02	2.18E-02	2.45E-02	2.60E-02	2.81E-02	2.89E-02	2.28E-02	5.96E-03
	z	m,p-Xylene	1.61E-02	1.80E-02	1.76E-02	1.80E-02	1.74E-02	1.74E-02	1.48E-02	1.70E-02	1.19E-03
	z	o-Cresol	8.65E-03	1.18E-02	1.46E-02	1.57E-02	1.73E-02	1.94E-02	1.78E-02	1.50E-02	3.72E-03
x	z	2-Methylnaphthalene	7.64E-03	1.10E-02	1.42E-02	1.60E-02	1.70E-02	1.86E-02	1.93E-02	1.48E-02	4.22E-03
x	z	1-Methylnaphthalene	4.28E-03	6.06E-03	7.70E-03	8.60E-03	9.23E-03	1.02E-02	1.06E-02	8.09E-03	2.27E-03
	z	o-Xylene	6.79E-03	7.47E-03	6.24E-03	6.40E-03	7.13E-03	6.15E-03	6.07E-03	6.61E-03	5.36E-04
	z	2-Butanone	4.23E-03	6.81E-03	6.00E-03	6.97E-03	7.33E-03	7.17E-03	7.30E-03	6.54E-03	1.12E-03
	z	Acetaldehyde	3.33E-03	4.53E-03	3.92E-03	4.03E-03	4.06E-03	3.97E-03	3.62E-03	3.92E-03	3.75E-04
	z	Ethylbenzene	3.66E-03	4.05E-03	3.88E-03	3.97E-03	3.82E-03	3.78E-03	3.36E-03	3.79E-03	2.27E-04
	z	Hexane	3.40E-03	4.03E-03	5.64E-03	4.75E-03	3.49E-03	2.86E-03	2.32E-03	3.78E-03	1.13E-03
x	z	1,3-Dimethylnaphthalene	1.09E-03	1.33E-03	2.80E-03	3.05E-03	3.21E-03	3.82E-03	3.61E-03	2.70E-03	1.08E-03
	z	m,p-Cresol	ND	ND	1.49E-03	1.61E-03	1.90E-03	2.50E-03	2.43E-03	1.42E-03	1.04E-03
	z	Styrene	8.98E-04	1.00E-03	1.95E-03	1.05E-03	2.10E-03	1.24E-03	9.95E-04	1.32E-03	4.96E-04

Test DD Sand System Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD001	DD002	DD003	DD004	DD005	DD006	DD007	AVERAGE	STDEV
		Pour Date	11/21/00	11/21/00	11/21/00	11/21/00	11/21/00	11/21/00	11/21/00		
x	z	1,2-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,5-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Acrolein	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Biphenyl	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Cumene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Formaldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Propionaldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,2,4-Trimethylbenzene	4.75E-03	1.31E-02	5.68E-02	5.72E-02	6.27E-02	5.13E-02	3.70E-02	4.04E-02	2.31E-02
		1,3,5-Trimethylbenzene	3.93E-03	5.29E-03	5.58E-03	5.41E-03	5.54E-03	4.90E-03	5.01E-03	5.10E-03	5.73E-04
		1,2,3-Trimethylbenzene	3.28E-03	4.15E-03	4.37E-03	4.76E-03	4.83E-03	4.81E-03	4.21E-03	4.34E-03	5.51E-04
		Dodecane	2.04E-03	2.50E-03	2.76E-03	5.83E-03	5.42E-03	6.14E-03	2.78E-03	3.92E-03	1.78E-03
		Octane	2.59E-03	2.82E-03	2.67E-03	5.46E-03	5.26E-03	5.30E-03	2.06E-03	3.73E-03	1.52E-03
		Undecane	2.86E-03	3.25E-03	3.43E-03	3.69E-03	3.66E-03	3.52E-03	3.28E-03	3.38E-03	2.88E-04
		3-Ethyltoluene	1.67E-03	2.28E-03	2.48E-03	3.07E-03	2.69E-03	5.29E-03	3.24E-03	2.96E-03	1.15E-03
		2-Ethyltoluene	2.08E-03	2.51E-03	2.64E-03	3.05E-03	2.91E-03	2.99E-03	2.61E-03	2.68E-03	3.39E-04
		Indene	1.27E-03	1.61E-03	2.50E-03	1.76E-03	2.27E-03	2.96E-03	2.21E-03	2.08E-03	5.74E-04
		2,6-Dimethylphenol	1.26E-03	1.62E-03	1.83E-03	2.06E-03	2.21E-03	2.45E-03	2.15E-03	1.94E-03	4.02E-04
		Decane	1.16E-03	1.41E-03	1.20E-03	1.34E-03	1.14E-03	1.34E-03	ND	1.08E-03	4.89E-04

Test DD Sand System Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD001	DD002	DD003	DD004	DD005	DD006	DD007	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
		Indan	ND	ND	1.41E-03	1.32E-03	1.63E-03	1.61E-03	1.32E-03	1.04E-03	7.22E-04
		4-Ethyltoluene	ND	1.28E-03	1.37E-03	1.59E-03	1.54E-03	ND	1.42E-03	1.03E-03	7.10E-04
		Nonane	1.05E-03	ND	1.08E-03	1.06E-03	1.03E-03	ND	ND	6.03E-04	5.64E-04
		Tetradecane	ND	ND	1.17E-03	ND	1.03E-03	1.16E-03	ND	4.80E-04	6.00E-04
		1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x		Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Anthracene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Benzaldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Butylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Butyraldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Methacrolien	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Cyclohexane	ND	ND	ND	ND	ND	ND	ND	N/A	N/A

Test DD Sand System Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD001	DD002	DD003	DD004	DD005	DD006	DD007	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
		Heptane	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Isobutylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		p-Cymene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Pentanal	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Tridecane	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Other Analytes									
		Acetone	7.68E-03	1.30E-02	1.57E-02	1.47E-02	1.64E-02	1.45E-02	1.67E-02	1.41E-02	3.10E-03
		Carbon Monoxide	I	I	ND	ND	I	I	I	N/A	N/A
		Methane	I	I	ND	ND	I	I	I	N/A	N/A
		Carbon Dioxide	I	I	5.24E+01	5.32E+01	I	I	I	5.28E+01	5.48E-01
		Condensibles	2.08E+00	1.28E+00	6.48E-01	5.78E-01	8.35E-01	4.77E-01	6.59E-01	9.36E-01	5.66E-01

I: Data was rejected based on data validation considerations.

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

N/A: Not Applicable; **NT:** Not Tested

Test DD Combined Pouring/Cooling/Shakeout Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD021	DD022	DD023	DD024	DD025	DD026	DD027	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
		TGOC (THC) as Propane	**2.91E+00**	**2.76E+00**	**3.27E+00**	**3.05E+00**	**2.97E+00**	**2.96E+00**	**2.87E+00**	**2.97E+00**	**1.60E-01**
		HC as Hexane	**1.40E+00**	**1.45E+00**	**1.19E+00**	**1.28E+00**	**7.99E-01**	**9.13E-01**	**I**	**1.17E+00**	**2.63E-01**
		Sum of VOCs	**6.43E-01**	**8.02E-01**	**6.91E-01**	**7.26E-01**	**7.71E-01**	**7.83E-01**	**7.28E-01**	**7.35E-01**	**5.56E-02**
		Sum of HAPs	**5.59E-01**	**6.87E-01**	**6.04E-01**	**6.40E-01**	**6.81E-01**	**6.86E-01**	**6.44E-01**	**6.43E-01**	**4.79E-02**
		Sum of POMs	**3.29E-02**	**5.02E-02**	**4.70E-02**	**5.01E-02**	**6.41E-02**	**6.77E-02**	**6.46E-02**	**5.38E-02**	**1.24E-02**
			Individual HAPs and VOCs								
	z	Benzene	**2.36E-01**	**2.76E-01**	**2.40E-01**	**2.59E-01**	**2.56E-01**	**2.51E-01**	**2.36E-01**	**2.51E-01**	**1.46E-02**
	z	Aniline	**7.40E-02**	**7.85E-02**	**6.78E-02**	**7.13E-02**	**6.96E-02**	**7.61E-02**	**7.38E-02**	**7.30E-02**	**3.71E-03**
	z	Toluene	**5.95E-02**	**7.31E-02**	**6.25E-02**	**6.50E-02**	**6.58E-02**	**6.81E-02**	**6.36E-02**	**6.54E-02**	**4.35E-03**
	z	Phenol	**4.45E-02**	**7.38E-02**	**5.32E-02**	**5.14E-02**	**7.17E-02**	**6.77E-02**	**5.92E-02**	**6.02E-02**	**1.12E-02**
	z	N,N-Dimethylaniline	**2.64E-02**	**3.92E-02**	**3.89E-02**	**4.56E-02**	**4.73E-02**	**4.75E-02**	**4.99E-02**	**4.21E-02**	**8.12E-03**
	z	m,p-Xylene	**2.46E-02**	**3.07E-02**	**2.57E-02**	**2.73E-02**	**2.76E-02**	**2.68E-02**	**2.62E-02**	**2.70E-02**	**1.92E-03**
	z	o-Cresol	**1.60E-02**	**2.30E-02**	**1.99E-02**	**2.15E-02**	**2.66E-02**	**2.66E-02**	**2.42E-02**	**2.25E-02**	**3.82E-03**
x	z	Naphthalene	**1.23E-02**	**1.99E-02**	**1.83E-02**	**2.02E-02**	**2.42E-02**	**2.58E-02**	**2.51E-02**	**2.08E-02**	**4.72E-03**
x	z	2-Methylnaphthalene	**1.10E-02**	**1.85E-02**	**1.67E-02**	**1.81E-02**	**2.23E-02**	**2.36E-02**	**2.24E-02**	**1.89E-02**	**4.35E-03**
	z	Hexane	**1.49E-02**	**1.57E-02**	**1.51E-02**	**1.60E-02**	**1.71E-02**	**2.02E-02**	**1.18E-02**	**1.58E-02**	**2.52E-03**
x	z	1-Methylnaphthalene	**5.91E-03**	**9.26E-03**	**8.31E-03**	**9.02E-03**	**1.10E-02**	**1.17E-02**	**1.11E-02**	**9.46E-03**	**2.00E-03**
	z	o-Xylene	**8.28E-03**	**8.52E-03**	**8.55E-03**	**7.21E-03**	**7.09E-03**	**6.84E-03**	**6.97E-03**	**7.64E-03**	**7.75E-04**
	z	Ethylbenzene	**6.03E-03**	**7.38E-03**	**6.12E-03**	**6.55E-03**	**6.52E-03**	**6.32E-03**	**6.24E-03**	**6.45E-03**	**4.53E-04**
	z	Acetaldehyde	**4.79E-03**	**I**	**5.35E-03**	**5.51E-03**	**5.25E-03**	**5.15E-03**	**5.37E-03**	**5.24E-03**	**2.50E-04**
	z	2-Butanone	**3.15E-03**	**4.69E-03**	**4.41E-03**	**4.85E-03**	**5.02E-03**	**4.80E-03**	**5.21E-03**	**4.59E-03**	**6.83E-04**
x	z	1,3-Dimethylnaphthalene	**3.61E-03**	**2.63E-03**	**3.68E-03**	**2.82E-03**	**4.88E-03**	**5.11E-03**	**4.57E-03**	**3.90E-03**	**9.81E-04**
	z	m,p-Cresol	**1.72E-03**	**2.75E-03**	**3.10E-03**	**3.35E-03**	**5.01E-03**	**4.73E-03**	**4.06E-03**	**3.53E-03**	**1.16E-03**
	z	Styrene	**3.22E-03**	**3.50E-03**	**3.27E-03**	**3.24E-03**	**3.39E-03**	**3.63E-03**	**3.34E-03**	**3.37E-03**	**1.49E-04**
	z	Formaldehyde	**3.11E-03**	**I**	**3.15E-03**	**3.07E-03**	**2.66E-03**	**2.52E-03**	**2.98E-03**	**2.92E-03**	**2.61E-04**
x	z	1,6-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**1.67E-03**	**1.64E-03**	**1.54E-03**	**6.92E-04**	**8.64E-04**
x	z	1,2-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x	z	1,5-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x	z	1,8-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**

Test DD Combined Pouring/Cooling/Shakeout Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD021	DD022	DD023	DD024	DD025	DD026	DD027	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
x	z	2,3,5-Trimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x	z	2,3-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x	z	2,6-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x	z	2,7-Dimethylnaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
	z	Acrolein	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
	z	Biphenyl	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
	z	Cumene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
	z	Propionaldehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		1,2,4-Trimethylbenzene	**3.34E-02**	**5.04E-02**	**2.71E-02**	**2.83E-02**	**2.26E-02**	**3.48E-02**	**2.38E-02**	**3.15E-02**	**9.48E-03**
		Octane	**1.40E-02**	**1.73E-02**	**1.42E-02**	**1.53E-02**	**1.47E-02**	**1.48E-02**	**1.46E-02**	**1.50E-02**	1.11E-03
		Heptane	**8.09E-03**	**9.64E-03**	**8.92E-03**	**8.78E-03**	**7.89E-03**	**8.01E-03**	**8.21E-03**	**8.50E-03**	**6.33E-04**
		1,3,5-Trimethylbenzene	**4.16E-03**	**6.52E-03**	**5.99E-03**	**5.29E-03**	**7.60E-03**	**6.14E-03**	**6.40E-03**	**6.02E-03**	**1.07E-03**
		Undecane	**3.94E-03**	**4.47E-03**	**3.92E-03**	**3.99E-03**	**4.56E-03**	**5.04E-03**	**4.50E-03**	**4.34E-03**	**4.16E-04**
		1,2,3-Trimethylbenzene	**3.33E-03**	**4.50E-03**	**4.06E-03**	**4.14E-03**	**4.72E-03**	**4.64E-03**	**4.54E-03**	**4.28E-03**	**4.85E-04**
		3-Ethyltoluene	**2.99E-03**	**3.94E-03**	**3.58E-03**	**3.79E-03**	**5.20E-03**	**4.46E-03**	**3.78E-03**	**3.96E-03**	**7.00E-04**
		2-Ethyltoluene	**2.24E-03**	**3.43E-03**	**2.81E-03**	**3.10E-03**	**3.12E-03**	**3.16E-03**	**3.16E-03**	**3.00E-03**	**3.82E-04**
		Dodecane	**2.15E-03**	**2.73E-03**	**2.64E-03**	**2.96E-03**	**3.33E-03**	**3.57E-03**	**3.15E-03**	**2.93E-03**	**4.75E-04**
		Nonane	**2.28E-03**	**2.65E-03**	**2.33E-03**	**2.51E-03**	**2.42E-03**	**2.29E-03**	**2.22E-03**	**2.39E-03**	**1.50E-04**
		Cyclohexane	**2.33E-03**	**2.48E-03**	**2.00E-03**	**2.06E-03**	**2.21E-03**	**1.91E-03**	**1.70E-03**	**2.10E-03**	**2.63E-04**
		Indene	**1.40E-03**	**1.70E-03**	**2.63E-03**	**1.63E-03**	**2.98E-03**	**2.41E-03**	**1.87E-03**	**2.09E-03**	**5.87E-04**
		Decane	**1.98E-03**	**2.17E-03**	**1.96E-03**	**2.09E-03**	**1.90E-03**	**2.03E-03**	**1.97E-03**	**2.01E-03**	**9.28E-05**
		2,6-Dimethylphenol	**ND**	**ND**	**1.58E-03**	**2.19E-03**	**2.91E-03**	**2.72E-03**	**2.18E-03**	**1.65E-03**	**1.21E-03**
		4-Ethyltoluene	**1.51E-03**	**2.26E-03**	**2.15E-03**	**ND**	**2.17E-03**	**ND**	**1.89E-03**	**1.42E-03**	**1.00E-03**
		Indan	**ND**	**ND**	**1.42E-03**	**ND**	**1.61E-03**	**1.58E-03**	**ND**	**6.58E-04**	**8.23E-04**
		1,2-Diethylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		1,3-Diethylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		1,3-Diisopropylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		1,4-Diethylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		2,3,5-Trimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**

Test DD Combined Pouring/Cooling/Shakeout Individual Test Results – Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DD021	DD022	DD023	DD024	DD025	DD026	DD027	AVERAGE	STDEV
		Pour Date	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**	**11/21/00**		
		2,3-Dimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		2,4,6-Trimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		2,4-Dimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		2,5-Dimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		3,4-Dimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		3,5-Dimethylphenol	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
x		Acenaphthalene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		a-Methylstyrene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Anthracene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Benzaldehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Butylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Butyraldehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Methacrolien	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Crotonaldehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Hexaldehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Isobutylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		n-Propylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		o,m,p-Tolualdehyde	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		p-Cymene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Pentanal	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**

Test DD Combined Pouring/Cooling/Shakeout Individual Test Results – Lbs/Ton Metal (Continued)											
POMs	**HAPS**	**COMPOUND / SAMPLE NUMBER**	**DD021**	**DD022**	**DD023**	**DD024**	**DD025**	**DD026**	**DD027**	**AVERAGE**	**STDEV**
		sec-Butylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		tert-Butylbenzene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Tetradecane	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
		Tridecane	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**N/A**	**N/A**
			Other Analytes								
		Acetone	**6.55E-03**	**1.06E-02**	**1.33E-02**	**1.32E-02**	**1.28E-02**	**1.11E-02**	**1.29E-02**	**1.15E-02**	**2.42E-03**
		Carbon Monoxide	**I**	**I**	**ND**	**I**	**I**	**I**	**I**	**N/A**	**N/A**
		Methane	**I**	**I**	**ND**	**I**	**I**	**I**	**I**	**N/A**	**N/A**
		Carbon Dioxide	**I**	**I**	**9.39E+01**	**I**	**I**	**I**	**I**	**9.39E+01**	**N/A**
		Condensibles	**1.25E+00**	**1.94E+00**	**1.10E+00**	**1.11E+00**	**1.61E+00**	**1.82E+00**	**1.44E+00**	**1.47E+00**	**3.35E-01**

I: Data was rejected based on data validation considerations.

All “**Other Analytes**” are not included in the sum of HAPs or VOCs.

N/A: Not Applicable; **NT:** Not Tested

Production Foundry Test Series DI Sand System Individual Results Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DI001	DI002	DI003	DI004	DI005	DI006	AVERAGE	STDEV
		Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		
		TGOC (THC) as Propane	**I**	**I**	**I**	**I**	**I**	**I**	**N/A**	**N/A**
		HC as Hexane	4.94E-01	5.42E-01	5.01E-01	6.12E-01	5.45E-01	4.51E-01	5.24E-01	5.54E-02
		Sum of VOCs	3.09E-01	2.26E-01	2.70E-01	3.33E-01	3.07E-01	2.58E-01	2.84E-01	3.95E-02
		Sum of HAPs	2.59E-01	1.91E-01	2.31E-01	2.84E-01	2.63E-01	2.22E-01	2.41E-01	3.33E-02
		Sum of POMs	4.00E-02	3.74E-02	4.32E-02	5.95E-02	5.35E-02	5.09E-02	4.74E-02	8.59E-03
			Individual HAPs and VOCs							
	z	Benzene	8.97E-02	6.48E-02	7.88E-02	9.34E-02	8.58E-02	6.95E-02	8.03E-02	1.14E-02
	z	Toluene	3.99E-02	2.71E-02	3.34E-02	3.87E-02	3.49E-02	2.75E-02	3.36E-02	5.40E-03
	z	Phenol	3.82E-02	1.81E-02	2.32E-02	3.29E-02	3.10E-02	2.64E-02	2.83E-02	7.24E-03
x	z	Naphthalene	1.86E-02	1.72E-02	2.06E-02	2.81E-02	2.56E-02	2.44E-02	2.24E-02	4.27E-03
	z	m,p-Xylene	1.79E-02	1.32E-02	1.54E-02	1.85E-02	1.65E-02	1.26E-02	1.57E-02	2.41E-03
x	z	2-Methylnaphthalene	1.11E-02	1.02E-02	1.26E-02	1.76E-02	1.56E-02	1.56E-02	1.38E-02	2.94E-03
x	z	1-Methylnaphthalene	1.03E-02	9.89E-03	1.01E-02	1.37E-02	1.23E-02	1.09E-02	1.12E-02	1.51E-03
	z	2-Butanone	8.21E-03	9.62E-03	7.44E-03	9.79E-03	8.35E-03	7.54E-03	8.49E-03	1.01E-03
	z	o-Cresol	4.84E-03	4.13E-03	6.52E-03	9.69E-03	9.10E-03	9.27E-03	7.26E-03	2.43E-03
	z	o-Xylene	8.42E-03	6.17E-03	6.99E-03	8.43E-03	7.36E-03	5.57E-03	7.16E-03	1.16E-03
	z	Acetaldehyde	5.18E-03	6.29E-03	5.33E-03	I	5.38E-03	5.01E-03	5.44E-03	4.96E-04
	z	Aniline	ND	ND	5.26E-03	6.49E-03	7.29E-03	7.50E-03	4.42E-03	3.52E-03
	z	Ethylbenzene	3.66E-03	2.08E-03	3.14E-03	3.87E-03	3.35E-03	ND	2.68E-03	1.45E-03
	z	Hexane	2.25E-03	1.43E-03	2.47E-03	1.62E-03	ND	ND	1.29E-03	1.07E-03
	z	Formaldehyde	3.66E-04	7.72E-04	ND	8.72E-04	ND	ND	3.35E-04	4.04E-04
x	z	1,2-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,3-Dimethylnaphthalene	ND	ND	ND	ND	I	ND	N/A	N/A
x	z	1,5-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Acrolein	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Biphenyl	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Cumene	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	m,p-Cresol	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	Propionaldehyde	ND	ND	ND	ND	ND	ND	N/A	N/A

Production Foundry Test Series DI Sand System Individual Results Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DI001	DI002	DI003	DI004	DI005	DI006	AVERAGE	STDEV
		Pour Date	2/21/01	2/21/01	2/21/01	2/21/01	2/21/01	2/21/01		
	z	Styrene	ND	ND	ND	I	ND	ND	N/A	N/A
		1,2,4-Trimethylbenzene	1.78E-02	1.35E-02	1.53E-02	1.91E-02	1.71E-02	1.38E-02	1.61E-02	2.27E-03
		1,2,3-Trimethylbenzene	8.06E-03	6.15E-03	7.18E-03	9.06E-03	8.07E-03	6.40E-03	7.49E-03	1.11E-03
		3-Ethyltoluene	7.31E-03	3.44E-03	4.41E-03	6.27E-03	5.91E-03	5.02E-03	5.39E-03	1.39E-03
		Undecane	4.21E-03	3.63E-03	4.04E-03	5.20E-03	4.76E-03	4.20E-03	4.34E-03	5.59E-04
		2-Ethyltoluene	4.32E-03	3.00E-03	3.56E-03	4.34E-03	3.87E-03	2.94E-03	3.67E-03	6.19E-04
		Indene	ND	ND	2.78E-03	3.40E-03	2.95E-03	2.57E-03	1.95E-03	1.53E-03
		Anthracene	7.09E-03	3.16E-03	ND	ND	ND	ND	1.71E-03	2.93E-03
		Benzaldehyde	1.63E-03	1.94E-03	1.35E-03	1.92E-03	1.36E-03	1.19E-03	1.57E-03	3.14E-04
		1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
		4-Ethyltoluene	I	ND	ND	ND	ND	ND	N/A	N/A
x		Acenaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
		a-Methylstyrene	ND	ND	ND	ND	ND	ND	N/A	N/A
		Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		Butyraldehyde/Methacrolien	ND	ND	ND	ND	ND	ND	N/A	N/A
		Crotonaldehyde	ND	ND	ND	I	ND	ND	N/A	N/A
		Cyclohexane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Decane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Dodecane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Heptane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Hexaldehyde	ND	ND	ND	ND	ND	ND	N/A	N/A
		Indan	ND	ND	ND	ND	ND	ND	N/A	N/A
		Isobutylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		Nonane	ND	ND	ND	ND	ND	ND	N/A	N/A

Production Foundry Test Series DI Sand System Individual Results Lbs/Ton Metal

POMs	HAPS	COMPOUND / SAMPLE NUMBER	DI001	DI002	DI003	DI004	DI005	DI006	AVERAGE	STDEV
		Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		
		n-Propylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	N/A	N/A
		Octane	ND	ND	ND	ND	ND	ND	N/A	N/A
		p-Cymene	ND	ND	ND	ND	ND	ND	N/A	N/A
		sec-Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		tert-Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
		Tetradecane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Tridecane	ND	ND	ND	ND	ND	ND	N/A	N/A
			Other Analytes							
		Condensables	5.39E-01	5.05E-01	5.46E-01	4.66E-01	4.07E-01	6.63E-01	5.21E-01	8.63E-02
		Carbon Monoxide	NT	ND	ND	ND	ND	ND	N/A	N/A
		Methane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Carbon Dioxide	NT	6.11E+01	5.10E+01	6.11E+01	5.54E+01	3.31E+01	5.23E+01	1.16E+01
		Ethane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Propane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Isobutane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Butane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Neopentane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Isopentane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Pentane	NT	ND	ND	ND	ND	ND	N/A	N/A
		Acetone	1.47E-02	1.32E-02	1.52E-02	1.56E-02	1.35E-02	I	1.44E-02	1.05E-03

I: Data was rejected based on data validation considerations**.**

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

N/A: Not Applicable; **NT:** Not Tested

Production Foundry Test Series DI Pouring/Cooling/Shakeout Individual Test Results

HAPS	COMPOUND / SAMPLE NUMBER	DI021	DI022	DI023	DI024	DI025	DI026	AVERAGE	STDEV
	Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		
	TGOC (THC) as Propane	I	I	I	I	I	I	N/A	N/A
	HC as Hexane	1.38E+00	1.41E+00	1.31E+00	1.30E+00	1.30E+00	1.13E+00	1.31E+00	9.72E-02
	Sum of VOCs	6.37E-01	6.61E-01	6.29E-01	6.45E-01	5.70E-01	6.57E-01	6.33E-01	3.32E-02
	Sum of HAPs	5.85E-01	6.06E-01	5.80E-01	5.94E-01	5.18E-01	6.02E-01	5.81E-01	3.25E-02
	Sum of POMs	1.22E-01	1.19E-01	1.05E-01	7.50E-02	6.57E-02	7.42E-02	9.35E-02	2.48E-02
		Individual HAPs and VOCs							
z	Benzene	2.26E-01	2.43E-01	2.39E-01	2.56E-01	2.70E-01	2.60E-01	2.49E-01	1.57E-02
z	Toluene	5.67E-02	6.09E-02	5.79E-02	6.18E-02	6.32E-02	6.15E-02	6.03E-02	2.50E-03
z	1-Methylnaphthalene	8.50E-02	7.12E-02	6.72E-02	2.27E-02	2.41E-02	2.48E-02	4.92E-02	2.83E-02
z	Phenol	3.97E-02	4.43E-02	4.17E-02	4.12E-02	3.52E-02	4.48E-02	4.11E-02	3.50E-03
z	N,N-Dimethylaniline	3.69E-02	3.05E-02	3.28E-02	4.12E-02	I	4.04E-02	3.64E-02	4.69E-03
z	Aniline	2.16E-02	1.93E-02	2.08E-02	2.85E-02	I	2.84E-02	2.37E-02	4.38E-03
z	m,p-Xylene	2.07E-02	2.25E-02	2.09E-02	2.30E-02	2.24E-02	2.25E-02	2.20E-02	9.69E-04
z	Naphthalene	1.84E-02	2.22E-02	1.83E-02	2.31E-02	1.93E-02	2.28E-02	2.07E-02	2.27E-03
z	2-Methylnaphthalene	1.43E-02	1.98E-02	1.57E-02	2.25E-02	1.73E-02	2.07E-02	1.84E-02	3.13E-03
z	o-Cresol	1.09E-02	1.41E-02	1.29E-02	1.38E-02	1.11E-02	1.65E-02	1.32E-02	2.08E-03
z	Hexane	1.20E-02	1.12E-02	1.16E-02	1.25E-02	1.23E-02	1.15E-02	1.18E-02	4.95E-04
z	Acetaldehyde	9.32E-03	9.05E-03	9.76E-03	1.20E-02	1.08E-02	1.07E-02	1.03E-02	1.10E-03
z	o-Xylene	9.52E-03	1.07E-02	9.71E-03	1.08E-02	1.02E-02	1.02E-02	1.02E-02	5.08E-04
z	2-Butanone	8.39E-03	8.35E-03	9.10E-03	1.08E-02	9.66E-03	9.90E-03	9.38E-03	9.61E-04
z	1,3-Dimethylnaphthalene	4.26E-03	5.73E-03	4.30E-03	6.62E-03	4.95E-03	5.85E-03	5.28E-03	9.42E-04
z	Ethylbenzene	4.71E-03	5.26E-03	4.85E-03	5.35E-03	5.20E-03	5.16E-03	5.09E-03	2.52E-04
z	Formaldehyde	2.74E-03	2.39E-03	2.37E-03	2.70E-03	1.93E-03	3.02E-03	2.53E-03	3.79E-04
z	Styrene	3.77E-03	4.02E-03	ND	ND	ND	4.13E-03	1.99E-03	2.18E-03
z	Propionaldehyde	ND	9.81E-04	8.90E-04	ND	ND	ND	3.12E-04	4.84E-04
z	1,2-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	1,5-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
z	Acrolein	ND	ND	ND	ND	ND	ND	N/A	N/A
z	Biphenyl	ND	ND	ND	ND	ND	ND	N/A	N/A
z	Cumene	ND	ND	ND	ND	ND	ND	N/A	N/A

Production Foundry Test Series DI Pouring/Cooling/Shakeout Individual Test Results

HAPS	COMPOUND / SAMPLE NUMBER	DI021	DI022	DI023	DI024	DI025	DI026	AVERAGE	STDEV
	Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		
z	m,p-Cresol	ND	ND	ND	ND	ND	ND	N/A	N/A
	1,2,4-Trimethylbenzene	1.56E-02	1.61E-02	1.57E-02	1.76E-02	1.61E-02	1.70E-02	1.63E-02	7.84E-04
	Octane	7.99E-03	8.67E-03	8.16E-03	8.90E-03	9.02E-03	8.81E-03	8.59E-03	4.19E-04
	1,2,3-Trimethylbenzene	7.24E-03	7.90E-03	7.03E-03	7.88E-03	7.13E-03	7.61E-03	7.47E-03	3.83E-04
	Heptane	6.08E-03	6.09E-03	5.68E-03	5.68E-03	6.17E-03	5.40E-03	5.85E-03	3.07E-04
	3-Ethyltoluene	4.90E-03	5.47E-03	5.15E-03	5.10E-03	4.35E-03	5.56E-03	5.09E-03	4.36E-04
	Undecane	3.93E-03	5.51E-03	4.72E-03	5.55E-03	4.58E-03	4.87E-03	4.86E-03	6.12E-04
	2-Ethyltoluene	3.81E-03	3.84E-03	ND	ND	3.62E-03	3.77E-03	2.50E-03	1.94E-03
	Benzaldehyde	2.39E-03	2.11E-03	2.11E-03	I	1.83E-03	2.02E-03	2.09E-03	2.01E-04
	1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	N/A	N/A
	4-Ethyltoluene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Acenaphthalene	ND	ND	ND	ND	ND	ND	N/A	N/A
	a-Methylstyrene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Anthracene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Butyraldehyde/Methacrolien	ND	ND	ND	ND	ND	ND	N/A	N/A
	Crotonaldehyde	ND	ND	ND	ND	ND	ND	N/A	N/A
	Cyclohexane	ND	ND	ND	ND	ND	ND	N/A	N/A
	Decane	ND	ND	ND	ND	ND	ND	N/A	N/A
	Dodecane	ND	ND	ND	ND	ND	ND	N/A	N/A
	Hexaldehyde	ND	ND	ND	ND	ND	ND	N/A	N/A
	Indan	ND	ND	ND	ND	ND	ND	N/A	N/A
	Indene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Isobutylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Nonane	ND	ND	ND	ND	ND	ND	N/A	N/A

Production Foundry Test Series DI Pouring/Cooling/Shakeout Individual Test Results

HAPS	COMPOUND / SAMPLE NUMBER	DI021	DI022	DI023	DI024	DI025	DI026	AVERAGE	STDEV
	Pour Date	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**	**2/21/01**		
	n-Propylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	N/A	N/A
	p-Cymene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Pentanal	ND	ND	ND	ND	ND	ND	N/A	N/A
	sec-Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	tert-Butylbenzene	ND	ND	ND	ND	ND	ND	N/A	N/A
	Tetradecane	ND	ND	ND	ND	ND	ND	N/A	N/A
	Tridecane	ND	ND	ND	ND	ND	ND	N/A	N/A
		Other Analytes							
	Condensables	I	2.22E+00	2.28E+00	2.06E+00	1.94E+00	1.65E+00	2.03E+00	2.51E-01
	Carbon Monoxide	NT	5.33E+00	6.28E+00	6.56E+00	6.60E+00	6.97E+00	6.35E+00	6.21E-01
	Methane	NT	1.04E+00	1.31E+00	1.39E+00	1.39E+00	1.40E+00	1.30E+00	1.52E-01
	Carbon Dioxide	NT	1.00E+02	8.98E+01	1.08E+02	1.12E+02	5.75E+01	9.34E+01	2.18E+01
	Ethane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Propane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Isobutane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Butane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Neopentane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Isopentane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Pentane	NT	ND	ND	ND	ND	ND	N/A	N/A
	Acetone	1.65E-02	1.53E-02	1.96E-02	2.09E-02	1.60E-02	2.58E-02	1.90E-02	3.98E-03

I: Data was rejected based on data validation considerations.

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

N/A: Not Applicable; **NT:** Not Tested

APPENDIX C PRODUCTION PROCESS DATA

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DD Production Baseline Process Data

	Compactability	Mold LOIs	Mold Clays	Core LOIs	Pour Temperatures
	36	4.65	9.43	1.50	2598
	38	4.74	9.3	1.51	2599
	37	4.77	9.3	1.42	2608
	38	4.54	9.43	1.57	2631
	38	4.55	9.43	1.54	2639
	42	4.63	9.43	1.53	2639
	41	4.55	9.56	1.64	2640
	40	4.47	8.91	1.51	2635
	38	4.59	9.04	1.53	2628
	38	4.48	8.91	1.41	2625
	40	4.92	8.91	1.51	2618
	42	4.54	8.4	1.38	2641
	40	4.61	8.66	1.50	2646
	39	4.62	8.4	1.57	2620
	41	4.57	8.4		2635
	42	4.36	8.4		2633
	43	4.68	8.52		2630
	42	4.58	8.4		2635
	41	4.77	8.53		2641
	43	4.56	8.27		
	41	4.67	8.27		
	45	4.78	8.27		
Standard Deviation	2.266354702	0.12	0.47	0.07	14.03
Average	40.22727	4.62	8.83	1.51	2628

DI Production Process Data

	Compactability	Mold LOIs	Mold Clays	Core LOIs 1400ºF	Pour Temperatures
	33	5.01	10.84	1.88	2577
	34	4.85	10.84	1.97	2634
	31	5.09	10.57	1.94	2624
	38	5.37	10.57	1.83	2610
	36	4.93	10.31	1.84	2639
	32	5.06	10.18	1.70	2620
	38	4.72	9.92	1.87	2630
	35	4.92	8.91	1.96	2612
	37	4.53	9.92		2634
	36	4.39	9.66		2620
	36	4.55	9.66		2647
	35	4.34	9.66		2608
	36	4.49	9.79		2639
	39	4.37	9.53		2610
	38	4.33	9.53		2640
	37	4.42	9.53		2636
	39	4.49	9.53		2642
			9.27		2628
					2618
Standard Deviation	2.3	0.3	0.5	0.1	16.7
Average	35.9	4.7	9.9	1.9	2624.6

APPENDIX D METHOD 25A CHARTS

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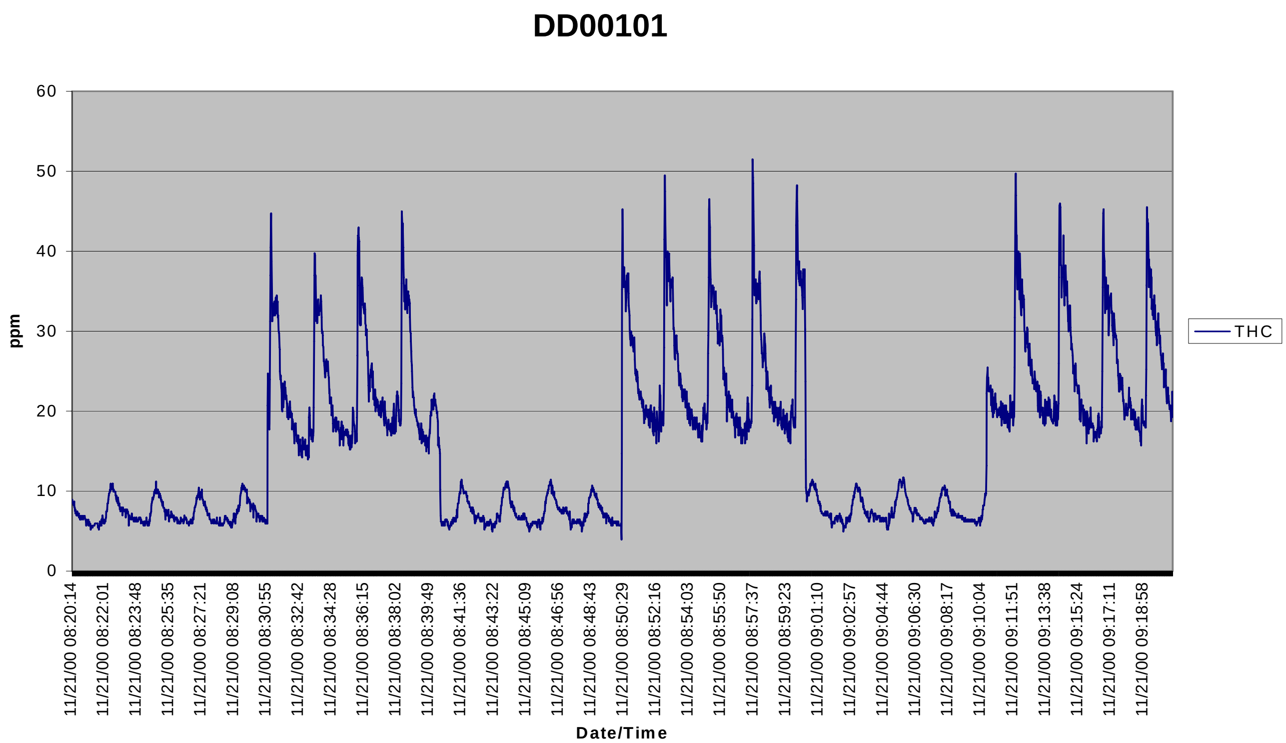
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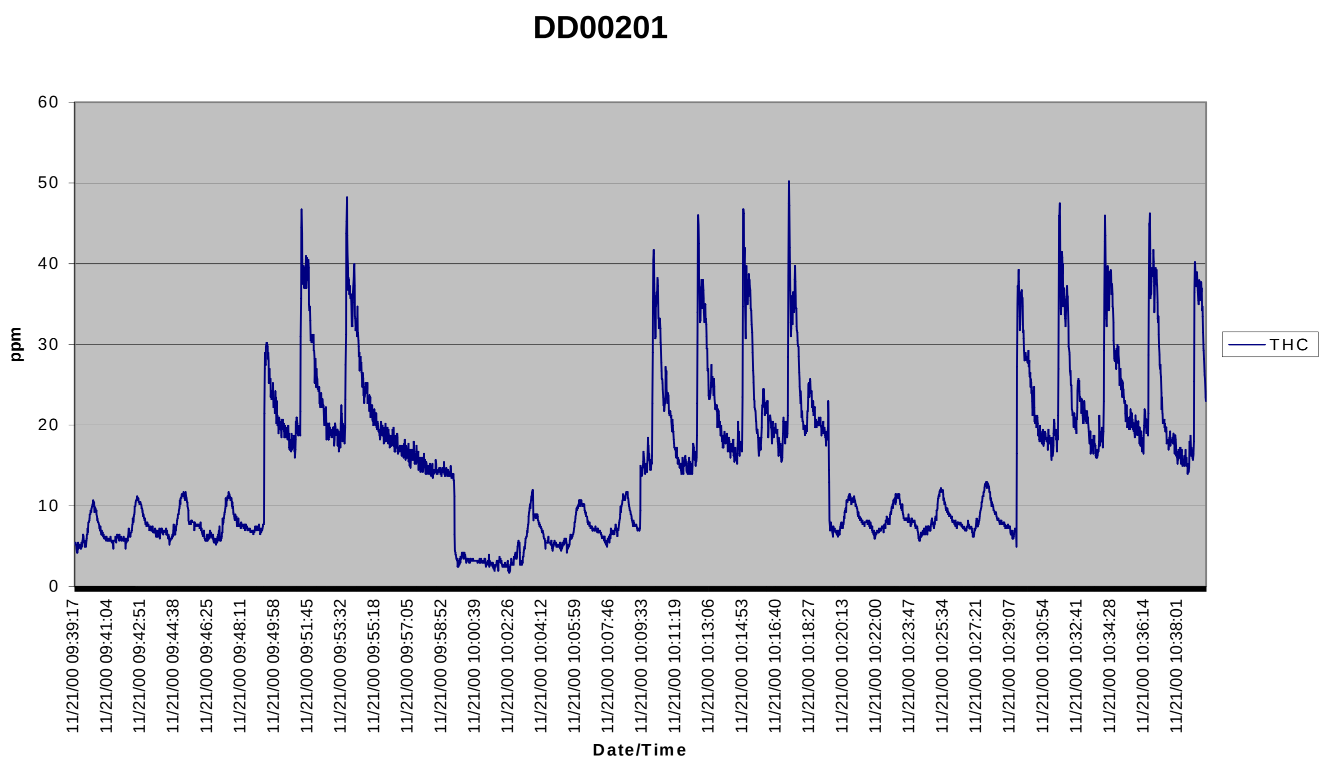
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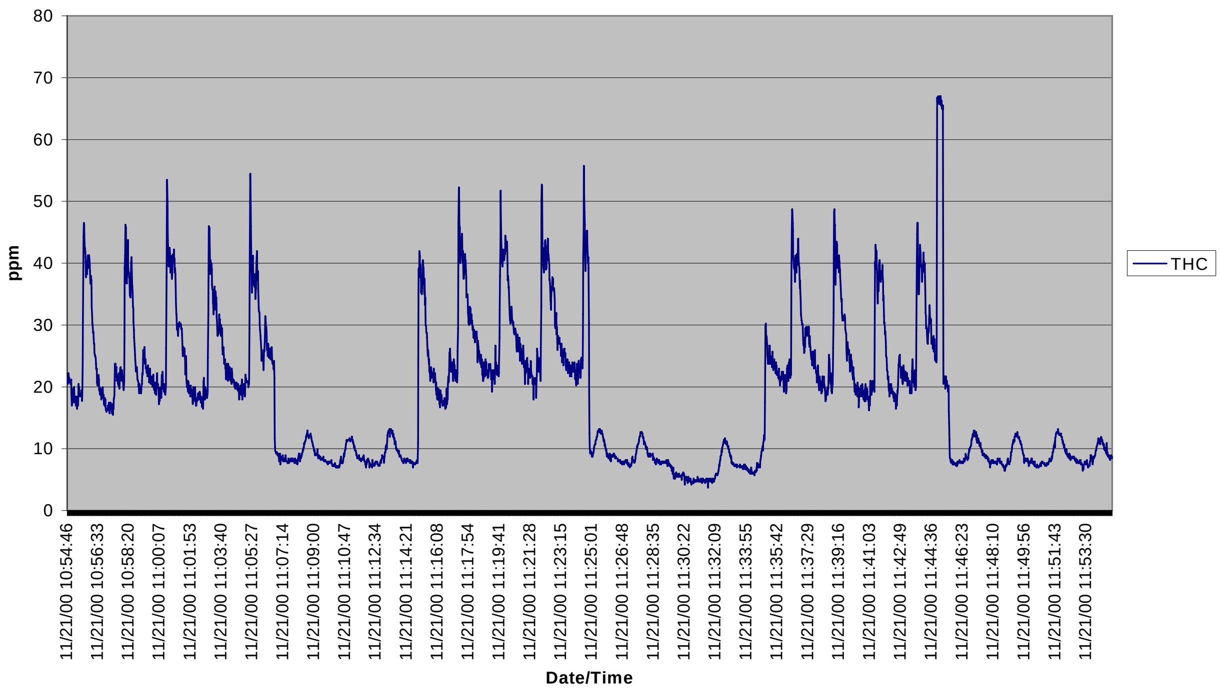

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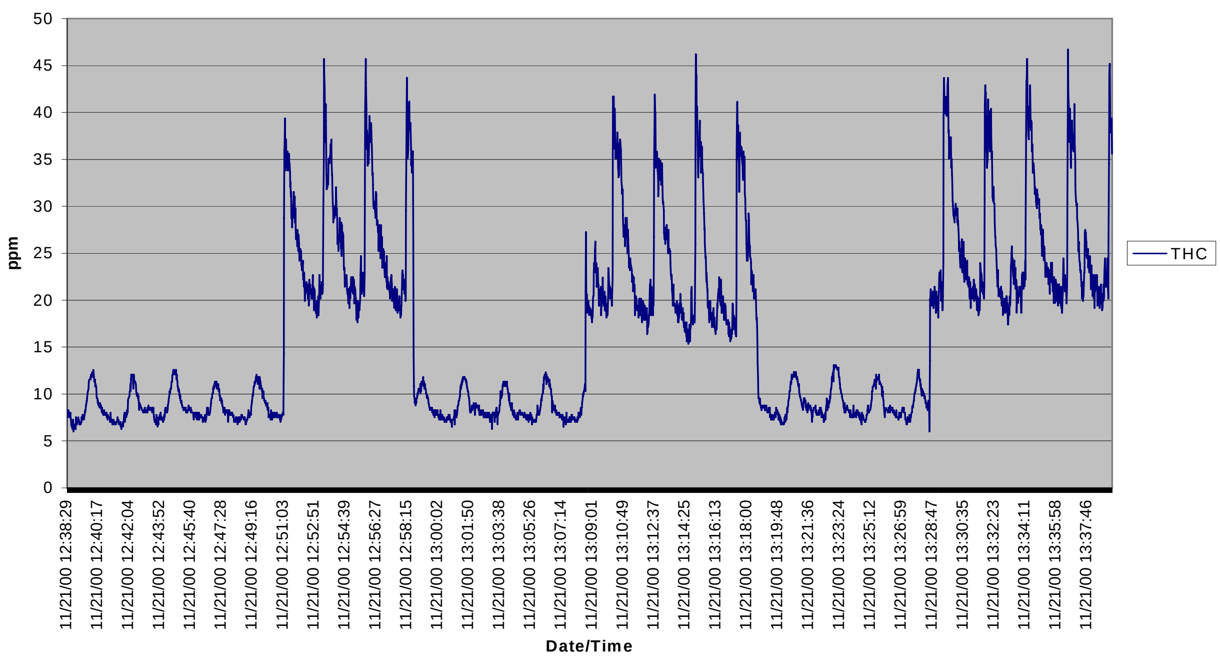

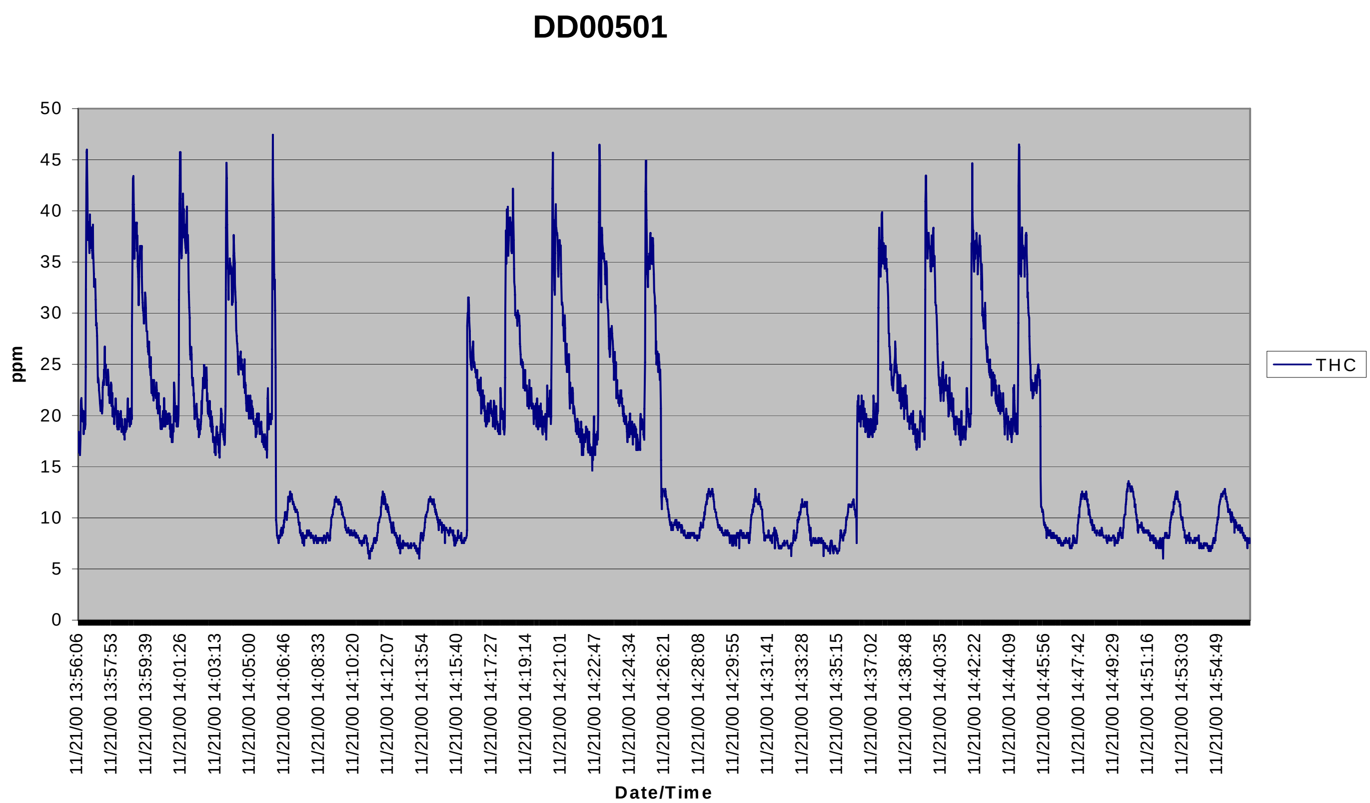
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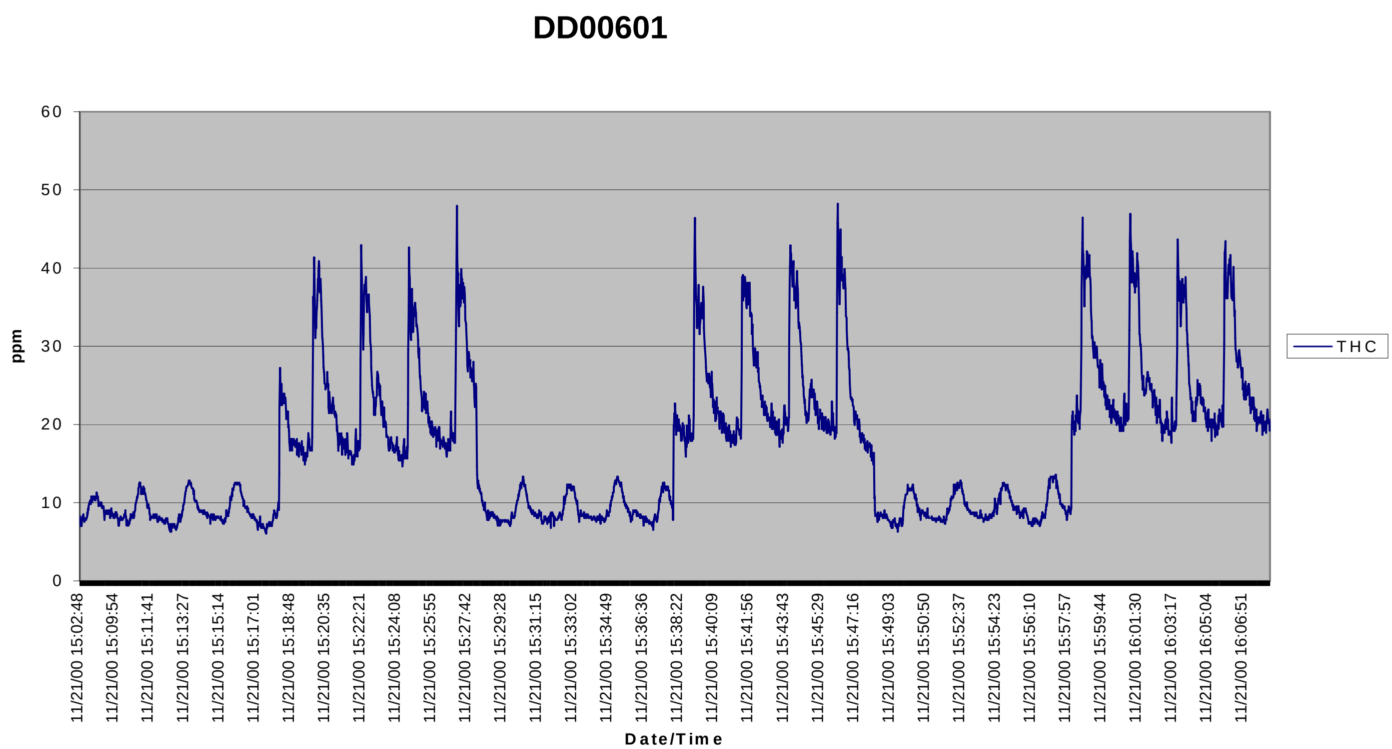
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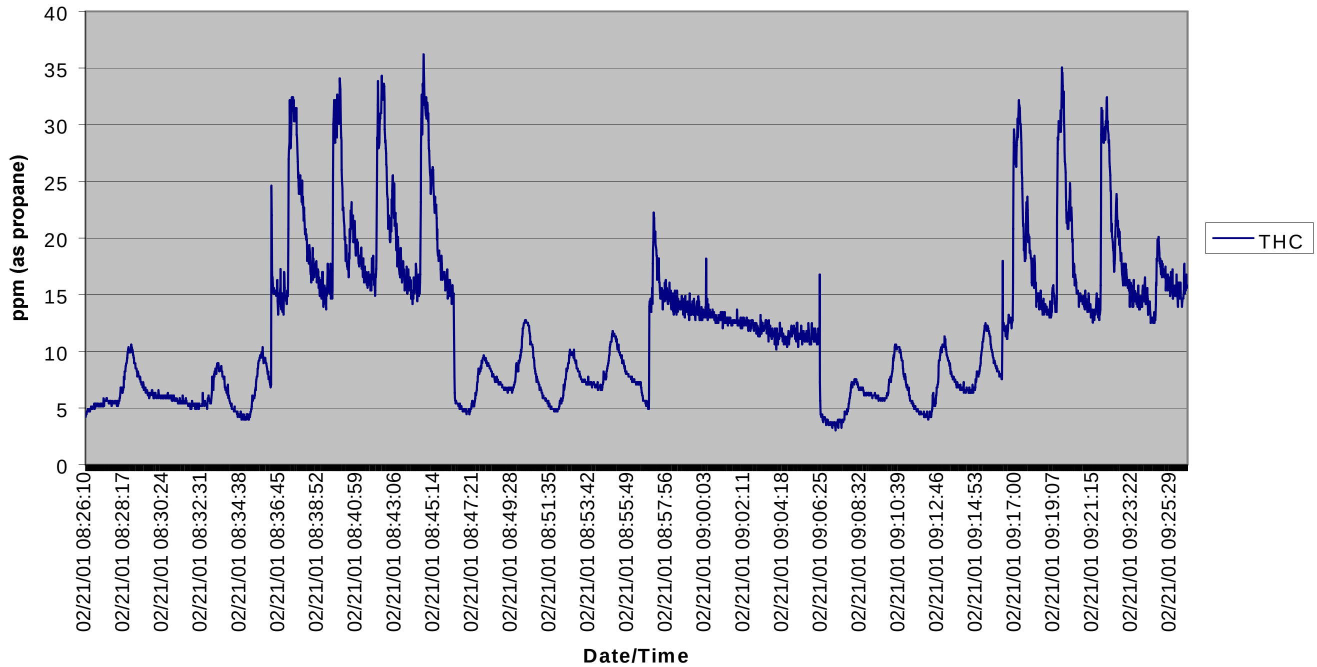
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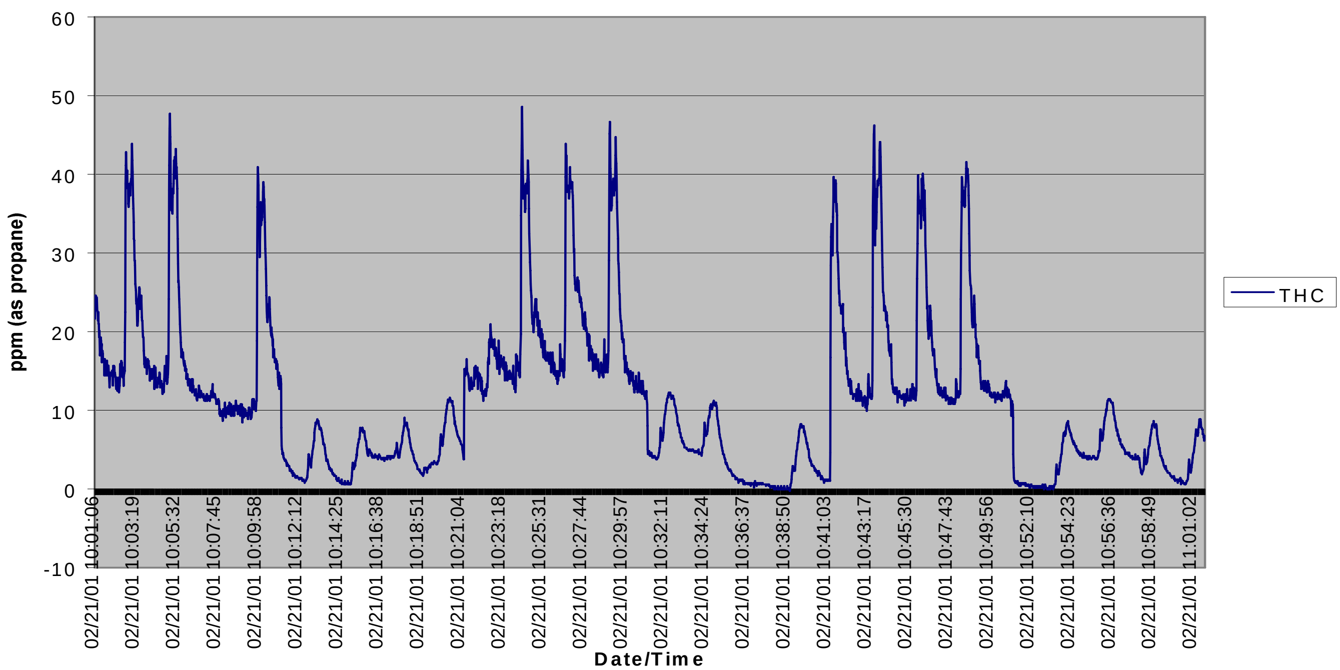
DI002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THC
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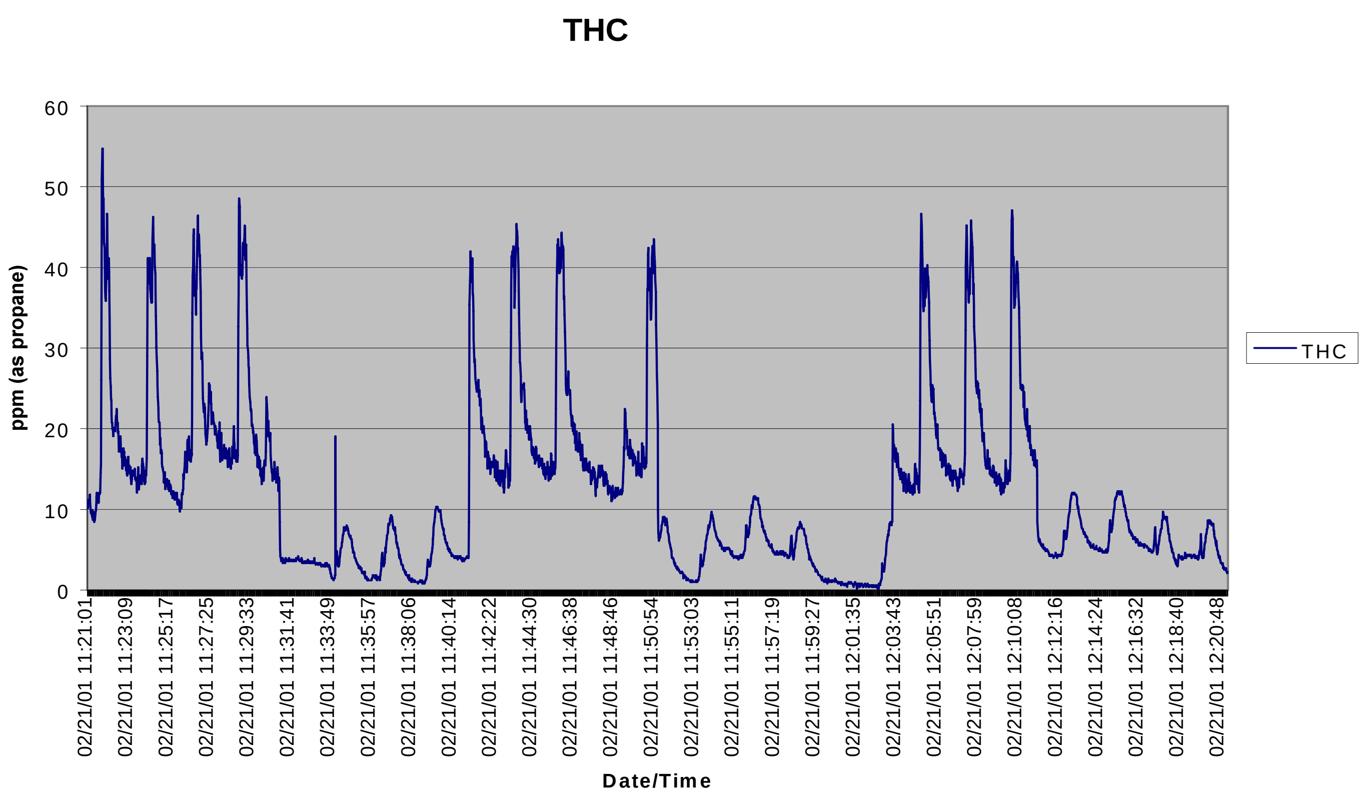
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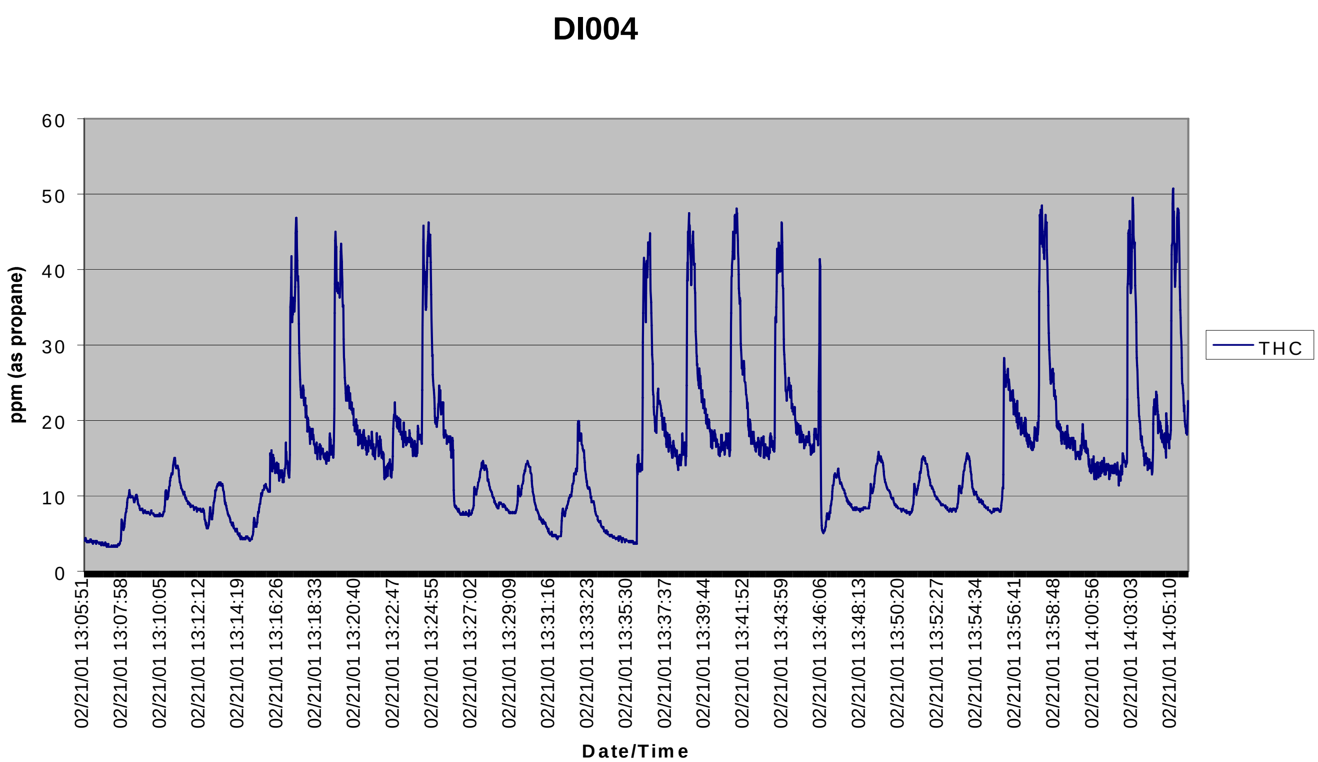
Date/Time
THC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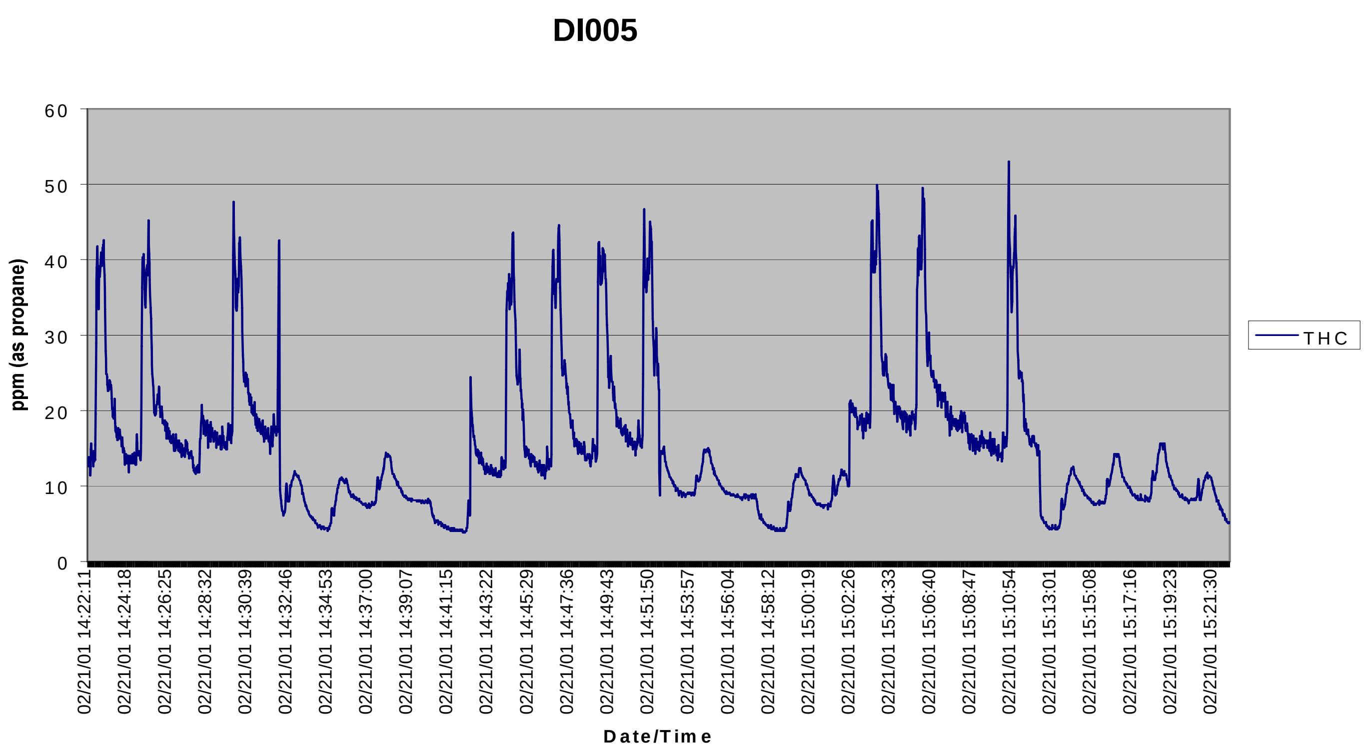
Date/Time
THC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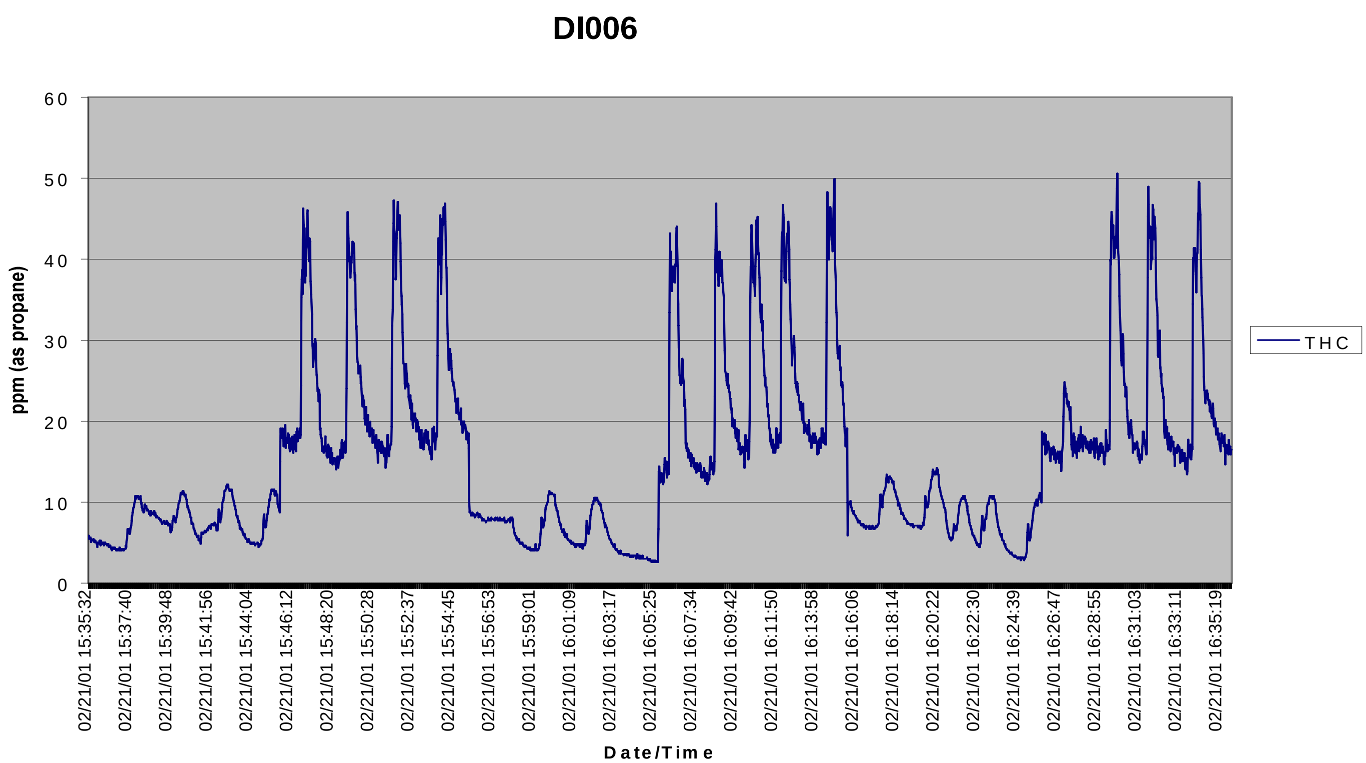
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02/21/01 16:26:47
02/21/01 16:28:55
02/21/01 16:31:03
02/21/01 16:33:11
02/21/01 16:35:19

APPENDIX E LISTING OF SUPPORT DOCUMENTS

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Listing of Support Document

The following documents contain specific test results, procedures, and documentation used in support of this Test Plan

1. Casting Emission Reduction Program – Foundry Product Testing Guide: Reducing Emissions by Comparative Testing, May 4, 1998.

2. CERP Testing, Quality Assurance/Quality Control Procedures Manual.

3. Emission Baseline Test Results for the CERP Pre-Production Foundry Processes.

4. Evaluation of the Required Number of Replicate Tests to Provide Statistically Significant Air Emission Reduction Comparisons for the CERP Pre-Production Foundry Test Program

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APPENDIX F GLOSSARY

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Glossary

t-Test The calculated T statistic, Ts, is compared against a table value. The table value is a function of the sample size and on the level of confidence desired. For tests with nine sample values each, the T value associated with a confidence level of 95% is 2.12. Calculated values of Ts greater than or equal to this value would indicate that there is 95% or better probability that the differences between the two test series were not the result of test variability.

ND Non Detect

No Test Lab testing was not done on this analyte.

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.

BO Based on ( ).

BOS Based on Sand.

Binder = Part 1 + Part 2 + Part 3.

Resin = Part 1.

Co-Reactant = Part 2.

Catalyst = Part 3.