CERP

Casting Emission Reduction Program

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US Army Task N256

Production Baseline Airborne Emission Test Report

Technikon #RE 2 00099DD

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This document was revised for unlimited public distribution.

EPA United States Environmental Protection Agency

CISA

AFS AMERICAN FOUNDRY SOCIETY, INC.

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

USCAR

DAIMLERCHRYSLER Ford Motor Company General Motors

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Production Foundry Airborne Emission Test Report

Test Plan # RE200099DD

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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Table of Contents

List of Figures

List of Tables

Appendices

Executive Summary

This report contains the results of testing conducted at the Technikon Production Foundry according to Test Plan DD. The testing was conducted under the Casting Emission Reduction Program (CERP) as a cooperative initiative between the Department of Defense (U.S. Army) and the United States Council for Automotive Research (US CAR). CERP's mission 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 baseline levels of Hazardous Air Pollutant (HAP) and Volatile Organic Compound (VOC) emissions produced by a greensand mold with seacoal under CERP Production Foundry standard conditions. The resultant emissions, expressed as pounds of emission per ton of iron (lb/ton), are then used to establish the Production Baseline test (DD).

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 several sixty (60) minute periods at 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.

Seven (7) individual sampling events were conducted for this test series. Sampling for the test series used procedures based on US EPA stack test methods. Test and duplicate air samples were collected for each of the sampling events. An independent laboratory analyzed the samples for individual organic HAPs and VOCs, using methods based on US EPA Method 18, Method TO11, and NIOSH Method 2002. The laboratory data were validated and reduced to a useable data set, according to CERP's validation process. The mass emission rate, in pounds of analyte per ton of metal processed, was calculated for each analyte using the validated laboratory analytical results, measured stack parameters and sample volumes, the average weight of the casting, and the number of mold/core packages processed at each emission point during a sampling event. Five "emission indicators" are calculated that represent the Total Gaseous Organic Matter (TGOM) as measured by US EPA Method 25A and four subsets of the TGOM. The subsets are: HC as Hexane, a measure of all VOCs collected during the sampling; Sum of VOCs, a measure of all the target VOCs detected; Sum of HAPs, a measure of all the target organic HAPs; and Sum of POMs, a measure of all target Polycyclic Organic Matter detected.

Table 1 presents a summary of the total emissions (sand system plus pouring/cooling/shakeout) for this baseline test. The variations of the measured process parameters and of the analytical test results during this test were within acceptable control ranges.

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 (gray 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.

Table 1: Summary Test Results Sand System and Combined Pouring/Cooling/Shakeout

Analyte	Baseline DD (lbs/tn)
TGOM (THC) as Propane	3.96
HC as Hexane	1.80
Sum of VOCs	1.14
Sum of HAPs	0.973
Sum of POMs	0.102
Benzene	0.326
Aniline	0.122
Phenol	0.102
Toluene	0.097
N,N-Dimethylaniline	0.077
o,m,p-Xylene	0.058
Methylnaphthalenes	0.051
Naphthalene	0.044
o,m,p-Cresol	0.043
Hexane	0.020
2-Butanone	0.011
Ethylbenzene	0.010
Acetaldehyde	0.009
Trimethylbenzenes	0.092
Octane	0.019
Ethyltoluenes	0.015
Heptane	0.009
Dodecane	0.007

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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 (U.S. Army) and the United States Council for Automotive Research (USCAR). Its mission 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 Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US EPA), 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. CERP is operated by Technikon, LLC.

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 <u>discrete</u> 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 Preproduction 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 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 (flask versus flask less) can have a significant impact on actual emission levels.

1.3 Report Organization

This report has been designed to document the methodology used and 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 F 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 at least six replicate tests are needed in order to 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 DD in the CERP Production Foundry. Table 2 provides a summary of Test Plan DD. The approved test plan is included in Appendix A.

Table 2: Test Plan DD Summary

Test Series	**DD**
Test Dates	**21 November, 2000**
Number of Test Runs	Seven (7) one-hour tests
Sampling Points	Two (2) sampling points: sand system and combined pouring/cooling/shakeout.
Mold Type	Greensand with Seacoal
Core Type	ISOCURE® 305/904 Resin
Casting Type	Single cavity automotive I-4 engine block
Emissions Measured	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, Moisture Content, Pressure, and Volumetric Flow Rate

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2.0 Test Methodology

2.1 Description of Process and Testing Equipment

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

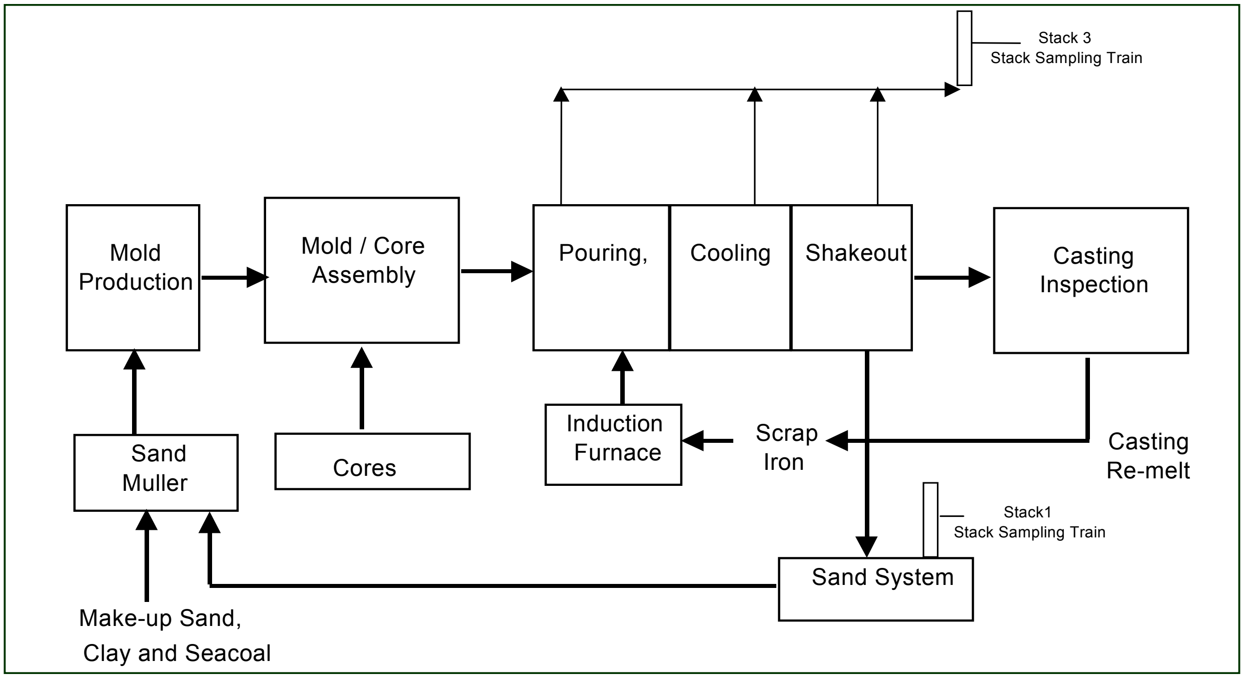


Figure 1: Production Foundry Process Flowchart

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 seven (7) 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 entering 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 samples were drawn from sampling ports located in conformance with USEPA Method 1 at each of the sampling points. The tip of the probe was located in the centroid of the duct as required by USEPA Method 18. The samples were collected at a constant rate in adsorption tubes and as sampling bags.

Emissions Sampling

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)
Alloy Weights	Ohaus DS10 (Gravimetric)
Mold Compactability	Dietert 319A Sand Squeezer (AFS procedure 221-87-S)

1. **Air Emissions Analysis:** The specific sampling and analytical methods used in the Production Foundry tests were based on the USEPA 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 Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual. Appendix G contains a list of all of the target analytes tested for along with their respective detection limits.

Table 4: Sampling and Analytical Methods

Measurement Parameter	Test Method
Port location	USEPA Method 1
Number of traverse points	USEPA Method 1
Gas velocity and temperature	USEPA Method 2
Gas density and molecular weight	USEPA Method 3
Gas moisture	USEPA Method 4 (wet bulb/dry bulb version)
HAPs analysis	USEPA Method 18 and TO11, and NIOSH 2002*
VOCs analysis	USEPA Method 18 and TO11, and NIOSH 2002*
Condensables	Technikon Method to estimate the USEPA Method 5 “back half” catch

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

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 Emission Testing and Analytical Testing Standard Operating Procedures.

The results for each analyte from the sampling events were 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.

Report Preparation and Review: A Preliminary Draft Report underwent review by the Emissions Supervisor and the Process Supervisor to ensure its completeness, consistency with the test plans, and adherence to the prescribed QA/QC procedures. Appropriate observations, conclusions and recommendations were added to the report to produce a Draft Report. The President of Technikon, the VP of Measurement Technologies, and the VP of Operations reviewed the Draft Report. Comments are incorporated into the Final Report.

2.3 Quality Assurance and Quality Control (QA/QC) Procedures

Detailed QA/QC and data validation procedures for the process parameters and stack measurements, and for the laboratory analytical procedures and data are included in the CERP Emission Testing and Analytical Testing Standard Operating Procedures. In order to ensure that timely review of critical quality control parameters were achieved, the following procedures were followed:

- Immediately following the individual sampling events performed for each test, the Emissions Measurement Team and the Manager-Process Engineering, reviewed specific process and stack parameters to ensure that the parameters were maintained within the prescribed control ranges. Where data were not within the prescribed ranges, the Vice President-Measurement Technologies and the Vice President-Operations determined whether the individual test samples should be invalidated or flagged as outliers following review of the laboratory data.

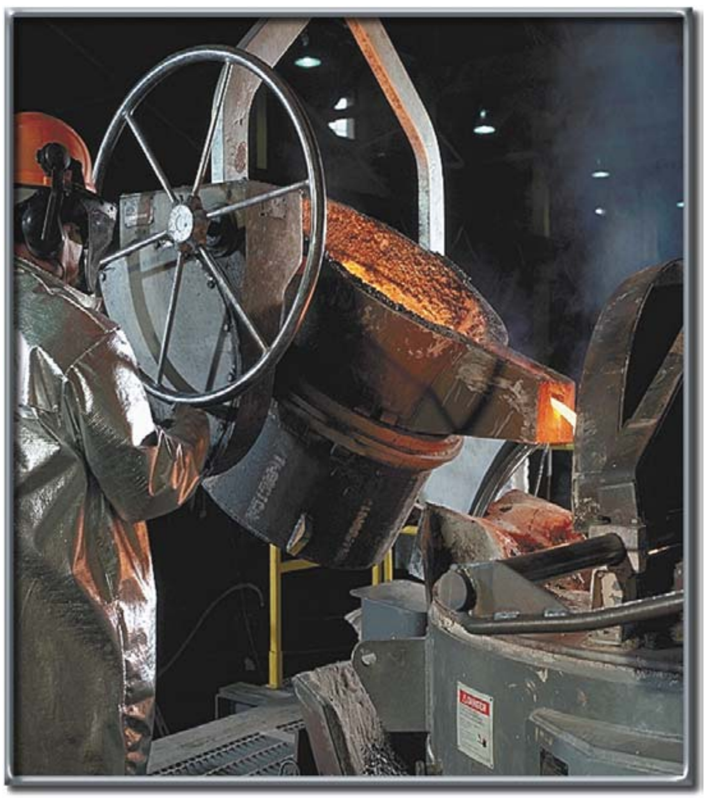
- The analytical results and corresponding laboratory QA/QC data were reviewed by the Emissions Measurement Team to confirm the validity of the data. The Emissions Measurement Team and the Vice President-Measurement Technologies determined whether individual sample data should be invalidated. Invalidated data, if any, were rejected from the database.

3.0 Test Results

Table 5 presents the measured process data. Table 6 presents the stack data and calculated volumetric flow rates.

A summary of the airborne emission results for this baseline test, in pounds of analyte per ton of metal poured, is presented in Table 7. 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 this Production Baseline test (DD), based on results shown in Table 7.



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

Appendix B contains tables presenting the results for all analytes measured during this Production Baseline test (DD). The results presented in this report are not blank or background corrected.

Table 5: Production Foundry Test DD Process and Stack Data

Average Casting Weight, lbs./mold	152
Average Mold Sand Weight lbs./mold	1,260
Average Core Sand Weight, lbs./mold	55.2
Average Resin Weight, lbs./mold	0.95

Process Parameter	# of Samples	Minimum	Maximum	Average	Std Dev.
Compactability, %	22	36	45	40	2.3
LOI, % (at mold)	22	4.36	4.92	4.62	0.12
Clays, % (at mold)	22	8.27	9.56	8.83	0.47
Core LOI, %	14	1.38	1.64	1.51	0.07
Pouring Temperature, ^oF	19	2598	2646	2628	14.0

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
Test Number	DD001	DD002	DD003	DD004	DD005	DD006	DD007
Number of Molds at Sand System	26	22	25	25	26	26	24
Test Number	DD021	DD022	DD023	DD024	DD025	DD026	DD027
Number of Molds at Combined Pouring/Cooling/Shakeout	26	21	26	25	26	26	24

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

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

* Moisture is based on Relative Humidity and Atmospheric Temperature

Table 7: Test Plan DD Total Average Test Results Sand System and Combined Pouring/Cooling/Shakeout

Compound Name	Sand System (Average)	Combined P, C, S (Average)	Total (Average)
TGOM (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 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			
Carbon Monoxide	ND	ND	ND
Methane	ND	ND	ND
Carbon Dioxide	52.8	93.9	147
Condensibles	0.936	1.47	2.40

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

Figure 2: Emission Indicators of Test DD Combined Sand System and Pouring/Cooling/Shakeout

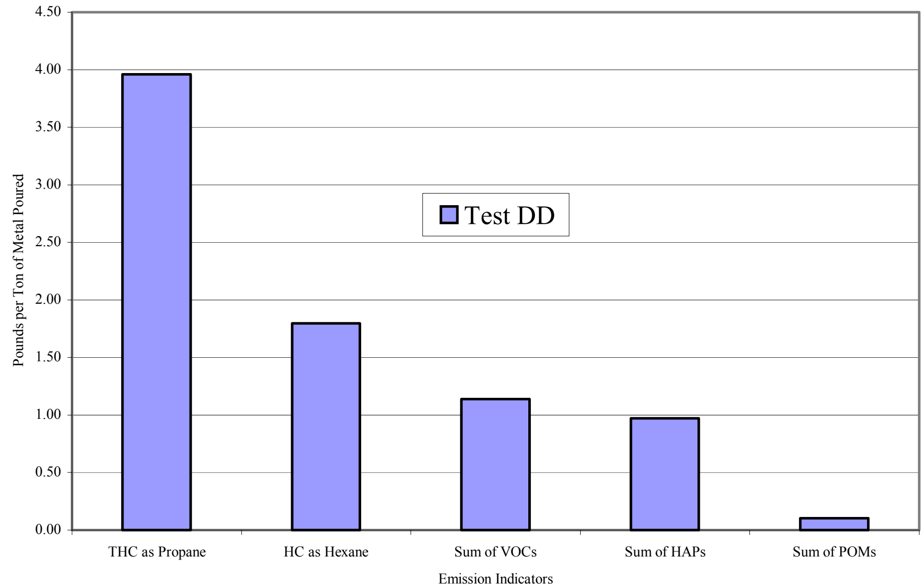


Figure 3: Selected HAP Emissions of Test DD Combined Sand System and Pouring/Cooling/Shakeout

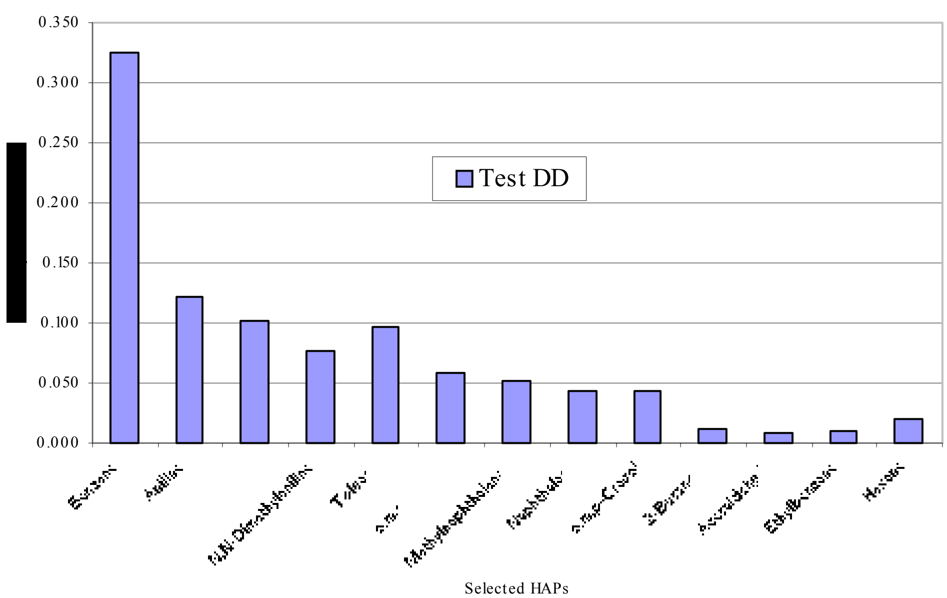


Figure 4: Selected VOC Emissions of Test DD Combined Sand System and Pouring/Cooling/Shakeout

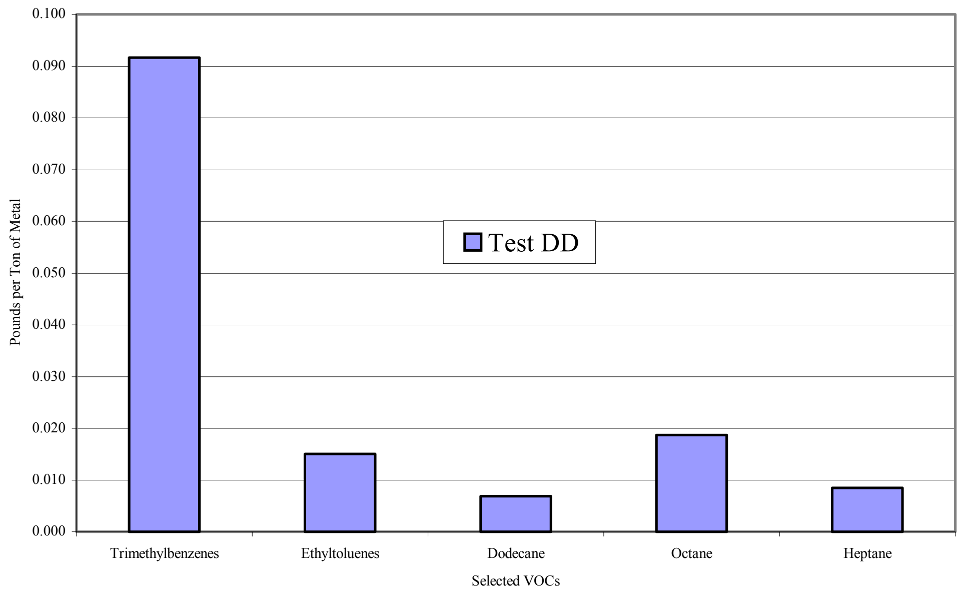


Figure 5: Emission Indicators of Test DD Sand System Only

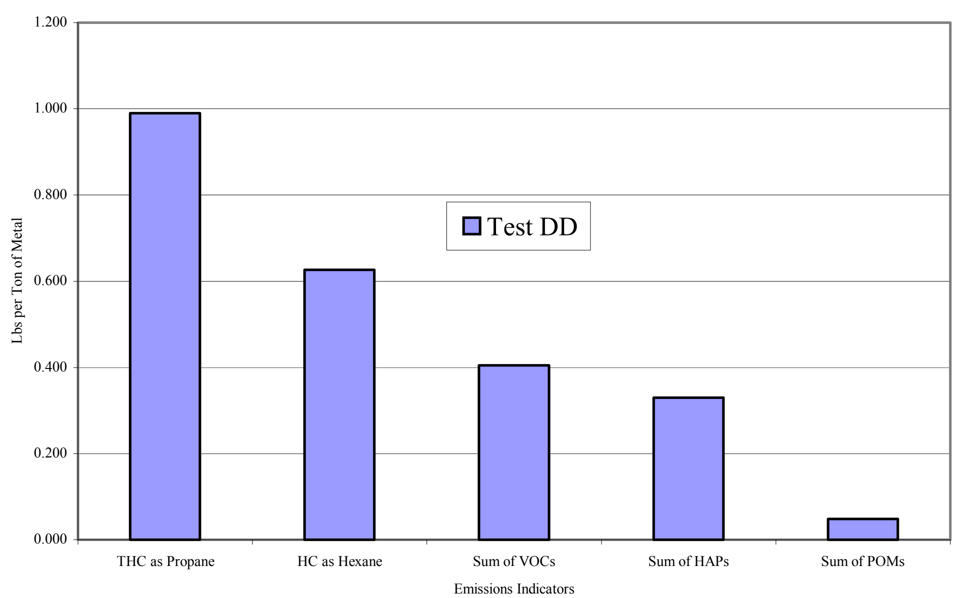


Figure 6: Selected HAP Emissions of Test DD Sand System Only

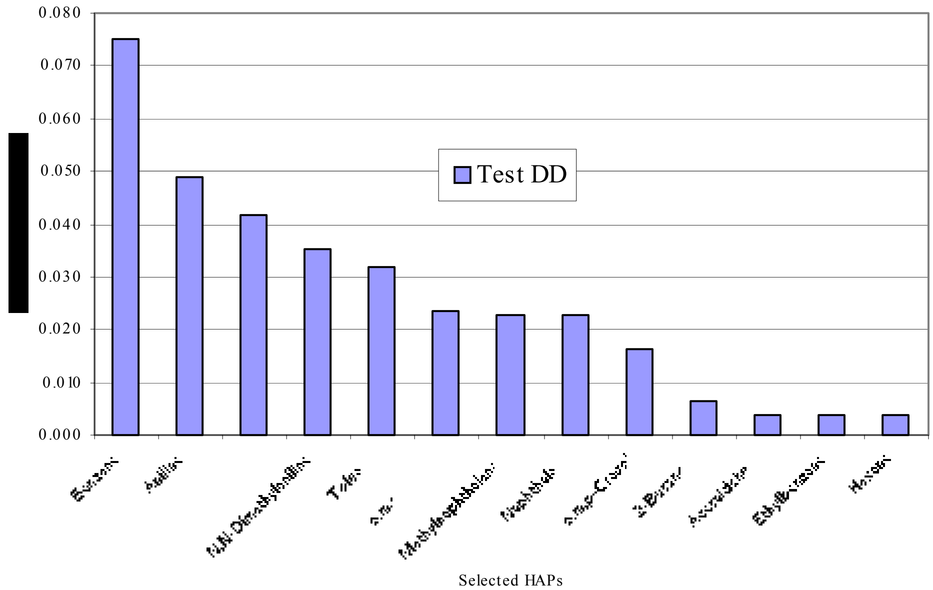


Figure 7: Selected VOC Emissions of Test DD Sand System Only

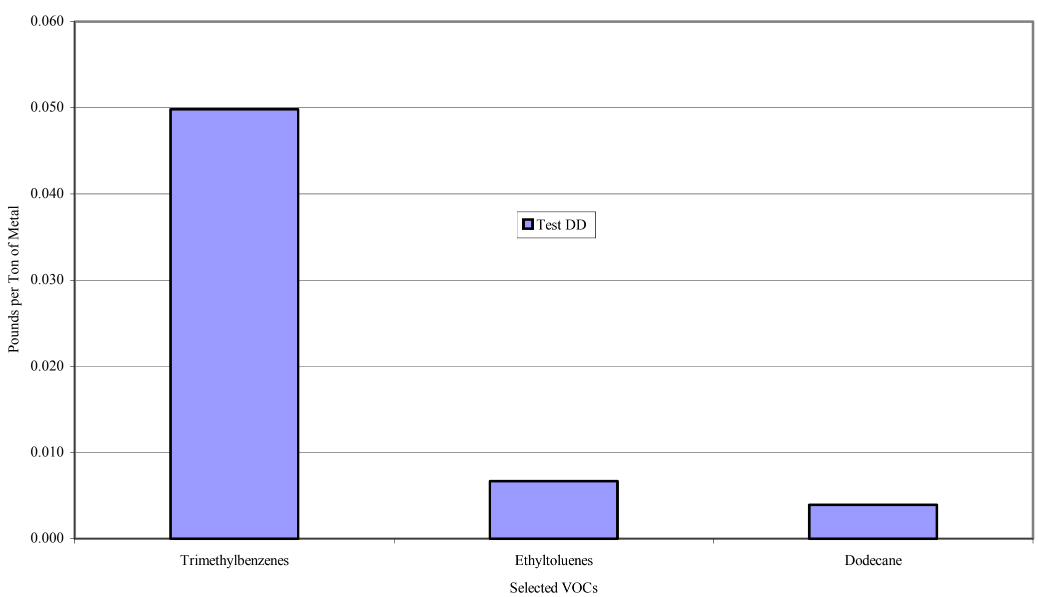


Figure 8: Emission Indicators of Test DD Pouring/Cooling/Shakeout Only

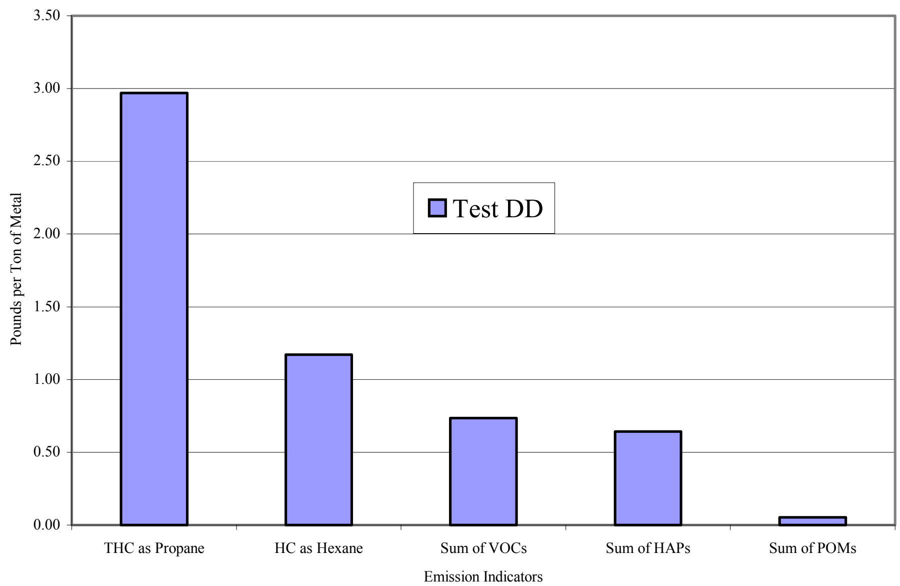


Figure 9: Selected HAP Emissions of Test DD Pouring/Cooling/Shakeout Only

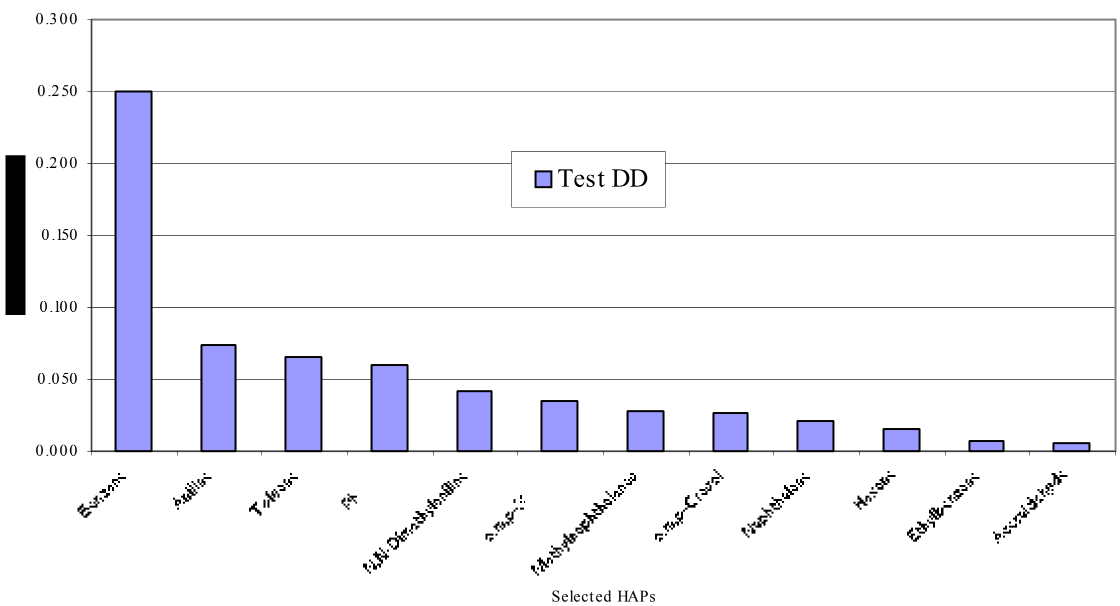
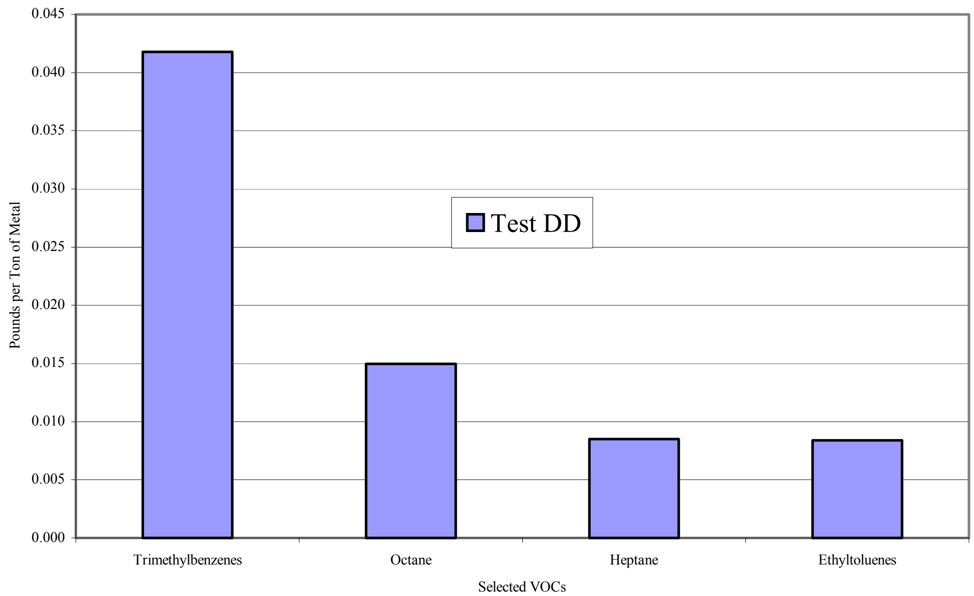


Figure 10: Selected VOC Emissions of Test DD Pouring/Cooling/Shakeout Only



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4.0 Discussion of Results and Conclusions

Protocols used for the core production, greensand preparation, collection of process parameters, sampling, and analysis for this test series (DD) were consistent with those used for previous Production Foundry baseline testing. Samples were collected in Tedlar bags, and were 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 the pouring/cooling/shakeout. ‘

Emission indicators include TGOM (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, TGOM (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, TGOM (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 show that hydrocarbon emissions from pouring/cooling/shakeout, measured as TGOM (THC) as Propane, comprised approximately 75% of the total TGOM emissions measured from both stacks, and sand system TGOM emissions comprised 25% of the total. When measuring as HC as hexane, pouring/cooling/shakeout emissions comprised 65% of the total from both stacks, and sand system HC (hexane) emissions comprised 35% 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. 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.

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APPENDIX A APPROVED TEST PLAN DD

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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:** 21 November 2000
  FINISH: 21 November 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 2630º F.
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 know 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 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 CONDIGTIIONS: 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 form interstitial fines. The assembled sand system shall undergo two additional mulling-only passes to homogenize and pulverize the materials and develop mush 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	*12/05/00*
Emissions Team (USCAR)	**Date**
Original Signed	*12/05/00*
Process and Facilities Team (USCAR)	**Date**
Original Signed	*12/12/00*
Project Manager (CTC)	

Series DD

PILOT FOUNDRY CASTING
QUALITY BASELINE PROCESS INSTRUCTIONS

A. Introduction:

1. 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

1. 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

1. 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 <u>Production Foundry Operating and Safety Manual.</u>

1. Start the sand system baghouse and visually verify the airflow 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.

3. 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 clay 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. M0B 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. This 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 and 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-degree 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. **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 spectro-chemical analysis on all spectro-lugs.

L. Casting sampling

1. Thirty-two castings 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-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 though out 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
Manager, Process Engineering

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

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	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)	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	Breakthroug h	Spike	Spike Amount	Flow (ml/min)		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)		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	Breakthroug h	Spike	Spike Amount	Flow (ml/min)		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)		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	Breakthroug h	Spike	Spike Amount	Flow (ml/min)		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	h	Spike	Amount	Flow (ml/min)	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	Breakthroug h	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	Breakthroug h	Spike	Spike Amount	Flow (ml/min)		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	Breakthroug h	Spike	Spike Amount	Flow (ml/min)		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)		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)		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

APPENDIX B TEST SERIES DD EMISSION TEST RESULTS

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Test Plan DD Sand System Emissions Test Results – lbs/tons metal – Stack 1

OMs	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**		
		TGOM (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
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

OMs	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	**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
		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

OMs	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**		
		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
		Butyl benzene	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
		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
		Condensables	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. N/A: Not Applicable; NT: Not Tested; ND: Non Detect

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

Test Plan DD Pouring/Cooling/Shakeout Emissions Test Results – lbs/tons metal – Stack 3

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**		
		TGOM (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

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	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
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

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		
		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
		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
		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

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**		
		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; ND: Non Detect

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APPENDIX C TEST SERIES DD PROCESS DATA

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SAMPLE NUMBER	%CLAY	% LOI	% VOL	% H2O	AVG. MOLD STRENGTH	% COMP.
001121-0549	9.43	4.65	1.12	1.95	17.61	36
001121-0608	9.30	4.74	1.08	1.93	17.66	38
001121-0631	9.30	4.77	1.14	1.98	16.81	37
001121-0654	9.43	4.54	0.94	2.22	17.96	38
001121-0713	9.43	4.55	1.10	2.03	17.35	38
001121-0729	9.43	4.63	1.28	2.04	17.01	42
001121-0801	9.56	4.55	1.14	1.91	17.26	41
001121-0835	8.91	4.47	1.00	2.07	18.50	40
001121-0904	9.04	4.59	1.12	2.08	18.47	38
001121-0940	8.91	4.48	1.02	1.98	18.79	38
001121-1018	8.91	4.92	1.00	1.94	17.44	40
001121-1055	8.40	4.54	1.00	1.92	17.20	42
001121-1125	8.66	4.61	1.12	2.05	18.16	40
001121-1200	8.40	4.62	1.00	1.81	16.24	39
001121-1229	8.40	4.57	1.12	2.01	17.09	41
001121-1303	8.40	4.36	1.00	1.94	17.98	42
001121-1333	8.52	4.68	1.10	1.95	17.21	43
001121-1405	8.40	4.58	1.04	1.80	16.85	42
001121-1440	8.53	4.77	1.14	1.77	16.51	41
001121-1511	8.27	4.56	1.18	1.37	17.94	43
001121-1541	8.27	4.67	1.06	1.90	17.51	41
001121-1614	8.27	4.78	1.06	1.91	16.66	45

PRODUCTION FOUNDRY SERIES DD									SPECTROMETER RESULTS							DATE: 21 NOV. 2000	RUBEN JIMENEZ	FLOYD R. GIROCCO
SAMPLE #	Fe	FeUV	C	Si	CE	Cr	Cu	Al	Mg	Mo	Ni	Mn	P	Pb	Ti	SnUV	S	Zn
DD00112101	92.06	24184	3.53	2.72	4.44	0.332	0.393	0.007	0.000	0.027	0.129	0.700	0.037	0.001	0.003	0.009	0.054	0.000
DD00112103	93.45	26619	2.84	2.32	3.61	0.265	0.275	0.007	0.000	0.025	0.120	0.598	0.020	0.001	0.003	0.005	0.048	0.000
DD00112104	93.08	25862	2.94	2.44	3.75	0.310	0.810	0.008	0.000	0.030	0.139	0.657	0.024	0.001	0.003	0.005	0.052	0.000
DD00112106	93.43	25482	2.84	2.34	3.62	0.286	0.272	0.008	0.000	0.026	0.121	0.602	0.022	0.001	0.003	0.005	0.049	0.000
DD00112107	93.38	25487	3.02	2.23	3.76	0.267	0.266	0.008	0.000	0.025	0.122	0.586	0.028	0.001	0.003	0.005	0.055	0.000
DD00112108	93.42	25936	3.02	2.20	3.75	0.266	0.264	0.007	0.000	0.025	0.117	0.591	0.027	0.001	0.003	0.005	0.054	0.000
DD00112111	92.44	24000	3.72	2.38	4.51	0.268	0.302	0.009	0.000	0.027	0.142	0.610	0.035	0.001	0.003	0.006	0.067	0.000
DD00112113	92.33	23655	3.82	2.39	4.62	0.268	0.302	0.009	0.000	0.026	0.143	0.609	0.035	0.001	0.003	0.007	0.067	0.000
DD00112109	92.96	25391	3.14	2.43	3.95	0.286	0.303	0.009	0.000	0.027	0.135	0.605	0.035	0.001	0.003	0.006	0.058	0.000
DD00112115	92.76	24566	3.58	2.27	4.34	0.267	0.295	0.008	0.000	0.026	0.135	0.588	0.018	0.001	0.003	0.006	0.053	0.000
DD00112117	92.73	24187	3.58	2.28	4.34	0.268	0.293	0.009	0.000	0.026	0.134	0.593	0.020	0.001	0.003	0.006	0.054	0.000
DD00112119	92.75	24488	3.52	2.31	4.29	0.271	0.299	0.009	0.000	0.027	0.140	0.592	0.019	0.001	0.003	0.006	0.057	0.000
DD00112121	92.80	24559	3.45	2.31	4.22	0.273	0.301	0.010	0.000	0.028	0.143	0.599	0.019	0.001	0.003	0.008	0.055	0.000
DD00112123	93.01	23670	3.39	2.18	4.12	0.276	0.294	0.002	0.000	0.027	0.142	0.603	0.016	0.001	0.004	0.008	0.055	0.000
DD00112125	92.62	23578	3.51	2.34	4.29	0.275	0.304	0.002	0.000	0.027	0.143	0.603	0.016	0.001	0.003	0.008	0.054	0.000
DD00112112	93.29	25053	3.02	2.30	3.79	0.274	0.299	0.003	0.000	0.027	0.132	0.575	0.016	0.001	0.003	0.006	0.054	0.000
DD00112114	93.30	25398	3.07	2.27	3.83	0.273	0.293	0.000	0.000	0.025	0.128	0.579	0.016	0.001	0.003	0.006	0.050	0.000
DD00112116	93.49	24478	3.02	2.19	3.75	0.265	0.272	0.008	0.000	0.025	0.120	0.545	0.017	0.001	0.003	0.006	0.051	0.000
DD00112118	93.55	24863	2.95	2.18	3.68	0.268	0.276	0.008	0.000	0.025	0.121	0.550	0.017	0.001	0.003	0.006	0.050	0.000
DD00112127	93.44	24843	3.05	2.17	3.77	0.273	0.273	0.008	0.000	0.026	0.128	0.562	0.017	0.001	0.003	0.005	0.045	0.000
DD00112129	93.45	24863	3.05	2.16	3.77	0.272	0.270	0.007	0.000	0.026	0.126	0.558	0.018	0.001	0.003	0.005	0.047	0.000
DD00112131	93.28	24336	3.28	2.12	3.97	0.264	0.272	0.008	0.000	0.026	0.129	0.555	0.019	0.001	0.003	0.006	0.052	0.000
DD00112133	93.24	24403	3.22	2.19	3.95	0.266	0.279	0.008	0.000	0.027	0.133	0.560	0.019	0.001	0.003	0.006	0.048	0.000
AVERAGE	93.06	24778	3.24	2.29	4.00	0.276	0.291	0.007	0.000	0.026	0.131	0.592	0.022	0.001	0.003	0.006	0.053	0.000
S.D.	0.406	768.8	0.287	0.126	0.303	0.016	0.026	0.003	0.000	0.001	0.008	0.034	0.007	0.000	0.000	0.001	0.005	0.000
RSD %	0.436	3.103	8.868	5.503	7.57	5.613	8.935	36.613	0.000	4.422	6.41	5.70	31.06	0.000	6.7006	14.478	9.8983	0.000
DD001121A	93.21	25913	2.83	2.46	3.65	0.306	0.805	0.008	0.000	0.030	0.136	0.635	0.026	0.001	0.003	0.005	0.053	0.000
DD001121B	92.89	25283	3.39	2.30	4.16	0.271	0.287	0.007	0.000	0.025	0.131	0.594	0.033	0.001	0.003	0.006	0.060	0.000
DD001121C	92.81	23883	3.50	2.30	4.27	0.270	0.294	0.007	0.000	0.024	0.131	0.580	0.013	0.001	0.003	0.006	0.053	0.000
DD001121D	92.87	24763	3.37	2.34	4.15	0.275	0.301	0.008	0.000	0.027	0.141	0.590	0.019	0.001	0.003	0.006	0.054	0.000
DD001121E	93.44	24594	3.05	2.16	3.79	0.269	0.277	0.007	0.000	0.025	0.123	0.547	0.019	0.001	0.003	0.006	0.048	0.000
AVERAGE	93.04	24887	3.23	2.32	4.00	0.279	0.293	0.007	0.000	0.026	0.132	0.589	0.023	0.001	0.003	0.006	0.054	0.000
S.D.	0.242	681	0.249	0.090	0.241	0.014	0.010	0.000	0.000	0.002	0.006	0.028	0.006	0.000	0.000	0.000	0.004	0.000
RSD %	0.260	2.736	7.720	3.877	6.03	5.10	3.418	6.620	0.000	8.150	4.522	4.79	25.05	0.000	0.000	6.8966	7.1385	0.000

APPENDIX D METHOD 25A CHARTS

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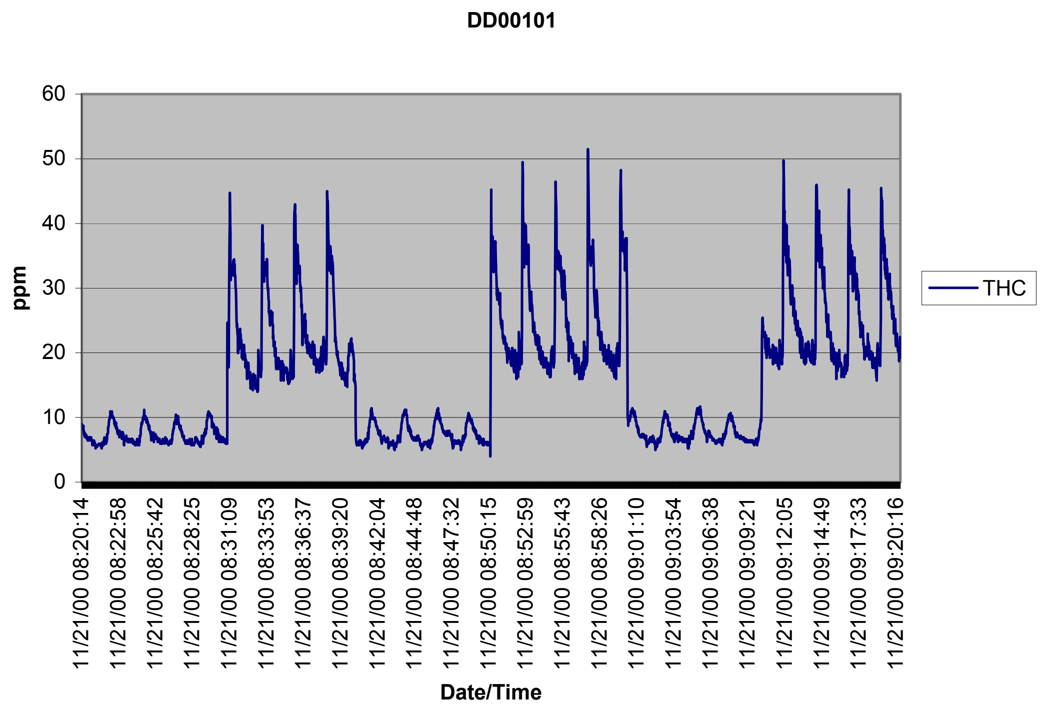
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30
20
10
0
ppm
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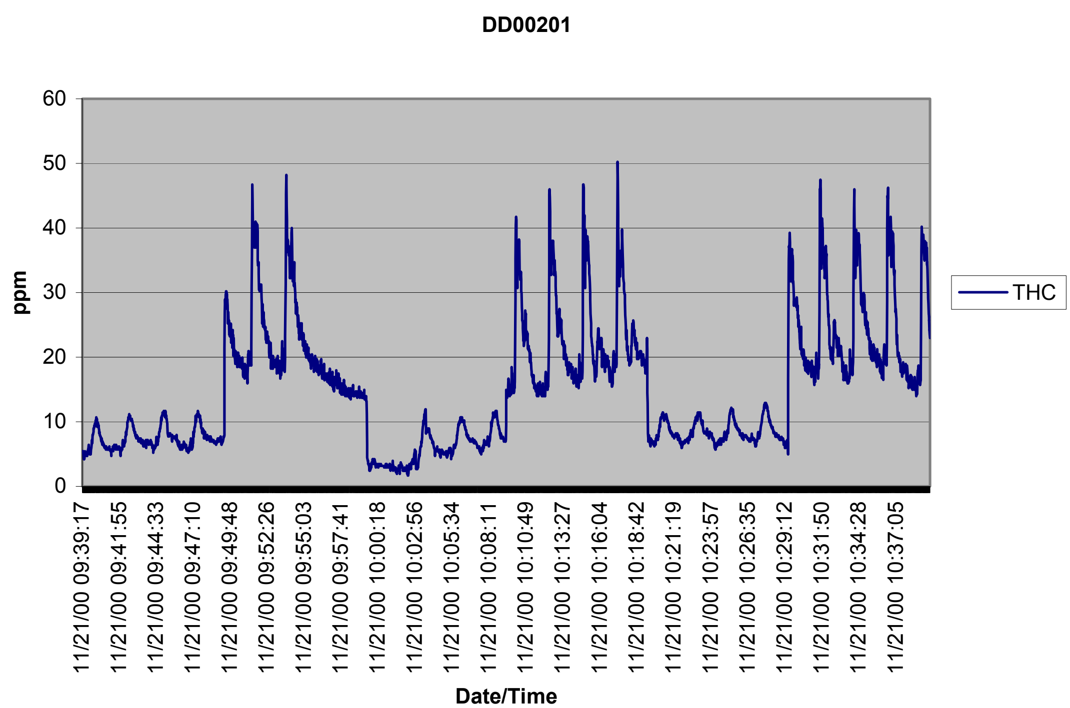
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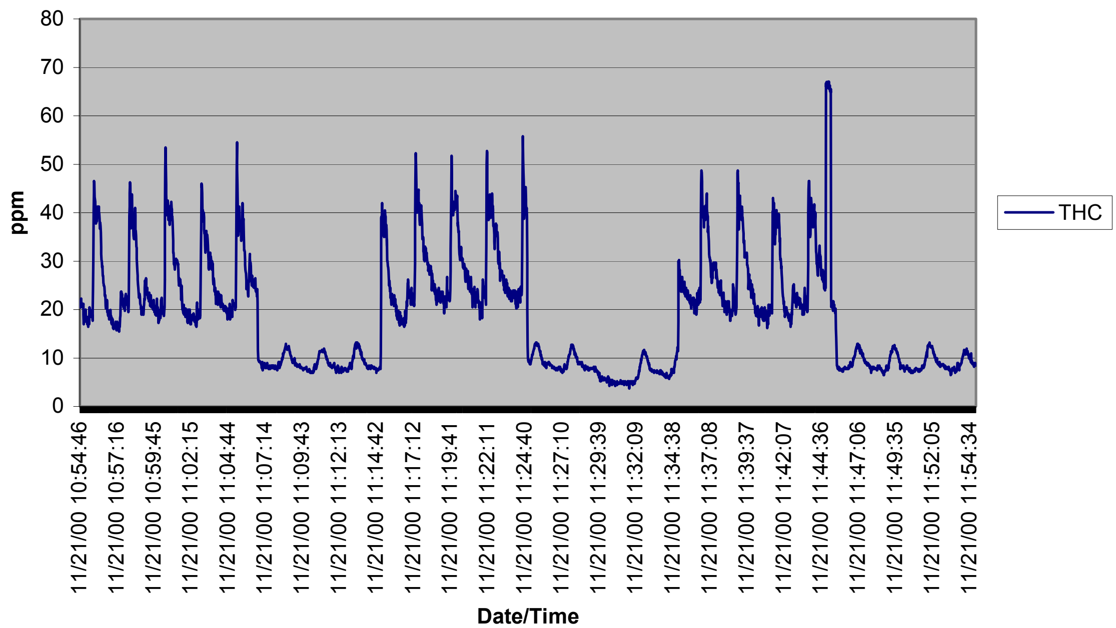

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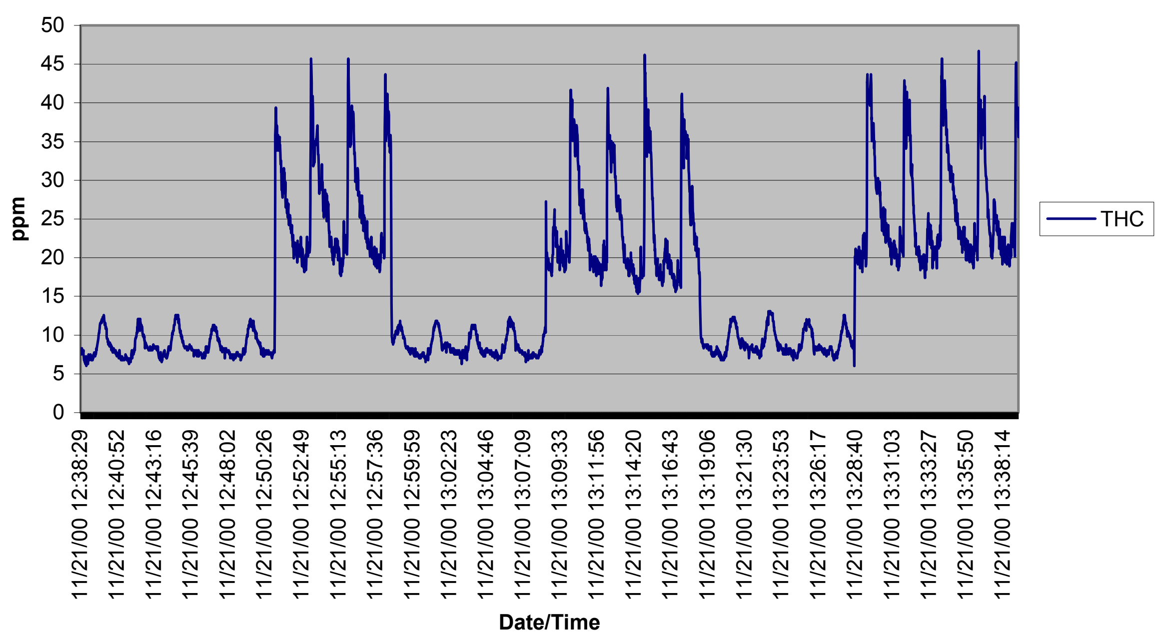

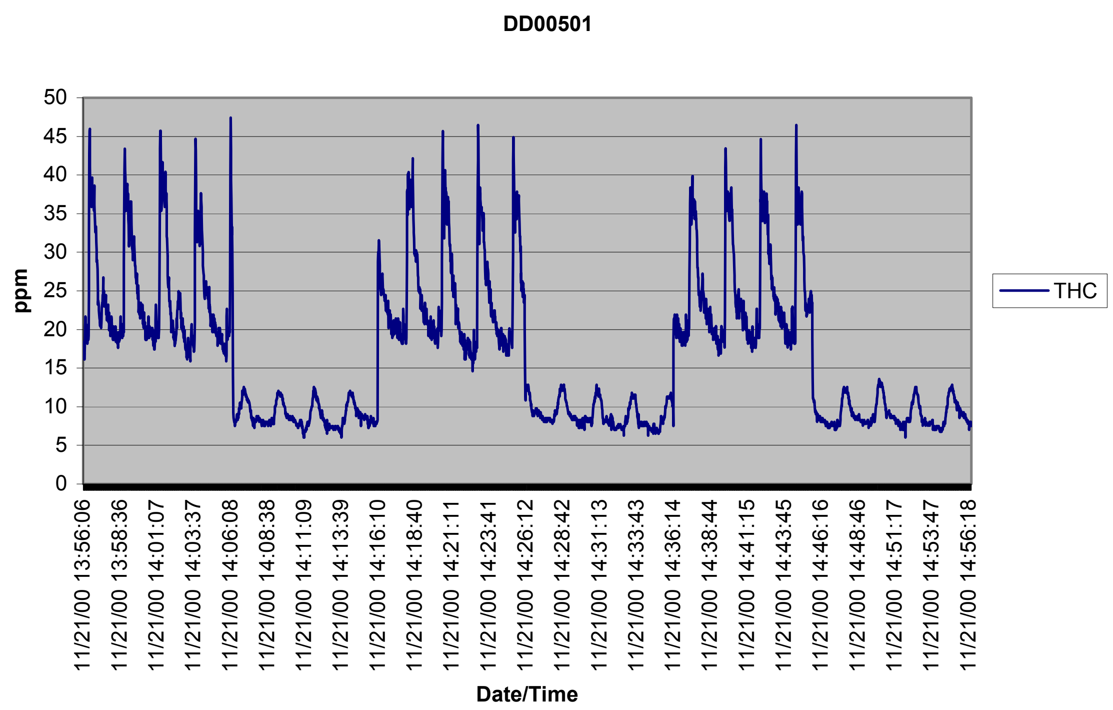
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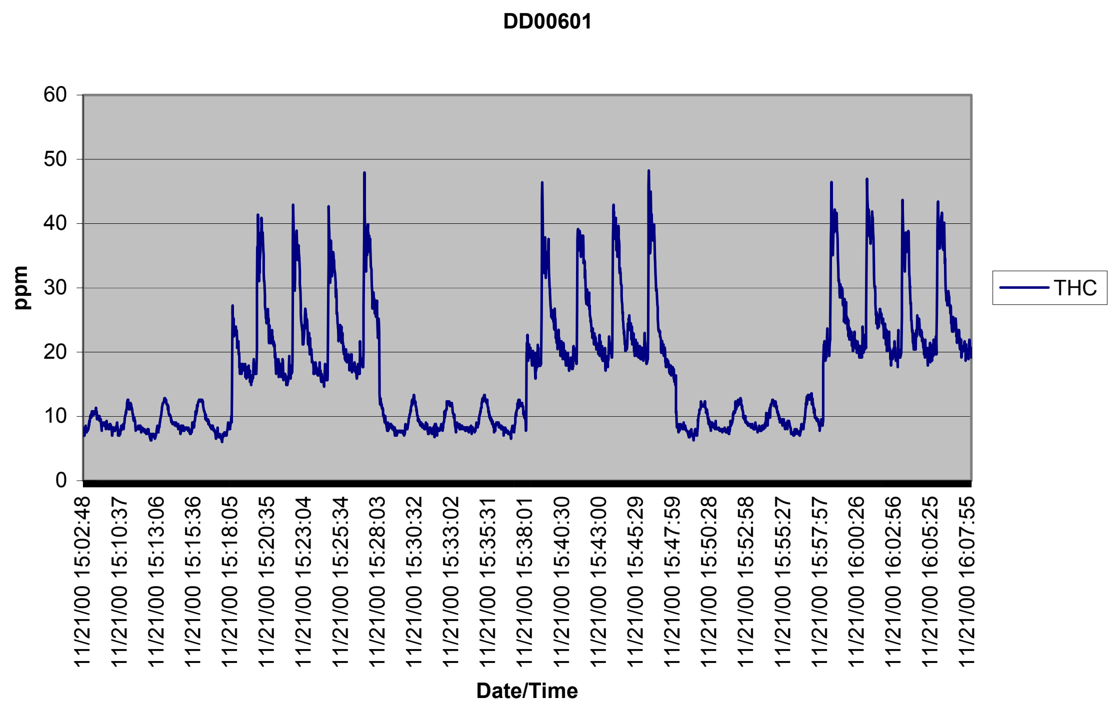
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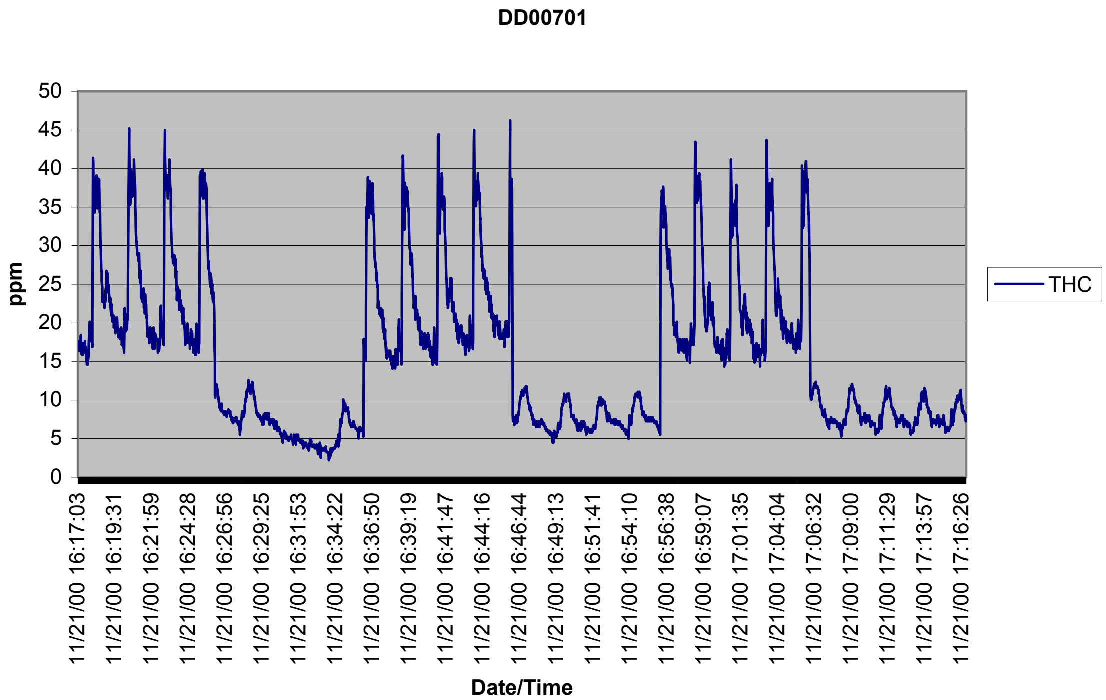
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THC
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Date/Time

APPENDIX E VALIDATION LOG

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APPENDIX F SUPPORT DOCUMENTS

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Support Documents

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

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

2. CERP Emission Testing and Analytical Testing Standard Operating Procedures.

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

4. Baseline (DD) data binder.

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APPENDIX G 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 2.18. 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 Data

No Test Lab testing was not done on this analyte.

Organic Compound of Concern Organic compounds routinely found in foundry processes that are not considered HAPs but because of their presence are monitored.

HC Calculated by the summation of all area before elution of Hexane to after the elution of Anthracene. The quantity of HC is performed against a five-point calibration curve of Hexane by dividing the total area count from C6 to C16 to the area of Hexane curve from the initial calibration curve.