CERP

Casting Emission Reduction Program

Prepared by:

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US Army Task N256

Delta Aluminum Urethane No-Bake 20-260 and 23-227

Technikon # RE 1 001 03 DH

25 June 2001

This document was revised for unlimited public distribution.

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Pre-Production Air Emission Test Report

No-Bake Binder Systems

Delta Aluminum Urethane No-Bake 20-260 and 23-227

RE100103DH

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

Written by:	Carmen Hornsby	6/25/01 Date
Process Engineering Manager:	Steven Knight	6/25/01 Date
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VP Operations:	George Crandell	6-25-01 Date
President:	William Walden	6-25-01 Date

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 emission testing to evaluate the pouring, cooling, and shakeout emissions from Test DH, an Polyether Polyol Urethane No-Bake binder system. These data are compared to results from Test DK, a Phenolic Urethane No-Bake baseline binder system. All testing was conducted by Technikon, LLC in its Pre-Production foundry.

The Pre-Production Foundry is a simple general purpose manual foundry that was adapted and instrumented to make detailed organic emission measurements, using methods based on EPA protocols for pouring, casting cooling, and shakeout processes on *discrete* molds. The measurements are conducted under tightly controlled conditions not feasible in a commercial foundry. Evaluating a new product or process in the Technikon Pre-Production Foundry reduces the risk of new material or product introduction for the foundry industry.

The specific objective of Test DK was to establish air emission data for No-Bake binders poured with aluminum against which the air emissions from new materials, equipment and processes, designed to reduce organic Hazardous Air Pollutants (HAPs) and Volatile Organic Compounds (VOCs) can be compared. This report documents the following test series: A comparison of a Polyether Polyol Urethane binder (Test DH) to the baseline Phenolic Urethane binder system (Test DK). Both tests were poured with aluminum metal.

The testing performed involved the collection of continuous air samples over a seventy-five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and include: the weights of the casting, mold, binder; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack temperature, pressure, volumetric flow rate and moisture content. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility 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 Concentration (TGOC), formerly Total Hydrocarbon Content (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 each casting. Results for structural isomers have been grouped and reported as a single entity. For example, ortho, meta, and para xylene are the three (3) structural isomers of 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 sub-groups 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.

Results for the emission indicators for Test DK and DH are shown in the following table. All results are reported as pounds emitted per ton of metal.

Emissions Indicators	Test DK	Test DH	% Change from DK
TGOC (THC) as Propane	29.9	2.25	-93%
HC as Hexane	30.3	0.951	-97%
Sum of VOCs	6.48	0.342	-95%
Sum of HAPs	1.79	0.282	-84%
Sum of POMs	0.336	0.048	-86%

The results from the above table show a decrease in emission indicators for Test DH compared to DK ranging from 84% to 97% lower emissions. Both Test DH and DK were poured with aluminum and used 1.1% binder.

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

1.0 Introduction

1.1 Background

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes. Other technical partners directly supporting the project include: the American Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US E PA); and the California Air Resources Board (CARB).

1.2 CERP Objectives

The primary objective of CERP is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions, especially for the 1990 Clean Air Act Amendment HAPs. The facility has two principal testing arenas: a Pre-Production Foundry designed to measure airborne emissions from individually poured molds, and a Production Foundry designed to measure air emissions in a continuous full scale production process. Each of these testing arenas has been specially designed to facilitate the collection and evaluation of airborne emissions and associated process data. The data collected during the various testing projects are evaluated to determine both the airborne emissions impact of the materials and/or process changes, and their stability and impact upon the quality and economics of casting and core manufacture. The materials, equipment, and processes may need to be further adapted and defined so that they will integrate into current casting facilities smoothly and with minimum capital expenditure.

Normally, Pre-Production testing is conducted first in order to evaluate the air emissions impact of a proposed alternative material, equipment, or process in the most cost effective manner. The Pre-Production Foundry is a simple general purpose manual foundry that was adapted and instrumented to make detailed emission measurements using methods based on EPA protocols for pouring, casting cooling, and shakeout processes on *discrete* molds under tightly controlled conditions not feasible in a commercial foundry. The Pre-Production Foundry uses a four-cavity, AFS irregular gear mold as its test pattern for No-Bake testing. All No-Bake testing occurs in the Pre-Production Foundry.

The Production Foundry's design as a basic greensand foundry was deliberately chosen so that whatever is tested in this facility will also be convertible to existing mechanized commercial foundries. The type and size of equipment, materials, and processes used emulate an automotive foundry. This facility is used to evaluate materials, equipment, and processes in a *continuous* process that is allowed to vary to the limits of commercial experience in a controlled manner. The Production Foundry provides simultaneous detailed individual emission measurements using methods based on US E P A protocols of the melting, pouring, sand preparation, mold making, and core making processes. It is instrumented so that the data on all activities of the metal casting process can be simultaneously and continuously collected, in order to completely evaluate the economic impact of the prospective emission reducing strategy. The Production Foundry's test casting is a single cavity Ford Motor Company I-4 engine block. Castings are randomly selected to evaluate the impact of the material, equipment, or process on casting quality. Alternative materials, equipment, and processes that demonstrate significant air emission reduction potential, preserve casting quality parameters, and that are economically viable based on the Pre-Production testing, may be further evaluated in the Production Foundry.

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

1.3 Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate the performance of an alternative material, equipment, or process in the Pre-Production Foundry. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test are summarized in Section 3 of this report, with detailed data included in Appendices B and C of this report. Section 4 of this report contains a discussion of the results and recommendations for additional testing, if any.

The raw data for this test series are included in a data binder that is maintained at the Technikon facility. There are several support documents that provide details regarding the testing and analytical procedures used. Appendix F contains a listing of these support documents.

1.4 Preliminary Testing

The foundation for the specific test protocols and airborne emission measurements have been determined from testing performed to:

- Establish the required number of samples needed to statistically support the evaluation of emission reduction potentials of the alternative materials, equipment, and processes that may be evaluated;

- Provide a series of standardized emissions from standard mold packages.

It has been determined that nine replicate tests will provide a statistically significant sample for the purposes of evaluating the emission reductions from alternative materials, equipment, and processes. The results of the testing conducted in support of this conclusion is included in a report entitled *Evaluation of the Required Number of Replicate Tests to Provide Statistically Significant Air Emission Reduction Comparisons for the CERP Pre-Production Foundry Test Program.*

1.5 Specific Test Plan and Objectives

This report contains the results of testing performed to assess the emission reduction potential of two different No-bake binder systems. The test hypothesis is that the test binder system will have lower VOC and HAP emissions than a reference (baseline) No-Bake binder system. Table 1-1 provides a summary of the test plans. The details of the approved test plans are included in Appendix A.

Table 1-1 Test Plan Summary

	Test Plans	
Type of Process tested	Phenolic Urethane	Polyether Polyol Urethane
Test Plan Number	RV100106DK	RE100103DH
Binder System	Delta HA TECHNISET® 20-015/23-133/17-971	Delta HA TECHNISET® 20-260/23-227/17-971
Metal Poured	Aluminum	Aluminum
Casting Type	Four-cavity AFS Irregular Gear Mold	
Number of molds poured	9	9
Test Dates	1/3/01 > 1/5/01	4/11/01 > 4/13/01
Emissions Measured	70 organic HAPs and VOCs	
Process Parameters Measured	Total Casting, Mold and Binder Weights, Metallurgical data, % LOI, Stack Temperature, Stack Moisture Content, Stack Pressure, and Stack Volumetric Flow Rate	

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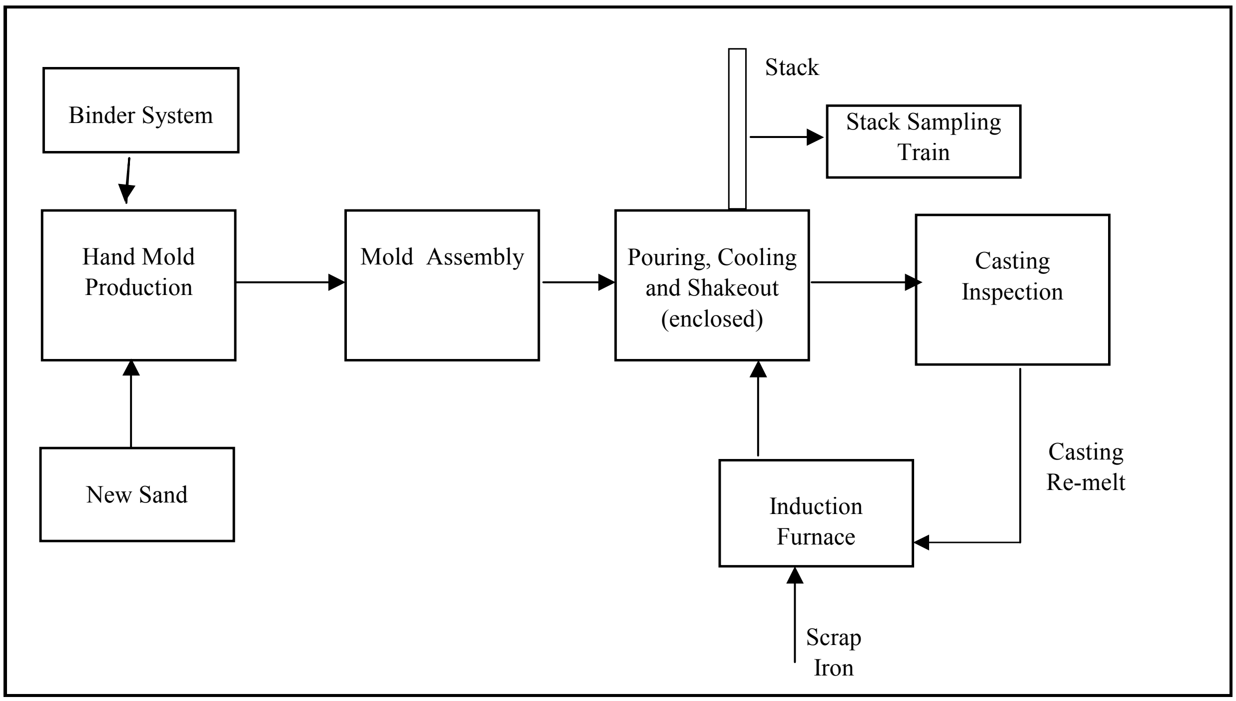
2.0 Test Methodology

2.1 Description of Process and Testing Equipment

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

Figure 2-1 Pre-Production Foundry Layout Diagram



2.2 Description of Testing Program

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

1. **<u>Test Plan Review and Approval:</u>** The proposed test plan was reviewed by the Technikon staff and CTC Program Manager, and approved.

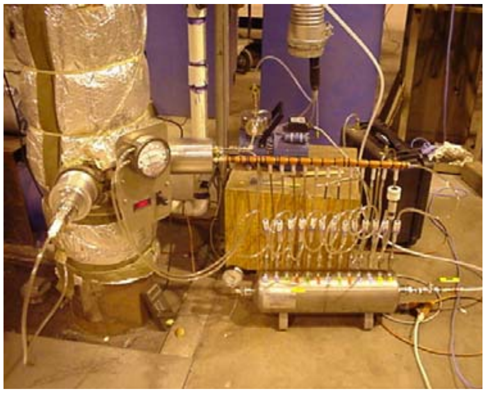
2. **<u>Mold and Metal Preparation:</u>** The molds are prepared to a standard composition by the Technikon production team. Relevant process data are collected during mold preparation.


No-Bake Mold Preparation

Iron is melted in a 1,000 lb. Ajax induction furnace. The amount of metal melted is determined from the poured weight of the casting and the number of molds to be poured. The metal composition is prescribed by a metal composition worksheet. The weight of metal poured into each mold is recorded on the process data summary sheet.


Pouring of Molds Through Opening in Collection Hood

3. <u>Individual Sampling Events:</u> Replicate tests are performed on several mold packages. The mold packages are each placed into an enclosed test stand. Iron is poured through an opening in the top of the enclosure. The opening is closed as soon as pouring is completed. Continuous air samples are collected during the forty-five minute pouring and cooling process, during the fifteen minute shakeout of the mold, and for an additional fifteen minute period following shakeout. The total sampling time is seventy-five minutes.


Volatiles and Condensables Sampling

The weight of each mold and the weight of binder used to prepare that mold are recorded on the Process Data Summary Sheet. In addition, the pouring temperature, number of cavities poured, the %LOI of the mold before pouring are also recorded on the Process Data Summary Sheet.

The unheated emission hood is ventilated at approximately 700 SCFM through a 12-inch diameter heated duct. Emissions samples are drawn from sampling ports located to ensure conformance with EPA Method 1. The tip of the probe is located in the centroid of the duct.


Castings after Shake Out

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

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Acme 4260 Crane Scale (Gravimetric)
Casting Weight	Westweigh PP2847 Platform Scale (Gravimetric)
Binder Weight	Mettler PJ8000 Digital Scale (Gravimetric)
Sand Resin Tensile Strength	Dietert 405 Universal Strength Machine
Tensile Test Bar Weight	Mettler PJ 4000 Digital Scale (Gravimetric)
LOI, %	Denver Instruments XE-100 Analytical Scale (AFS procedure 321-87-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C immersion pyrometer)
Carbon/Silicon, and Fusion Temperature	Electro-Nite Datacast 2000 (Thermal Arrest)
Alloy Weights	OHAUS MP-2
Carbon/Silicon	Baird Foundry Mate Optical Emission Spectrometer

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

Table 2-2 Sampling and Analytical Methods

Measurement Parameter	Test Method
Port location	EPA Method 1
Number of traverse points	EPA Method 1
Gas velocity and temperature	EPA Method 2
Gas density and molecular weight	EPA Method 3a
Gas moisture	EPA Method 4, gravimetric
HAPs concentration	EPA Method 18, TO11, NIOSH 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.

6. **Data Reduction, Tabulation and Preliminary Report Preparation:** The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is

calculated from the measured stack gas velocity and duct diameter, and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the casting poured to provide emissions data in pounds of analyte per ton of metal.

The results of each of the sampling events are included in Appendix B of this report. The results of each test are also averaged and are shown in Table 3-1.

7. **Report Preparation and Review:** The Preliminary Draft Report is reviewed by the Process Team and Emissions Team to ensure its completeness, consistency with the test plan, and adherence to the prescribed QA/QC procedures. Appropriate observations, conclusions and recommendations are added to the report to produce a Draft Report. The Draft Report is reviewed by the Vice President-Measurement Technologies, the Vice President-Operations, and the Technikon President. Comments are incorporated into a draft Final Report prior to final signature approval and distribution.

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

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

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

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

3.0 Test Results

The average emission results, in pounds per ton of metal poured, is presented in Table 3-1 for tests reported in this document. This table includes the individual VOC compounds that comprise at least 95% of the total VOCs measured, along with the corresponding sum of VOCs, sum of HAPs, and sum of POMs. The table also includes the TGOC (THC) as Propane, HC as Hexane and the percentage difference between the baseline (DK) and the test system (DH). Percentage differences in **bold** are the result of emissions differences, not test variability. Figures 3-1, 3-2, and 3-3 represent the comparisons of the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-1 in graphical form. Appendix B contains the detailed data including the results for all analytes measured. Table 3-2 includes the averages of the key process and source parameters and the data target ranges. Detailed process and source data are presented in Appendix C.

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

A laboratory analytical data validation log is maintained in the Technikon offices.

Table 3-1 Summary of Test Plan DK and DH Average Results

Analytes	Test DK (Lb/Tn)	Test DH (Lb/Tn)	% Change from DK
TGOC (THC) as Propane	29.9	2.25	**-93%**
HC as Hexane	30.3	0.951	**-97%**
Sum of VOCs	6.48	0.342	**-95%**
Sum of HAPs	1.79	0.282	**-84%**
Sum of POMs	0.336	0.048	**-86%**
	Individual Organic HAPs		
o,m,p-Cresol	0.889	ND	**-100%**
Phenol	0.310	0.021	**-93%**
Naphthalene	0.262	0.017	**-94%**
Acetaldehyde	0.091	0.114	**25%**
Aniline	0.077	0.025	**-67%**
Methylnaphthalenes	0.054	0.014	**-75%**
Propionaldehyde	0.053	0.051	-3%
Dimethylnaphthalenes	0.020	0.016	**-18%**
Toluene	0.009	0.011	18%
o,m,p-Xylenes	0.009	0.005	**-41%**
Benzene	0.004	0.004	-7%
Hexane	0.002	0.005	**148%**
Formaldehyde	0.001	0.009	**498%**
	Other VOCs		
Dimethylphenols	3.65	ND	**-100%**
Trimethylphenols	0.500	ND	**-100%**
Indan	0.286	ND	**-100%**
Trimethylbenzenes	0.146	0.005	**-97%**
Benzaldehyde	0.004	0.006	**32%**
Butyraldehyde/Methacrolein	0.003	0.011	**271%**
Diethylbenzenes	ND	0.026	**NA**
Crotonaldehyde	ND	0.005	**NA**
	Other Analytes		
Condensables	2.26	2.36	4%
Carbon Monoxide	1.84	ND	**-100%**
Methane	ND	ND	NA
Carbon Dioxide	114	102	**-11%**

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

ND: Non Detect; **NA**: Not Applicable

All "**Other Anlaytes**" are not included in the Sum of HAPs or VOCs.
"Percent Change from Test DK" values in bold indicate a 95% probability that the differences in the average values were not from test variability.
Test DH carbon dioxide ambient background level: 114 Lb/Tn

Table 3-2 Summary of Test Plan DK and DH Process and Stack Parameters

Average Process and Stack Parameters	Average of DK	Average of DH	% Difference	Target Range for DH
Casting Metal Weight: casting & sprue, lbs.	51	49	-3.92	50 - 54
Pouring Temperature, °F	1251	1251	0.00	1240 - 1260
No-Bake Mold Weight, lbs.	331	278	-16.01	275 - 335
% Resin (Resin + co-reactant) BOS	1.1	1.09	-0.91	1.10
Ratio Resin to co-reactant	50 / 50	40 / 60	N/A	40 / 60
Total (Resin + co-reactant), true % BO (Binder + sand)	1.09	1.09	0	1.07 - 1.11
Total Binder, True % BO (Binder + sand)	1.09	1.13	3.67	1.05 - 1.15
No Bake Mold LOI, % @ 1400°F	1.37	1.17	-14.60	1.0 - 1.9
Dog Bone Tensile Strength 2 hrs, psi	63	52	-17.46	30 - 80
Dog Bone Tensile Strength 24 hrs at 90% RH, psi	23	11	-52.17	10 - 30
Average Stack Temperature, °F	79	84	6.3	110 ± 10
Total Moisture Content, %	0.82	0.88	7.3	N/A
Average Stack Velocity, ft./sec.	15.8	15.2	-3.4	15 ± 2
Avg. Stack Pressure, in. Hg	30.22	30.09	-0.4	N/A
Stack Flow Rate, scfm	730	695	-4.8	700 ± 50

(DK) Binder = Resin + co-reactants

(DH) Binder = Resin + co-reactant + catalyst

BO = Based on ( )

Figure 3-1 Comparison of Emission Indicators from Test DK and DH

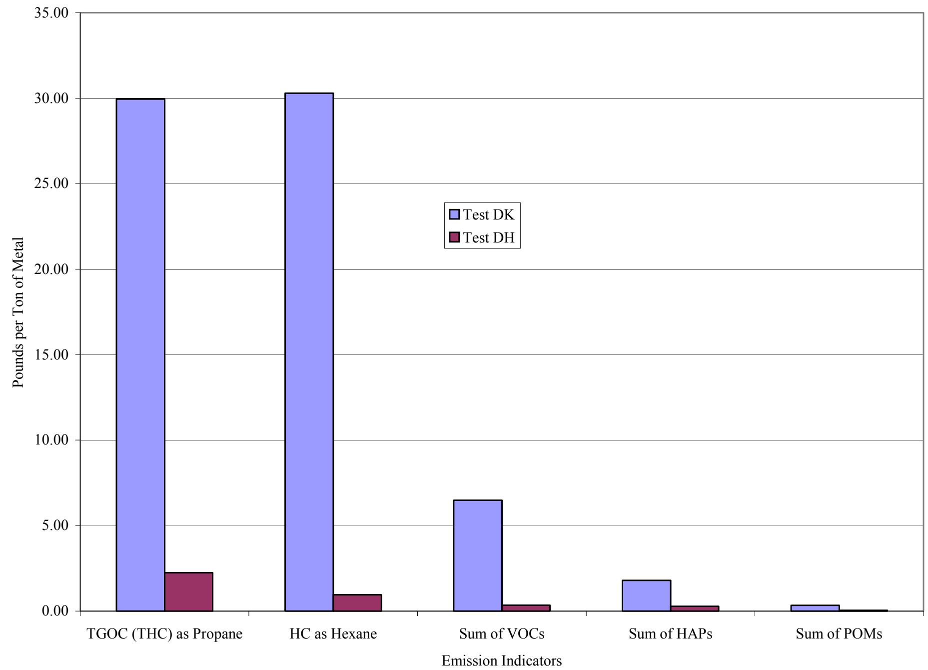


Figure 3-2 Comparison of Selected HAP Emissions from Test DK and DH

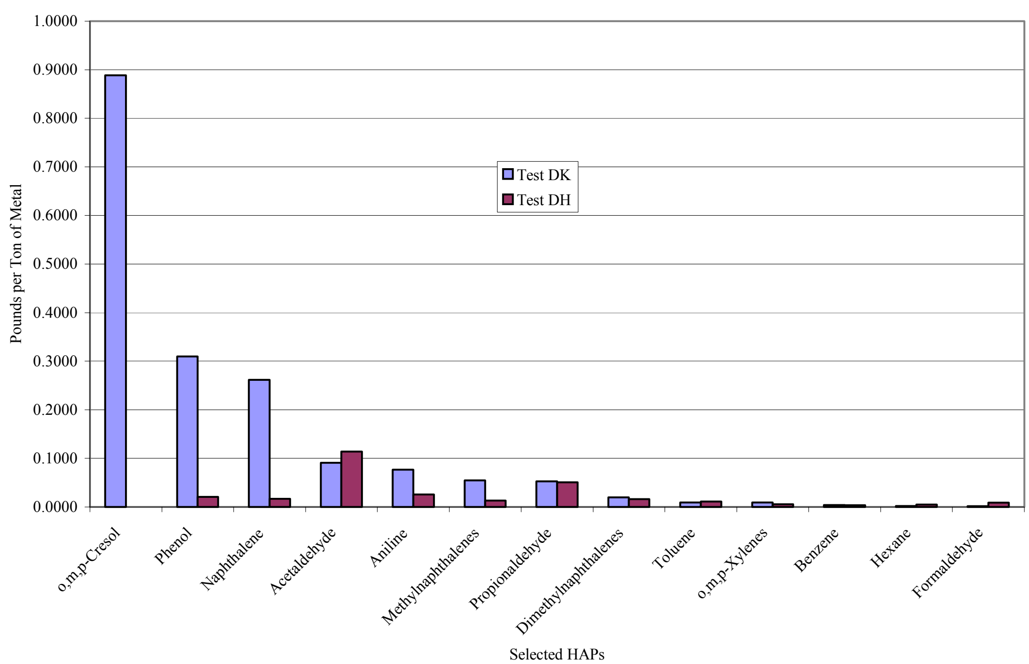
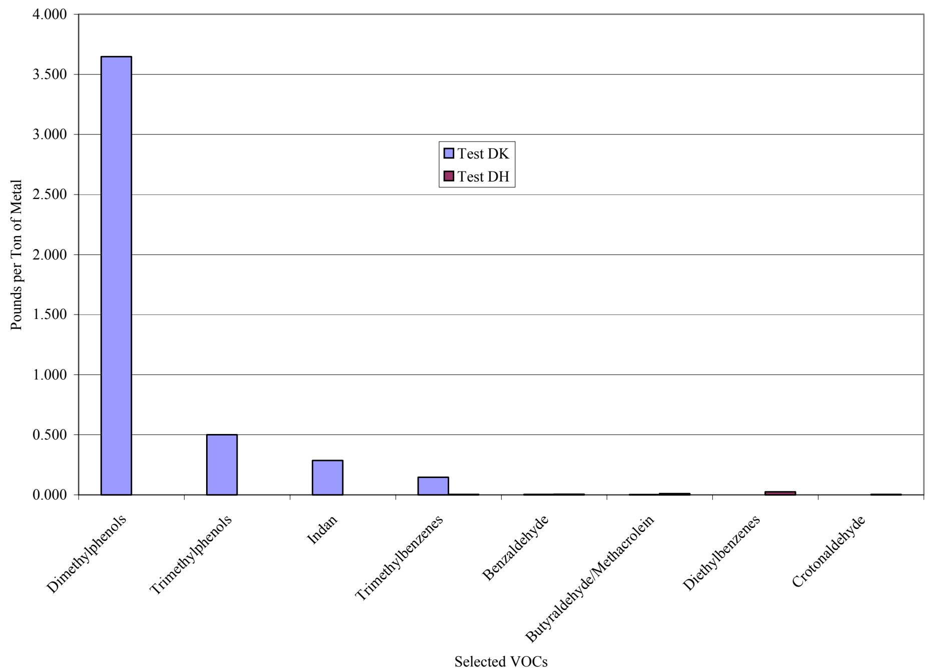


Figure 3-3 Comparison of Selected VOC Emissions from Test DK and DH



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4.0 Discussion of Results

The sampling and analytical methodologies were the same for Test Plans DK and DH.

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

In Table 3-1, the "% Change from Test DK" values presented in **bold** letters indicate a greater than 95% probability that the differences in the average values were not the result of variability in the test protocol determined from T-Statistic calculations. A table showing the T-Statistics calculated is found in Appendix B.

The results of the tests performed for the comparison of Test DH to DK show a **93%** reduction in TGOC (THC) as propane, a **97%** reduction in HC as hexane, a **95%** reduction in VOCs, an **84%** reduction in HAPs, and an **86%** reduction in POMs.

For the baseline Test DK, the three largest contributors to the Sum of HAPs were o,m,p-cresol, phenol, and naphthalene. In comparison, acetaldehyde, propionaldehyde, and aniline were found to be the three largest contributors to the Sum of HAPs for Test DH.

Sampling was performed to determine local ambient background levels of carbon dioxide (CO_2) for Test DH near the sampling stack in the Pre-production foundry. The ambient CO_2 was calculated to be 114 pounds per ton of metal for Test DH. Ambient background sampling was not performed for the reference Test DK; therefore, direct comparisons between the two tests cannot be made. (See footnote on Table 3-1.)

USEPA Method 25A, TGOC (THC) 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 and detects hydrocarbon compounds in the alkane range between C6 and C16, with results calibrated against a six-carbon alkane (hexane).

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APPENDIX A APPROVED TEST PLANS FOR TEST SERIES DK AND DH

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TECHNIKON TEST PLAN

- > **CONTRACT NUMBER: 1256 TASK NUMBER: 120**
- > **CONTROL NUMBER: RV 1 00106**
- > **SAMPLE FAMILY: DK**
- > **SAMPLE EVENTS: 001 thru 009**
- > **SITE: __X__PRE-PRODUCTION (243)____PRODUCTION (238)**
- > **TEST TYPE:** Delta HA Phenolic Urethane No-Bake (20-015 Part I, 23-133 Part II Aluminum Baseline
- > **MOLD TYPE:** Phenolic Urethane No-Bake Aluminum System
- > **NUMBER OF MOLDS:** 9
- > **CORE TYPE:** N/A
- > **TEST DATE:** **START:** 3 Jan 2001
  FINISH: 5 Jan 2001

TEST OBJECTIVES:

Primary:

To measure emissions from No-Bake molds, formulated for use with Aluminum, and manufactured based on protocols developed in capability studies CQ and CW to establish a No-Bake Aluminum baseline. The THC analyzer will be used to monitor the test. Sample tubes and bags will be collected for analysis by an outside laboratory.

VARIABLES:

Three part No-bake resin at 1.1% resin (BOS) in the ratio of 50% Delta-HA Techniset® 20-015 resin, 50% Delta-HA Techniset® 23-133 co-reactant.

BRIEF OVERVIEW:

The molds will be the standard 4-on variable-tooth gear made from Nevada 70 silica sand with the above resin system. The molds will be transferred to the pouring/cooling/shakeout hooded station used for greensand and core baselines.

SPECIAL CONDITIONS:

A shakeout fixture, which will promote disintegration of the no-bake mold shall be installed on the shakeout device. This fixture will carry the no-bake mold and locate the pouring basin in the standard pouring position. Steel hangers will be implanted in each cavity to promote separation of castings from the no bake sand during shakeout.

Manager Process Engineering (Technikon)	12·28·00 Date
V.P. Measurement Technologies (Technikon)	1-04-01 Date
V.P. Operations (Technikon)	12-28-00 Date
Emissions Team (USCAR)	2/22/01 Date
Process and Facilities Team (USCAR)	2/22/01 Date
Project Manager (CTC)	4/25/01 Date

TECHNIKON/CERP TEST PLAN

- > **CONTRACT NUMBER: 1256 TASK NUMBER: 120**
- > **CONTROL NUMBER: RE 1 00103**
- > **SAMPLE FAMILY: DH**
- > **SAMPLE EVENTS: 001 thru 009**
- > **SITE: X PRE-PRODUCTION(243)____CERP FOUNDRY(238)**
- > **TEST TYPE:** Aluminum: No-Bake Phenolic- Aluminum Study
- > **MOLD TYPE:** Delta HA Techniset® 20-260, 23-227, 17-971
- > **NUMBER OF MOLDS:** 9
- > **CORE TYPE:** N/A
- > **TEST DATE:** **START:** 11 Apr 2001
  FINISH: 13 Apr 2001

TEST OBJECTIVES:

Primary: To measure emissions from No-Bake molds, formulated for use with Aluminum, and manufactured based on protocols developed in capability study CQ and CW. The THC analyzer will be used to monitor the test. Sample tubes and bags will be collected for analysis by an outside laboratory.

VARIABLES:

Three part No-bake resin at 1.1% resin (BOS) in the ratio of 40% Delta-HA Techniset® 20-260 resin, 60% Delta-HA Techniset®23-227 co-reactant, and 7% (BOR Part I) Delta-HA Techniset® 17-971 Part III activator.

BRIEF OVERVIEW:

The molds will be the standard 4-on variable-tooth gear made from Amador 70 silica sand with the above resin system. The molds will be transferred to the Pouring/cooling/shakeout hooded station used for greensand and core baselines.

SPECIAL CONDITIONS:

Sand will be pre heated as necessary to be available in 70 to 80^{o}F range. A shakeout fixture, which will promote disintegration of the no-bake mold shall be installed on the shakeout device.

This fixture will carry the no-bake mold and locate the pouring basin in the standard pouring position. Steel hangers will be implanted in each cavity to promote separation of castings from the no bake sand during shakeout.

Manager Process Engineering (Technikon)	4-9-01 Date
V.P. Measurement Technologies (Technikon)	4-9-01 Date
V.P. Operations (Technikon)	Apr. 5, '01 Date
Emissions Team (USCAR)	4-24-01 Date
Process and Facilities Team (USCAR)	4-24-01 Date
Project Manager (CTC)	4/25/01 DATE

Series DK

Pre-Production No-Bake Process Instructions

A. Experiment

1. Measure the emissions to establish an Aluminum Phenolic Urethane no-bake baseline against which other no-bakes in the same material family will be compared.

B. Materials

1. No-bake molds: Nevada 70 Silica Sand and 1.1% Delta-HA Techniset NF ® No-bake organic core resin composed of 20-015 Part I resin, 23-133 Part II co-reactant. This resin is designed for aluminum applications.
2. Metal: A356/357 Aluminum.

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

C. No-bake Core Sand preparation

1. The no-bake sand shall contain 1.1% total resin (BOS), Part I/Part II ratio 50/50.

Note: This material is auto-catalytic and therefore does not require a separate catalyst.

2. Calibrate the Kloster no-bake sand mixer to dispense 240 pounds/min more or less.
3. Calibrate the resin pumps:

   a) Part I: Based on the actual measured sand dispensing rate calibrate the Part I resin to be 50% of 1.1% total resin or 0.55% +/- .01% (BOS).
   b) Part II: Based on the actual measured sand dispensing rate calibrate the Part II co-reactant to be 50% of 1.1% total resin or 0.55% +/- 0.01% (BOS).

D. Dog bones

1. Make 24 dogbones: two (2) 12-piece sets of test dogbones using 12-on core box.
2. Use sand measuring 70-80^{o}F when exiting the Kloster mixer. Preheat if necessary.
3. Record the sand temperature.
4. Place the core box on the vibrating compaction table.
5. Start the Kloster mixer and waste a few pounds of sand.
6. Flood the core box with sand then stop the mixer.
7. Strike off the core box to ½ inch deep
8. Turn on the vibrating compaction table for 15 seconds.
9. Screed off most of the excess sand.

10. Screed the core box a second time moving very slowly in a back and forth manner to remove all excess sand.

Note: It is important to neither gouge the sand nor leave excess sand in center neck portion of the dogbone or the test results will be affected

11. Set aside for about 6-7 minutes or until hard to the touch.
12. Carefully remove the cores from the core box by separating the corebox components.
13. Weigh each dogbone and record the weight to the nearest 0.1 grams using the PJ 4000 electronic scale.

Note: Data from dogbones whose weight varies by more than 10% of the mean value should be recorded but disregarded.

14. Place 6 bones in the 90% Rh cabinet.
15. Perform tensile tests on 6 bones at each of the following times after dogbone manufacture: 30 minutes, 2 hours, 24 hours, and 24 hours@ 90% Rh. Report the average and standard deviation for each set of six (6) at each time for each mold.
16. Perform scratch the hardness test on six bones 1 hour after core manufacture. The 30-minute tensile test bones may be used for this test. Conduct the test on the smooth mold side of the dogbone. Report the average and standard deviation for each mold.
17. Run a 1400^{o}F core LOI on three (3) of the 30-minute tensile test dogbones. Report the average value for each mold.
18. Run a 1400^{o}F core LOI on the raw uncoated sand sampled at the same time as the dogbones are made. Calculate a Core Resin LOI as the difference between the average Core LOI and raw sand core LOI. Report this value for each mold.

E. No-bake mold making: 4 on gear core box.

1. Inspect the box for cracks and other damage. Repair before use.
2. Prepare the core box halves by wire brushing any adhered sand and coating with a light coating of Ashland Zipslip®IP 78. Allow to fully dry.
3. Place the drag core box on the vibrating compaction table.
4. Begin filling the box.
5. Immediately start the table vibration.
6. Manually spread the sand around the box as it is filling.
7. Strike off the box until it is level full.
8. Allow the vibrator to run an additional 10 seconds after the box is full.

a) Strike off the drag core box so that the drag core mold is 5-1/2 inches thick parting line to back.

Note: When the mold is closed the visible drag height will be 6 +/- 1/8 inch

b) Strike off the cope core box so that the cope core mold is 5 inches thick parting line to back

Note: When the mold is closed the visible cope height will be 5 +/- 1/8 inch

9. Set the core box aside for 5 to 6 minutes or until it is hard to the touch.
10. Invert the box and place a fractional inch above a flat transport pallet.
11. Loosen the core mold half by tapping on the box with a rubber mallet.
12. Lower the mold on to the pallet. Maintain full support of the sand mold while removing it from the core box or warpage of mold will result. Remove the pivot hole pins.
13. Lift the core box off the core mold
14. Set the drag core box aside.
15. Place the cope core box on the vibrating compaction table.
16. Follow steps E3-E14.
17. Rotate the unboxed core to set it on edge.
18. Drill vent holes as per template.
19. Hand trim the pour basin to promote minimum splash and minimum cup volume.
20. Close cope onto drag. Visually check for closure. (Note : The total mold height should be 10-1/2 +/- 1/8 inch)
21. Install two (2) steel straps, one on either side of the pouring cup, with 4 metal corner protectors each to hold the mold tightly closed. (Note: Break the sand edge under the 4 metal corner protectors)
22. Weigh and record the weight of the closed mold. (nominal 325 +/- 10 Lbs.)

F. Emission hood:

1. Loading.

   a) Hoist the mold onto the shakeout deck fixture within the emission hood with the pouring cup side toward the furnace.
   b) Install the cope weighting device.
   c) Install a half inch re-rod casting hangers through the cope into each of the four riser cavities and suspend them over the horizontal mold retaining bars.
   d) Close, seal, and lock the emission hood

2. Shakeout.

   a) After the cooling time prescribed in the emission test plan has elapsed turn on the shakeout unit and run for the time prescribed in the emission test plan.
   b) Turn off the shakeout
   c) Wait for the emission team to signal that they are finished sampling.
   d) Open the hood, remove the castings
   e) Clean core sand out of the pit and off the shakeout.
   f) Weigh and record cast metal weight.

G. Melting

1. Initial charge:

a) Use the 250 KW Ajax induction furnace
b) Charge the furnace with A-356/357 aluminum sows.
c) No other alloys need to be added for emission testing purposes.
d) Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
e) Add the balance of A-356/357 aluminum sows under full power until all is melted and the temperature has reached 1250-1300^{o}F.
f) Slag the furnace and cover it.
g) Hold the furnace at 1250-1300^{o}F until near ready to tap.
h) When ready to tap adjust the temperature to 1300-1325^{o}F and slag the furnace.
i) Record all metallic additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with the associated time.

2. Back charging.

a) Back charging may be necessary because of the pour weight of about 90 pounds. If additional aluminum is desired back charge with A-356/357 Aluminum sows or scrap aluminum of the same source.
b) Follow the above steps beginning with G.1.e

H. Emptying the furnace.

a) Pig the extra metal into steel sow molds away from the test hood.
b) You need not wait for emission testing to be concluded to pig the metal.

I. Pouring

1. Preheat the ladle.

a) Tap 180 pounds more or less of 1350^{o}F metal into the cold ladle.
b) Casually pour the metal back to the furnace.
c) Cover the ladle.
d) Reheat the metal to 1320 +/- 20^{o}F.
e) Tap 180 pounds, more or less, of Aluminum into the ladle.
f) Cover the ladle to conserve heat .
g) Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 1250 +/- 10^{o}F.
h) Commence pouring keeping the sprue full.
i) Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.

Steven Knight
Sr. Process Engineer

Series DH

Pre-Production No-Bake Process Instructions

A. Experiment

1. Measure the emissions to establish an Aluminum Phenolic Urethane no-bake baseline against which other no-bakes in the same material family will be compared.

B. Materials

1. No-bake molds: Amador 70 Silica Sand and 1.1% Delta-HA Techniset NF®No-bake organic core resin composed of 20-260 Part I resin, 23-227 Part II co-reactant, & 17-971 Part III activator. This resin is designed for aluminum applications.
2. Metal: A356/357 Aluminum.

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

C. No-bake Core Sand preparation:

1. The no-bake sand shall contain 1.1 % total resin (BOS), Part I/Part II ratio 40/60, Part III at 7% of Part I.
2. Calibrate the Kloster no-bake sand mixer to dispense 240 pounds/min more or less.
3. Calibrate the resin pumps:

   a) Part I: Based on the actual measured sand dispensing rate calibrate the Part I resin to be 40% of 1.1% total resin or 0.44% +/- .01% (BOS).
   b) Part II: Based on the actual measured sand dispensing rate calibrate the Part II co-reactant to be 60% of 1.1% total resin or 0.66% +/- 0.01% (BOS).
   c) Determine the amount of Part III activator in section D as a percent of Part I.

D. Pre test catalyst trials

1. The sand lab will make pretest trials to confirm the correct amount of catalyst.
2. The sand temperature shall be 75 to 79^{o}F.
3. Make 5 pound batches to the above formulation in the Hobart mixer
4. The batches shall have catalyst content at 7, 15, 20, 25%
5. Make 3 dogbones from each mix.
6. Perform a strip time test on the dogbones test using the penetrator strength meter.
7. Record the hardness at 5 minute intervals until three readings greater than 30 psi are achieved.
8. The strip time vs. catalyst report shall be returned to the process engineer in a timely manner prior to the scheduled test.

E. Dog bones

1. Make 24 dogbones: two (2) 12-piece sets of test dogbones using 12-on core box
2. Use sand measuring 70-80^{o}F when exiting the Kloster mixer. Preheat if necessary.
3. Record the sand temperature.
4. Place the core box on the vibrating compaction table.
5. Start the Kloster mixer and waste a few pounds of sand.
6. Flood the core box with sand then stop the mixer.
7. Strike off the core box to ½ inch deep
8. Turn on the vibrating compaction table for 15 seconds.
9. Screed off most of the excess sand.
10. Screed the core box a second time moving very slowly in a back and forth manner to remove **all** excess sand.

Note: It is important to neither gouge the sand nor leave excess sand in center neck portion of the dogbone or the test results will be affected

11. Set aside for about 6-7 minutes or until hard to the touch.
12. Carefully remove the cores from the core box by separating the corebox components.
13. Weigh each dogbone and record the weight to the nearest 0.1 grams using the PJ 4000 electronic scale.

Note: Maintain the correlation between the weight of a dogbone and its tensile strength and scratch hardness.

14. Place 6 bones in the 90% Rh cabinet.
15. Perform tensile tests on 6 bones at each of the following times after dogbone manufacture: 30-minutes, 2 hours, 24 hours, and 24 hours@ 90% Rh. Report the average and standard deviation for each set of six (6) at each time for each mold.
16. Run a 1400^{o}F core LOI on three (3) of the 30-minute tensile test dogbones. Report the average value for each mold.

F. No-bake mold making: 4 on gear core box.

1. Inspect the box for cracks and other damage. Repair before use.
2. Prepare the core box halves by wire brushing any adhered sand and coating with a light coating of Ashland Zipslip®IP 78. Allow to fully dry.
3. Place the drag core box on the vibrating compaction table.
4. Begin filling the box.
5. Manually spread the sand around the box as it is filling. Over fill 1-1.5 inches.
6. Vibrate the box for 10 seconds. Look for when the sand stops moving within the box.
7. Strike off the drag core box so that the drag core mold is 5-1/2 inches thick parting line to back.
8. Strike off the cope core box so that the cope core mold is 5 inches thick parting line to back. Set the core box aside for 5 to 6 minutes or until it is hard to the touch.

9. Invert the box and place on a flat transport pallet.
10. Remove the pivot hole pins.
11. Remove the core mold half by tapping lightly on the box with a soft hammer.
12. Maintain full support of the sand mold while removing it from the core box or warpage of mold will result.
13. Set the drag core box aside.
14. Place the cope core box on the vibrating compaction table.
15. Follow steps F3-F13.
16. Rotate the unboxed core to set it on edge.
17. Drill vent holes as per template.
18. Hand trim the pour basin to promote minimum splash and minimum cup volume.
19. Close cope onto drag. Visually check for closure. (Note : The total mold height should be 10-1/2 +/- 1/8 inch)
20. Install two (2) steel straps, one on either side of the pouring cup, with 4 metal corner protectors each to hold the mold tightly closed.

Note: Break the sand edge under the 4 metal corner protectors

21. Weigh and record the weight of the closed mold. (nominal 290 +/- 10 Lbs.)

G. Emission hood:

1. Loading.
a) Hoist the mold onto the shakeout deck fixture within the emission hood with the pouring cup side toward the furnace.
b) Install the cope weighting device.
c) Install a half inch re-rod casting hangers through the cope into each of the four riser cavities and suspend them over the horizontal mold retaining bars.
d) Close, seal, and lock the emission hood

2. Shakeout.

a) After the cooling time prescribed in the emission test plan has elapsed turn on the shakeout unit and run for the time prescribed in the emission test plan.
b) Turn off the shakeout
c) Wait for the emission team to signal that they are finished sampling.
d) Open the hood, remove the castings
e) Clean core sand out of the pit and off the shakeout.
f) Weigh and record cast metal weight.

H. Melting

1. Initial charge:

a) Use the 250 KW Ajax induction furnace
b) Charge the furnace with A-356/357 aluminum sows.

c) No other alloys need to be added for emission testing purposes.
d) Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
e) Add the balance of A-356/357 aluminum sows under full power until all is melted and the temperature has reached 1250-1300^{o}F.
f) Slag the furnace and cover it.
g) Hold the furnace at 1250-1300^{o}F until near ready to tap.
h) When ready to tap adjust the temperature to 1300-1325^{o}F and slag the furnace.
i) Record all metallic additions to the furnace, tap temperature, and pour temperature.
j) Record all furnace activities with the associated time.

2. Back charging.

a) Back charging may be necessary because of the pour weight of about 90 pounds. If additional aluminum is desired back charge with A-356/357 Aluminum sows or scrap aluminum of the same source.
b) Follow the above steps beginning with G.1.e

3. Emptying the furnace.

a) Pig the extra metal into steel sow molds away from the test hood.
b) You need not wait for emission testing to be concluded to pig the metal.

I. Pouring:

1. Preheat the ladle.
2. Tap 180 pounds more or less of 1350^{o}F metal into the cold ladle.
3. Casually pour the metal back to the furnace.
4. Cover the ladle.
5. Reheat the metal to 1320 +/- 20^{o}F.
6. Tap 180 pounds, more or less, of Aluminum into the ladle.
7. Cover the ladle to conserve heat .
8. Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 1250 +/- 10^{o}F.
9. Commence pouring keeping the sprue full.
10. Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.

Steven Knight
Sr. Process Engineer

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/3/01											
EVENT 1											
AIRSENSE	DK00101										TOTAL
THC	DK00102	X									TOTAL
M-18	DK00103		1						200	1	TOTAL
M-18	DK00104			1					200	2	TOTAL
M-18	DK00105				1				0	2	Manifold Blank
M-18 MS	DK00106		1						200	3	Sample will not be analyzed
M-18 MS	DK00107				1				0	3	Sample will not be analyzed
M-18 MS (quant)	DK00108		1						200	4	TOTAL
M-18 MS (quant)	DK00109			1					200	5	TOTAL
M-18 MS (quant)	DK00110				1				0	5	Manifold Blank
Gas, CO+CO2	DK00111		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00112		1						1000	7	TOTAL Orbo 32L
NIOSH 1500 (long list)	DK00113				1				0	7	Manifold Blank
Excess	---								1000	8	Excess
NIOSH 2002	DK00114		1						1000	9	TOTAL (SKC 226-15)
NIOSH 2002	DK00115				1				0	9	Manifold Blank
TO11	DK00116		1						1000	10	TOTAL
TO11	DK00117				1				0	10	Manifold Blank
Excess	---								1000	11	Excess
Moisture	---		1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK001								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/3/01											
EVENT 2											
AIRSENSE	DK00201										TOTAL
THC	DK00202	X									TOTAL
M-18	DK00203		1						200	1	TOTAL
M-18	DK00204					1			200	1	QC - Breakthrough
M-18	DK00205			1					200	2	TOTAL
M-18	DK00206					1			200	2	QC - Breakthrough
M-18 MS	DK00207		1						200	3	Sample will not be analyzed
M-18 MS	DK00208					1			200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00209		1						200	4	TOTAL
M-18 MS (Quant)	DK00210					1			200	4	QC - Breakthrough
M-18 MS (Quant)	DK00211			1					200	5	TOTAL
M-18 MS (Quant)	DK00212					1			200	5	QC - Breakthrough
Gas, CO+CO2	DK00213		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00214		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00215		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00216		1						1000	10	TOTAL
TO11	DK00217					1			1000	10	QC - Breakthrough
Excess	---								1000	11	Excess
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK002								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/4/01											
EVENT 3											
AIRSENSE	DK00301										TOTAL
THC	DK00302	X									TOTAL
M-18	DK00303		1						200	1	TOTAL
M-18	DK00304			1					200	2	TOTAL
M-18	DK00305				1				0	2	QC Blank
M-18 MS	DK00306		1						200	3	Sample will not be analyzed
M-18 MS	DK00307				1				0	3	Sample will not be analyzed
M-18 MS (Quant)	DK00308		1						200	4	TOTAL
M-18 MS (Quant)	DK00309			1					200	5	TOTAL
M-18 MS (Quant)	DK00310				1				0	5	QC Blank
Gas, CO+CO2	DK00311		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00312		1						1000	7	TOTAL Orbo 32L
NIOSH 1500 (long list)	DK00313			1					1000	8	TOTAL Orbo 32L
NIOSH 1500 (long list)	DK00314				1				0	8	QC Blank
NIOSH 2002	DK00315		1						1000	9	TOTAL (SKC 226-15)
NIOSH 2002	DK00316			1					1000	10	TOTAL (SKC 226-15)
NIOSH 2002	DK00317				1				0	10	QC Blank
TO11	DK00318		1						1000	11	TOTAL
TO11	DK00319				1				0	11	QC Blank
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK003								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/4/01											
EVENT 4											
AIRSENSE	DK00401										TOTAL
THC	DK00402	X									TOTAL
M-18	DK00403		1						200	1	TOTAL
M-18	DK00404			1					200	2	TOTAL
M-18 MS	DK00405		1						200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00406		1						200	4	TOTAL
M-18 MS (Quant)	DK00407			1					200	5	TOTAL
Gas, CO+CO2	DK00408		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00409		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00410		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00411		1						1000	10	TOTAL
TO11	DK00412			1					1000	11	TOTAL
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK004								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/4/01											
EVENT 5											
AIRSENSE	DK00501										TOTAL
THC	DK00502	X									TOTAL
M-18	DK00503		1						200	1	TOTAL
M-18	DK00504			1					200	2	TOTAL
M-18 MS	DK00505		1						200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00506		1						200	4	TOTAL
M-18 MS (Quant)	DK00507			1					200	5	TOTAL
Gas, CO+CO2	DK00508		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00509		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00510		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00511		1						1000	10	TOTAL
Excess	---								1000	11	Excess
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK005								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/4/01											
EVENT 6											
AIRSENSE	DK00601										TOTAL
THC	DK00602	X									TOTAL
M-18	DK00603		1						200	1	TOTAL
M-18	DK00604			1					200	2	TOTAL
M-18 MS	DK00605		1						200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00606		1						200	4	TOTAL
M-18 MS (Quant)	DK00607			1					200	5	TOTAL
Gas, CO+CO2	DK00608		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00609		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00610		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00611		1						1000	10	TOTAL
Excess	---								1000	11	Excess
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK006								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/5/01											
EVENT 7											
AIRSENSE	DK00701										TOTAL
THC	DK00702	X									TOTAL
M-18	DK00703		1						200	1	TOTAL
M-18	DK00704			1					200	2	TOTAL
M-18	DK00705				1				0	2	QC Blank
M-18 MS	DK00706		1						200	3	Sample will not be analyzed
M-18 MS	DK00707				1				0	3	Sample will not be analyzed
M-18 MS (Quant)	DK00708		1						200	4	TOTAL
M-18 MS (Quant)	DK00709			1					200	5	TOTAL
M-18 MS (Quant)	DK00710				1				0	5	QC Blank
Gas, CO+CO2	DK00711		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00712		1						1000	7	TOTAL Orbo 32L
NIOSH 1500 (long list)	DK00713			1					1000	8	TOTAL Orbo 32L
NIOSH 1500 (long list)	DK00714				1				0	8	QC Blank
NIOSH 2002	DK00715		1						1000	9	TOTAL (SKC 226-15)
NIOSH 2002	DK00716			1					1000	10	TOTAL (SKC 226-15)
NIOSH 2002	DK00717				1				0	10	QC Blank
TO11	DK00718		1						1000	11	TOTAL
TO11	DK00719				1				0	11	QC Blank
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK007								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/5/01											
EVENT 8											
AIRSENSE	DK00801										TOTAL
THC	DK00802	X									TOTAL
M-18	DK00803		1						200	1	TOTAL
M-18	DK00804			1					200	2	TOTAL
M-18 MS	DK00805		1						200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00806		1						200	4	TOTAL
M-18 MS (Quant)	DK00807			1					200	5	TOTAL
Gas, CO+CO2	DK00808		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00809		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00810		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00811		1						1000	10	TOTAL
TO11	DK00812			1					1000	11	TOTAL
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK008								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/5/01											
EVENT 9											
AIRSENSE	DK00901										TOTAL
THC	DK00902	X									TOTAL
M-18	DK00903		1						200	1	TOTAL
M-18	DK00904			1					200	2	TOTAL
M-18 MS	DK00905		1						200	3	Sample will not be analyzed
M-18 MS (Quant)	DK00906		1						200	4	TOTAL
M-18 MS (Quant)	DK00907			1					200	5	TOTAL
Gas, CO+CO2	DK00908		1						60	6	Tedlar Bag
NIOSH 1500 (long list)	DK00909		1						1000	7	TOTAL Orbo 32L
Excess	---								1000	8	Excess
NIOSH 2002	DK00910		1						1000	9	TOTAL (SKC 226-15)
TO11	DK00911		1						1000	10	TOTAL
Excess	---								1000	11	Excess
Moisture			1						500	12	TOTAL
Excess	---								2500	13	Excess
PUF	DK009								16L		
M-18	DK00912						X		200		BOTTLE - Mix 1A
M-18	DK00913						X		200		BOTTLE - Mix 1A
TO11	DK00914						X		1000		BOTTLE - Mix 2
TO11	DK00915						X		1000		BOTTLE - Mix 2

PRE-PRODUCTION DH SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/11/01											
EVENT 1											
THC	DH00101	X									TOTAL
M-18 MS	DH00102		1						20	1	TOTAL
M-18 MS	DH00103				1				0	1	QC Blank
M-18	DH00104		1						25	2	TOTAL
M-18	DH00105			1					25	3	Duplicate
M-18	DH00106				1				0	3	QC Blank
Gas, CO+CO2	DH00107		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00108		1						500	6	TOTAL (SKC 226-01)
NIOSH 1500	DH00109			1					500	7	Duplicate
NIOSH 1500	DH00110				1				0	7	QC Blank
NIOSH 2002	DH00111		1						500	8	TOTAL (SKC 226-15)
NIOSH 2002	DH00112			1					500	9	Duplicate (SKC 226-15)
NIOSH 2002	DH00113				1				0	9	QC Blank
TO11	DH00114		1						750	10	TOTAL
TO11	DH00115			1					750	11	Duplicate
TO11	DH00116				1				0	11	QC Blank
Moisture	---		1						500	12	TOTAL
Excess	---								5000	13	Excess
PUF	DH001								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/11/01											
EVENT 2											
THC	DH00201	X									TOTAL
M-18 MS	DH00202		1						20	1	TOTAL
M-18	DH00203		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00204		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00205		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00206		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00207		1						750	10	TOTAL
Excess									750	11	Excess
Moisture	---		1						500	12	TOTAL
Excess	---								5000	13	Excess
PUF	DH002								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/12/01											
EVENT 3											
THC	DH00301	X									TOTAL
M-18 MS (quant)	DH00302		1						20	1	TOTAL
M-18	DH00303		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00304		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00305		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00306		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00307		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH003								16L		
Gas, CO+CO2	DH00309		1						15L		Grab Sample outside hood, Tedlar Bag

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/12/01											
EVENT 4											
THC	DH00401	X									TOTAL
M-18 MS	DH00402		1						20	1	TOTAL
M-18	DH00403		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00404		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00405		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00406		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00407		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH004								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/12/01											
EVENT 5											
THC	DH00501	X									TOTAL
M-18 MS (quant)	DH00502		1						20	1	TOTAL
M-18	DH00503		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00504		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00505		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00506		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00507		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH005								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/12/01											
EVENT 6											
THC	DH00601	X									TOTAL
M-18 MS	DH00602		1						20	1	TOTAL
M-18	DH00603		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00604		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00605		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00606		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00607		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH006								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/13/01											
EVENT 7											
THC	DH00701	X									TOTAL
M-18 MS	DH00702		1						20	1	TOTAL
M-18	DH00703		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00704		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00705		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00706		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00707		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH007								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/13/01											
EVENT 8											
THC	DH00801	X									TOTAL
M-18 MS	DH00802		1						20	1	TOTAL
M-18	DH00803		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00804		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00805		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00806		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00807		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH008								16L		

PRE-PRODUCTION DK SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/13/01											
EVENT 9											
THC	DH00901	X									TOTAL
M-18 MS	DH00902		1						20	1	TOTAL
M-18	DH00903		1						25	2	TOTAL
Excess									25	3	Excess
Gas, CO+CO2	DH00904		1						60	4	Tedlar Bag
Excess									200	5	Excess
NIOSH 1500	DH00905		1						500	6	TOTAL (SKC 226-01)
Excess									500	7	Excess
NIOSH 2002	DH00906		1						500	8	TOTAL (SKC 226-15)
Excess									500	9	Excess
TO11	DH00907		1						750	10	TOTAL
Excess									750	11	Excess
Moisture			1						500	12	TOTAL
Excess									5000	13	Excess
PUF	DH009								16L		
M-18	DK00908						X		25		BOTTLE - Mix 1A
M-18	DK00909						X		25		BOTTLE - Mix 1A

APPENDIX B TEST SERIES DK AND DH DETAILED RESULTS

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Test Plan DK and DH Average Test Results with T-Statistics

Analytes	Test DK (Lb/Tn)	Test DH (Lb/Tn)	T-Statistic
TGOC (THC) as Propane	29.9	2.25	24.38
HC as Hexane	30.3	0.951	22.70
Sum of VOCs	6.48	0.342	4.02
Sum of HAPs	1.79	0.282	7.36
Sum of POMs	0.336	0.048	2.74
	Individual Organic HAPs		
o,m,p-Cresol	0.889	ND	4.06
Phenol	0.310	0.021	23.53
Naphthalene	0.262	0.017	2.36
Acetaldehyde	0.091	0.114	3.19
Aniline	0.077	0.025	8.56
Methylnaphthalenes	0.054	0.014	26.73
Propionaldehyde	0.053	0.051	0.89
Dimethylnaphthalenes	0.020	0.016	2.36
Toluene	0.009	0.011	1.14
o,m,p-Xylenes	0.009	0.005	6.22
Benzene	0.004	0.004	1.08
Hexane	0.002	0.005	2.37
Formaldehyde	0.001	0.009	7.55
	Other VOCs		
Dimethylphenols	3.65	ND	2.41
Trimethylphenols	0.500	ND	7.51
Indan	0.286	ND	3.97
Trimethylbenzenes	0.146	0.005	3.52
Benzaldehyde	0.004	0.006	4.58
Butyraldehyde/Methacrolein	0.003	0.011	22.00
Diethylbenzenes	ND	0.026	7.84
Crotonaldehyde	ND	0.005	18.91
	Other Analytes		
Condensables	2.26	2.36	0.74
Carbon Monoxide	1.84	ND	21.72
Methane	ND	ND	NA
Carbon Dioxide	114	102	4.98

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

ND: Non Detect; **NA**: Not Applicable

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

Test Plan DK Individual Test Results – Lb/Tn Metal

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DK001	DK002	DK003	DK004	DK005	DK006	DK007	DK008	DK009	AVERAGE	STDEV
		Pour Date	1/2/01	1/2/01	1/2/01	1/3/01	1/3/01	1/3/01	1/4/01	1/4/01	1/4/01		
		TGOC (THC) as Propane	3.72E+01	3.35E+01	2.95E+01	2.85E+01	2.91E+01	2.89E+01	2.92E+01	2.82E+01	2.55E+01	2.99E+01	3.40E+00
		HC as Hexane	3.72E+01	3.56E+01	2.94E+01	2.93E+01	2.99E+01	2.98E+01	2.84E+01	2.87E+01	2.44E+01	3.03E+01	3.88E+00
		Sum of VOCs	2.48E+00	3.03E+00	3.73E+00	2.98E+00	4.12E+00	5.11E+00	2.88E+00	4.80E+00	2.96E+00	3.57E+00	9.28E-01
		Sum of HAPs	1.14E+00	1.97E+00	2.04E+00	1.53E+00	1.46E+00	3.19E+00	1.48E+00	1.99E+00	1.33E+00	1.79E+00	6.14E-01
		Sum of POMs	2.86E-01	1.16E+00	2.80E-01	1.74E-01	1.92E-01	3.44E-01	1.85E-01	1.89E-01	2.08E-01	3.36E-01	3.16E-01
			Individual HAPs and VOCs										
	z	o-Cresol	2.04E-01	1.11E-01	1.27E+00	8.28E-01	6.76E-01	2.30E+00	7.12E-01	1.25E+00	6.58E-01	8.89E-01	6.57E-01
	z	Phenol	3.46E-01	3.80E-01	2.62E-01	2.81E-01	3.15E-01	2.97E-01	3.25E-01	3.08E-01	2.77E-01	3.10E-01	3.68E-02
x	z	Naphthalene	2.12E-01	1.08E+00	2.16E-01	1.04E-01	1.22E-01	2.68E-01	1.12E-01	1.13E-01	1.32E-01	2.62E-01	3.11E-01
	z	Acetaldehyde	1.02E-01	1.09E-01	8.05E-02	9.07E-02	9.92E-02	9.87E-02	7.93E-02	8.74E-02	7.20E-02	9.10E-02	1.22E-02
	z	Aniline	9.49E-02	1.10E-01	5.49E-02	6.61E-02	7.74E-02	6.35E-02	8.63E-02	6.74E-02	6.92E-02	7.66E-02	1.74E-02
	z	Propionaldehyde	5.27E-02	5.58E-02	4.64E-02	5.67E-02	5.55E-02	5.31E-02	5.28E-02	4.76E-02	I	5.26E-02	3.77E-03
x	z	2-Methylnaphthalene	3.78E-02	3.95E-02	2.99E-02	3.28E-02	3.35E-02	3.43E-02	3.27E-02	3.38E-02	3.83E-02	3.47E-02	3.15E-03
x	z	1-Methylnaphthalene	1.88E-02	2.12E-02	1.77E-02	1.94E-02	1.74E-02	2.09E-02	1.96E-02	2.13E-02	2.03E-02	1.96E-02	1.45E-03
	z	Biphenyl	1.36E-02	6.27E-03	1.56E-02	3.50E-03	1.34E-02	1.01E-02	7.34E-03	1.19E-02	1.48E-02	1.07E-02	4.20E-03
	z	Toluene	1.03E-02	1.09E-02	9.87E-03	8.50E-03	8.23E-03	9.45E-03	1.16E-02	8.42E-03	7.42E-03	9.41E-03	1.38E-03
	z	m,p-Xylene	8.26E-03	8.10E-03	7.48E-03	6.89E-03	6.63E-03	6.83E-03	7.89E-03	6.64E-03	5.98E-03	7.19E-03	7.77E-04
x	z	1,3-Dimethylnaphthalene	6.96E-03	7.74E-03	5.73E-03	6.05E-03	6.90E-03	6.71E-03	6.69E-03	6.83E-03	5.74E-03	6.59E-03	6.51E-04
	z	2-Butanone	4.99E-03	5.35E-03	2.81E-03	3.40E-03	4.12E-03	3.97E-03	3.11E-03	3.50E-03	3.64E-03	3.88E-03	8.39E-04
	z	Benzene	4.50E-03	4.37E-03	4.05E-03	3.57E-03	3.57E-03	3.99E-03	4.20E-03	3.48E-03	3.06E-03	3.87E-03	4.74E-04
x	z	2,7-Dimethylnaphthalene	2.42E-03	4.13E-03	3.03E-03	3.20E-03	3.61E-03	3.43E-03	3.48E-03	3.45E-03	2.97E-03	3.30E-03	4.75E-04
x	z	2,6-Dimethylnaphthalene	2.42E-03	4.13E-03	3.03E-03	3.19E-03	3.60E-03	3.44E-03	3.49E-03	3.45E-03	2.97E-03	3.30E-03	4.77E-04
x	z	2,3-Dimethylnaphthalene	3.30E-03	3.62E-03	2.72E-03	2.85E-03	3.15E-03	3.21E-03	3.14E-03	2.92E-03	2.41E-03	3.03E-03	3.52E-04
x	z	1,6-Dimethylnaphthalene	2.62E-03	2.96E-03	2.18E-03	2.33E-03	2.56E-03	2.59E-03	2.56E-03	2.61E-03	2.22E-03	2.52E-03	2.41E-04
	z	o-Xylene	2.92E-03	2.06E-03	1.22E-03	2.46E-03	2.13E-03	1.17E-03	2.45E-03	2.15E-03	2.35E-03	2.10E-03	5.74E-04
	z	Hexane	1.88E-03	1.95E-03	2.20E-03	2.22E-03	1.56E-03	2.24E-03	2.16E-03	1.48E-03	1.54E-03	1.91E-03	3.16E-04
	z	Ethylbenzene	1.31E-03	2.13E-03	1.68E-03	1.33E-03	1.14E-03	1.51E-03	1.97E-03	1.13E-03	1.10E-03	1.48E-03	3.78E-04
	z	Formaldehyde	1.49E-03	1.58E-03	1.34E-03	1.63E-03	1.46E-03	1.39E-03	1.56E-03	1.38E-03	1.17E-03	1.44E-03	1.42E-04

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DK001	DK002	DK003	DK004	DK005	DK006	DK007	DK008	DK009	AVERAGE	STDEV
		Pour Date	**1/2/01**	**1/2/01**	**1/2/01**	**1/3/01**	**1/3/01**	**1/3/01**	**1/4/01**	**1/4/01**	**1/4/01**		
x	z	**1,5-Dimethylnaphthalene**	ND	2.38E-03	ND	ND	ND	1.90E-03	1.81E-03	1.57E-03	1.08E-03	1.75E-03	4.75E-04
	z	**Cumene**	ND	ND	1.40E-03	ND	7.06E-04	1.58E-03	1.16E-03	7.64E-04	6.52E-04	1.04E-03	3.95E-04
	z	**Styrene**	3.33E-04	7.50E-04	1.92E-04	2.91E-04	4.06E-04	3.11E-04	5.32E-04	3.41E-04	ND	3.95E-04	1.74E-04
	z	**m,p-Cresol**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	**Acrolein**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
	z	**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,4,6-Trimethylphenol	6.27E-01	7.83E-01	3.45E-01	2.76E-01	6.49E-01	3.74E-01	6.19E-01	6.16E-01	2.12E-01	5.00E-01	2.00E-01
		2,5-Dimethylphenol	ND	ND	5.46E-01	5.21E-01	7.20E-01	7.60E-01	ND	1.29E+00	5.73E-01	7.35E-01	2.90E-01
		2,4-Dimethylphenol	3.55E-01	I	2.47E-01	1.30E-01	3.69E-01	2.62E-01	3.65E-01	3.57E-01	4.69E-01	3.19E-01	1.03E-01
		Indan	5.20E-02	ND	4.55E-01	2.67E-01	7.04E-01	3.42E-01	3.18E-01	3.12E-01	1.21E-01	3.21E-01	2.00E-01
		1,2,4-Trimethylbenzene	1.84E-01	9.38E-02	1.60E-02	1.78E-01	1.13E-01	6.07E-02	ND	1.34E-01	1.59E-01	1.17E-01	5.87E-02
		Tetradecane	3.82E-02	3.98E-02	3.06E-02	3.08E-02	3.31E-02	3.29E-02	3.16E-02	3.17E-02	2.79E-02	3.30E-02	3.76E-03
		3-Ethyltoluene	2.21E-02	2.42E-02	1.67E-02	1.79E-02	2.01E-02	1.90E-02	2.07E-02	1.97E-02	1.77E-02	1.98E-02	2.34E-03
		Decane	3.66E-02	9.09E-02	ND	ND	ND	ND	ND	ND	ND	6.38E-02	3.84E-02
		sec-Butylbenzene	1.20E-02	ND	6.15E-03	ND	1.96E-02	3.14E-02	1.51E-02	1.82E-02	2.40E-02	1.81E-02	8.20E-03
		2-Ethyltoluene	5.75E-03	1.38E-02	9.25E-03	9.17E-03	1.14E-02	1.14E-02	4.51E-03	1.24E-02	1.23E-02	1.00E-02	3.14E-03
		Benzaldehyde	4.80E-03	5.29E-03	3.82E-03	4.60E-03	4.59E-03	4.45E-03	4.43E-03	4.16E-03	3.58E-03	4.41E-03	5.13E-04
		Isobutylbenzene	ND	ND	1.43E-03	ND	ND	8.78E-03	3.27E-03	4.80E-03	1.00E-02	5.66E-03	3.64E-03
		Butyraldehyde/Methacrolien	3.08E-03	3.36E-03	2.59E-03	3.23E-03	3.11E-03	2.95E-03	2.93E-03	2.70E-03	2.25E-03	2.91E-03	3.44E-04
		Nonane	3.18E-03	3.07E-03	2.52E-03	3.09E-03	2.82E-03	2.69E-03	2.66E-03	2.65E-03	2.74E-03	2.82E-03	2.30E-04
		n-Propylbenzene	1.80E-03	2.24E-03	2.91E-03	2.01E-03	2.59E-03	1.48E-03	1.37E-03	3.06E-03	2.92E-03	2.26E-03	6.40E-04
		o,m,p-Tolualdehyde	3.36E-03	I	1.57E-03	1.80E-03	2.13E-03	1.99E-03	1.73E-03	7.45E-04	ND	1.90E-03	7.81E-04
		Pentanal	8.30E-04	1.32E-03	1.03E-03	1.27E-03	1.18E-03	1.07E-03	1.15E-03	1.04E-03	8.52E-04	1.08E-03	1.70E-04
		Hexaldehyde	ND	8.85E-04	ND	1.10E-03	7.70E-04	ND	7.10E-04	6.69E-04	ND	8.28E-04	1.75E-04
		Cyclohexane	ND	ND	2.67E-03	ND	ND	ND	ND	1.29E-03	ND	1.98E-03	9.81E-04
		1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DK001	DK002	DK003	DK004	DK005	DK006	DK007	DK008	DK009	AVERAGE	STDEV
		Pour Date	**1/2/01**	**1/2/01**	**1/2/01**	**1/3/01**	**1/3/01**	**1/3/01**	**1/4/01**	**1/4/01**	**1/4/01**		
		3,5-Dimethylphenol	ND	ND	I	ND	ND	I	ND	ND	I	N/A	N/A
		3,4-Dimethylphenol	ND	I	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,2,3-Trimethylbenzene	I	I	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		4-Ethyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
x		**Acenaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Octane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		p-Cymene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Tridecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
			Other Analytes										
		Carbon Monoxide	1.94E+00	1.80E+00	1.81E+00	1.80E+00	1.71E+00	1.82E+00	1.62E+00	2.44E+00	1.58E+00	1.84E+00	2.54E-01
		Methane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Carbon Dioxide	1.22E+02	1.08E+02	1.18E+02	1.11E+02	1.10E+02	1.12E+02	1.18E+02	1.18E+02	1.06E+02	1.14E+02	5.53E+00
		Ethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Propane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Isobutane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DK001	DK002	DK003	DK004	DK005	DK006	DK007	DK008	DK009	AVERAGE	STDEV
		Pour Date	**1/2/01**	**1/2/01**	**1/2/01**	**1/3/01**	**1/3/01**	**1/3/01**	**1/4/01**	**1/4/01**	**1/4/01**		
		Butane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Neopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Isopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Pentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
		Condensables	2.67E+00	2.54E+00	2.45E+00	2.10E+00	2.53E+00	2.29E+00	2.14E+00	1.77E+00	1.89E+00	2.26E+00	3.10E-01
		Acetone	1.12E-01	I	3.82E-02	3.80E-02	5.96E-02	7.28E-02	2.61E-02	5.30E-02	9.93E-02	6.24E-02	3.05E-02

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; **ND**: Non Detect

Test Plan DH Individual Test Results – Lb/Tn Metal

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DH001	DH002	DH003	DH004	DH005	DH006	DH007	DH008	DH009	Average	STDEV
		Pour Dates	**4/11/01**	**4/11/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/13/01**	**4/13/01**	**4/13/01**		
		TGOC (THC) as Propane	1.89E+00	2.07E+00	2.22E+00	2.52E+00	2.42E+00	2.25E+00	2.18E+00	2.27E+00	2.39E+00	2.25E+00	1.90E-01
		HC as Hexane	8.30E-01	8.26E-01	8.15E-01	1.00E+00	1.01E+00	9.18E-01	1.09E+00	1.03E+00	1.03E+00	9.51E-01	1.05E-01
		Sum of VOCs	3.26E-01	3.66E-01	2.53E-01	4.03E-01	3.77E-01	3.23E-01	3.49E-01	3.07E-01	3.72E-01	3.42E-01	4.50E-02
		Sum of HAPs	2.63E-01	2.98E-01	2.27E-01	3.42E-01	3.10E-01	2.63E-01	2.86E-01	2.53E-01	2.97E-01	2.82E-01	3.44E-02
		Sum of POMs	5.12E-02	5.32E-02	I	3.93E-02	4.99E-02	4.88E-02	4.45E-02	4.65E-02	4.75E-02	4.76E-02	4.31E-03
			Individual HAPs and VOCs										
	x	**Acetaldehyde**	8.29E-02	1.16E-01	1.03E-01	1.48E-01	1.20E-01	1.12E-01	1.11E-01	1.26E-01	1.07E-01	1.14E-01	1.77E-02
	x	**Propionaldehyde**	4.60E-02	5.11E-02	4.71E-02	6.11E-02	5.15E-02	5.04E-02	5.01E-02	I	4.91E-02	5.08E-02	4.60E-03
	x	**Aniline**	2.40E-02	2.34E-02	2.29E-02	2.49E-02	1.98E-02	I	3.11E-02	2.29E-02	3.35E-02	2.53E-02	4.60E-03
	x	**Phenol**	2.32E-02	2.20E-02	I	1.73E-02	2.23E-02	2.19E-02	1.98E-02	1.74E-02	2.16E-02	2.07E-02	2.27E-03
z	x	**Naphthalene**	1.73E-02	1.71E-02	I	1.41E-02	1.90E-02	1.77E-02	1.59E-02	1.55E-02	1.59E-02	1.66E-02	1.53E-03
z	x	**1,8-Dimethylnaphthalene**	1.39E-02	1.78E-02	8.63E-03	1.06E-02	1.14E-02	1.39E-02	1.24E-02	1.58E-02	1.65E-02	1.34E-02	2.98E-03
	x	**Toluene**	9.84E-03	7.60E-03	1.07E-02	1.81E-02	1.84E-02	9.96E-03	7.71E-03	9.38E-03	8.06E-03	1.11E-02	4.18E-03
	x	**Formaldehyde**	4.83E-03	1.03E-02	7.03E-03	1.38E-02	1.02E-02	6.84E-03	7.29E-03	1.11E-02	6.35E-03	8.64E-03	2.85E-03
z	x	**2-Methylnaphthalene**	9.88E-03	8.72E-03	5.89E-03	7.13E-03	9.40E-03	8.16E-03	7.71E-03	7.19E-03	7.15E-03	7.92E-03	1.26E-03
z	x	**1-Methylnaphthalene**	6.78E-03	6.40E-03	4.06E-03	5.13E-03	6.42E-03	5.88E-03	5.37E-03	5.08E-03	5.17E-03	5.59E-03	8.59E-04
	x	**m,p-Xylene**	5.73E-03	4.16E-03	4.93E-03	8.30E-03	7.64E-03	5.22E-03	4.29E-03	4.61E-03	4.36E-03	5.47E-03	1.51E-03
	x	**Hexane**	6.43E-03	2.56E-03	5.81E-03	2.92E-03	2.81E-03	ND	2.19E-03	9.00E-03	1.09E-02	4.74E-03	3.55E-03
	x	**2-Butanone**	4.51E-03	3.76E-03	4.59E-03	4.10E-03	3.01E-03	4.13E-03	4.60E-03	2.67E-03	5.48E-03	4.10E-03	8.61E-04
	x	**Benzene**	3.98E-03	4.03E-03	2.55E-03	3.68E-03	4.24E-03	3.61E-03	3.12E-03	3.86E-03	3.47E-03	3.61E-03	5.22E-04
z	x	**1,3-Dimethylnaphthalene**	3.29E-03	3.09E-03	I	2.38E-03	3.71E-03	3.10E-03	3.01E-03	2.84E-03	2.84E-03	3.03E-03	3.84E-04
	x	**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	I	ND	ND	I	NA	NA
z	x	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan DH Individual Test Results – Lb/Tn Metal

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DH001	DH002	DH003	DH004	DH005	DH006	DH007	DH008	DH009	Average	STDEV
		Pour Dates	4/11/01	4/11/01	4/12/01	4/12/01	4/12/01	4/12/01	4/13/01	4/13/01	4/13/01		
z	x	2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
z	x	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	Cumene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	o-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	o-Xylene	ND	ND	ND	I	ND	ND	ND	ND	ND	NA	NA
	x	Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	x	Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		1,4-Diethylbenzene	2.02E-02	1.98E-02	I	1.77E-02	2.26E-02	2.14E-02	2.17E-02	2.13E-02	2.18E-02	2.08E-02	1.56E-03
		Butyraldehyde/Methacrolein	1.03E-02	1.06E-02	1.11E-02	1.23E-02	1.06E-02	1.11E-02	1.15E-02	8.57E-03	1.12E-02	1.08E-02	1.02E-03
		1,3-Diethylbenzene	8.13E-03	8.05E-03	I	7.22E-03	9.04E-03	8.38E-03	8.52E-03	9.08E-03	8.50E-03	8.37E-03	5.93E-04
		Benzaldehyde	5.18E-03	5.38E-03	5.99E-03	5.97E-03	4.77E-03	6.10E-03	6.25E-03	5.35E-03	7.39E-03	5.82E-03	7.66E-04
		1,2,3-Trimethylbenzene	5.08E-03	4.91E-03	I	5.92E-03	6.03E-03	5.31E-03	5.42E-03	5.37E-03	5.43E-03	5.44E-03	3.80E-04
		Crotonaldehyde	4.32E-03	5.64E-03	5.55E-03	6.31E-03	4.20E-03	5.66E-03	5.38E-03	4.02E-03	5.92E-03	5.22E-03	8.29E-04
		Heptane	7.98E-03	8.42E-03	ND	ND	7.79E-03	ND	ND	ND	8.94E-03	3.68E-03	4.38E-03
		Hexaldehyde	2.53E-03	2.81E-03	2.40E-03	3.30E-03	2.55E-03	1.90E-03	2.47E-03	I	2.30E-03	2.53E-03	4.04E-04
		o,m,p-Tolualdehyde	ND	2.81E-03	ND	2.28E-03	ND	ND	2.32E-03	ND	2.38E-03	1.09E-03	1.30E-03
		Pentanal	ND	ND	9.07E-04	ND	ND	9.23E-04	ND	ND	1.04E-03	3.19E-04	4.79E-04
		1,2,4-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan DH Individual Test Results – Lb/Tn Metal

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DH001	DH002	DH003	DH004	DH005	DH006	DH007	DH008	DH009	Average	STDEV
		Pour Dates	**4/11/01**	**4/11/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/13/01**	**4/13/01**	**4/13/01**		
		1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		2-Ethyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		3-Ethyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		4-Ethyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Decane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Isobutylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Octane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		p-Cymene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan DH Individual Test Results – Lb/Tn Metal

POMs	HAPs	COMPOUND / SAMPLE NUMBER	DH001	DH002	DH003	DH004	DH005	DH006	DH007	DH008	DH009	Average	STDEV
		Pour Dates	**4/11/01**	**4/11/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/12/01**	**4/13/01**	**4/13/01**	**4/13/01**		
		tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Tridecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
		Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
			Other Analytes										
		Condensables	I	I	2.10E+00	2.49E+00	2.08E+00	2.31E+00	2.54E+00	2.53E+00	2.44E+00	2.36E+00	1.98E-01
		Acetone	2.23E-01	1.97E-01	2.12E-01	2.39E-01	1.97E-01	2.09E-01	2.15E-01	2.18E-01	2.20E-01	2.14E-01	1.30E-02
		Carbon Dioxide	9.76E+01	1.05E+02	1.11E+02	1.02E+02	1.01E+02	1.01E+02	I	9.87E+01			
		Carbon Monoxide	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Methane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Ethane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Propane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Isobutane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Butane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Neopentane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Isopentane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA
		Pentane	ND	ND	ND	ND	ND	ND	I	ND	ND	NA	NA

I: Data rejected due to data validation considerations.

ND: Non Detect; **NA**: Not Applicable

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

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APPENDIX C TEST SERIES DK AND DH DETAILED PROCESS AND SOURCE DATA

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Test DK Process and Source Data

Description	DK001	DK002	DK003	DK004	DK005	DK006	DK007	DK008	DK009	Averages
	1/3/01	1/3/01	1/4/01	1/4/01	1/4/01	1/4/01	1/5/01	1/5/01	1/5/01	
Casting Metal Weight, lbs. (Note 1)	49	52	52	52	50	47	54	51	54	51
Total No Bake Mold Weight, lbs.	326	332	328	330	332	331	331	332	334	331
Total Binder Weight including catalyst, lbs	3.572	3.638	3.569	3.590	3.612	3.601	3.594	3.604	3.626	3.60
No. Cavities Poured (four-on gear)	4	4	4	4	4	4	4	4	4	4
No Bake Mold LOI, % 1400°F	1.35	1.43	1.37	1.34	1.47	1.44	Note 4	1.26	1.30	1.37
Pouring Temperature, °F	1259	1260	1241	1236	1250	1257	1242	1260	1258	1251
Dog Bone Tensile Strength 30 min., psi	33.50	13.00	29.67	31.17	30.33	29.17	35.17	36.33	ND	29.79
Dog Bone Tensile Strength 2 hrs, psi	70.00	28.67	60.83	73.83	67.50	43.67	73.17	83.33	ND	62.63
Dog Bone Tensile Strength 24 hrs, psi	90.83	46.00	80.50	104.00	88.00	53.67	87.33	96.33	ND	80.83
Dog Bone Tensile Strength 24 hrs at 90% RH, psi	25.33	15.67	21.00	30.00	24.67	14.17	26.5	24.33	ND	22.71
Sand Flow Rate, lbs / 15 seconds	51.65	51.65	47.50	47.50	47.50	47.50	47	47.00	47.00	48.26
Resin + co-reactant, % BOS	1.11	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Resin, grams	129.40	129.40	118.90	118.90	118.90	118.90	116.80	116.80	116.80	120.53
Co-reactant, grams	130.40	130.40	118.30	118.30	118.30	118.30	117.4	117.40	117.40	120.69
Catalyst, BO Resin, grams	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Binder, true % BO(Binder + sand)	1.10	1.10	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Total (Resin + co-reactant), true % BO(Binder + sand)	1.10	1.10	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Average Stack Temperature, °F	78	82	74	78	80	81	74	78	82	79
Total Moisture Content, %	0.86	0.84	0.76	0.83	0.86	0.84	0.75	0.81	0.85	0.82
Average Stack Velocity, ft./sec.	15.90	15.70	15.60	15.70	15.70	15.80	15.90	15.70	15.80	15.76
Avg. Stack Pressure, in. Hg	30.39	30.34	30.30	30.21	30.18	30.15	30.20	30.14	30.07	30.22
Stack Flow Rate, scfm	741	726	731	728	726	725	742	727	723	730

Binder = Resin + co-reactant
BO = Based on ( )
Binder fraction = binder including catalyst(lbs)/(sand + binder including catalyst(lbs)). Binder fraction x mold weight used in mold = Total Binder Weight including catalyst
Example: (0.5723/(51.65 + 0.5723)) = 0.01096. 0.01096x 326 = 3.5726 (lbs binder per mold) 1.1% No Bake resin DK001-009.
NOTE 1: Casting metal used is Aluminum.
NOTE 2: Dog Bone Tensile Strength values are the average of six samples.
NOTE 3: DK006, Low total metal weight reflects malformed pour cup, casting is complete; ref picture DK006a
NOTE 4: DK007, Use this test, mixer calibration data, Dogbone test data, and THC data support correct manufacture even in absense of LOI confirmation

Test DH Process and Source Data

Description	DH001	DH002	DH003	DH004	DH005	DH006	DH007	DH008	DH009	Averages
	4/11/01	4/11/01	4/12/01	4/12/01	4/12/01	4/12/01	4/13/01	4/13/01	4/13/01	
Casting Metal Weight, lbs. (Note 1)	50	48	50	50	50	49	50	48	50	49
Total No Bake Mold Weight, lbs.	269	273	273	274	271	278	284	287	289	278
Total Binder Weight including catalyst, lbs	3.018	3.063	3.072	3.083	3.050	3.128	3.209	3.243	3.265	3.13
No. Cavities Poured (four-on gear)	4	4	4	4	4	4	4	4	4	4
No Bake Mold LOI, % 1400°F	1.14	1.21	1.16	1.23	1.25	1.05	1.04	1.28	1.17	1.17
Pouring Temperature, °F	1261	1260	1241	1261	1241	1257	1241	1248	1247	1251
Dog Bone Tensile Strength 30 min., psi	1	3	1	1	1	1	1	2	1	1
Dog Bone Tensile Strength 2 hrs, psi	59	60	48	47	46	30	79	29	69	52
Dog Bone Tensile Strength 24 hrs, psi	111	85	84	92	92	74	118	62	116	93
Dog Bone Tensile Strength 24 hrs at 90% RH, psi	19	13	5	7	12	11	15	6	13	11
Sand Flow Rate, lbs / 15 seconds	59.80	59.80	59.80	59.80	59.80	59.80	60	60.00	60.00	59.87
Resin + co-reactant, % BOS	1.09	1.09	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.09
Resin, grams	118.70	118.70	118.40	118.40	118.40	118.40	118.90	118.90	118.90	118.63
Co-reactant, grams	177.30	177.30	178.50	178.50	178.50	178.50	180.40	180.40	180.40	178.87
Catalyst, BO Resin, grams	12.10	12.10	12.10	12.10	12.10	12.10	12.00	12.00	12.00	12.07
Total Binder, true % BO (Binder + sand)	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Total (Resin + co-reactant), true % BO (Binder + sand)	1.08	1.08	1.08	1.08	1.08	1.08	1.09	1.09	1.09	1.08
Average Stack Temperature, °F	84	86	79	83	84	86	81	84	85	84
Total Moisture Content, %	0.99	1.04	0.84	0.89	0.86	0.77	0.88	0.85	0.84	0.88
Average Stack Velocity, ft./sec.	15.6	15.10	15.20	15.00	15.30	15.30	15.20	15.00	15.30	15.22
Avg. Stack Pressure, in. Hg	29.90	29.86	30.16	30.19	30.17	30.15	30.15	30.15	30.11	30.09
Stack Flow Rate, scfm	707	681	702	687	699	698	700	686	698	695

Based on ()
Binder = Resin + coreactant
Binder fraction = binder including catalyst(lbs)/(sand + binder including catalyst(lbs)). Binder fraction x mold weight used in mold = Total Binder Weight including catalyst.
Example: (0.6786/(59.80 + 0.6786)) = 0.01122. 0.01122x 269 = 3.0185 (lbs binder per mold) 1.1% No Bake resin DH001-009.
NOTE 1: Casting metal used is Aluminum.
NOTE 2: Dog Bone Tensile Strength values are the average of six samples. DH007-009 24hr dogbone test were done at the 72 hour mark due to weekend.
NOTE 3: DH002 - Casting hanger was broke with sledge hammer during the weighing process not during shakeout.
NOTE 4: Every test experienced the cope not breaking loose from the castings. After each test was concluded, prying on the large chunks of cope to dislodge them became a normality.

APPENDIX D METHOD 25A CHARTS

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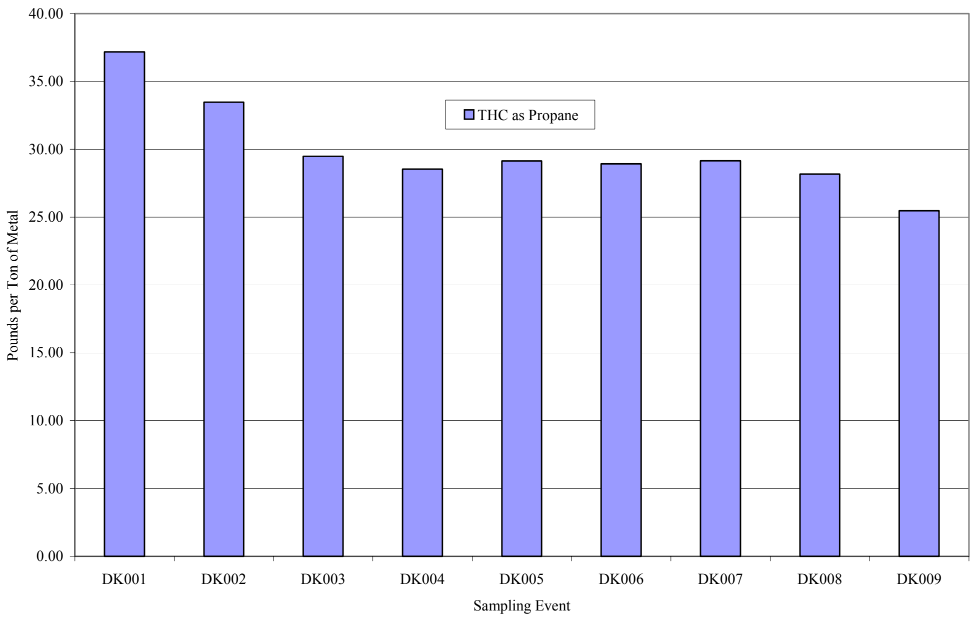
Test Series DK – TGOC (THC) as Propane



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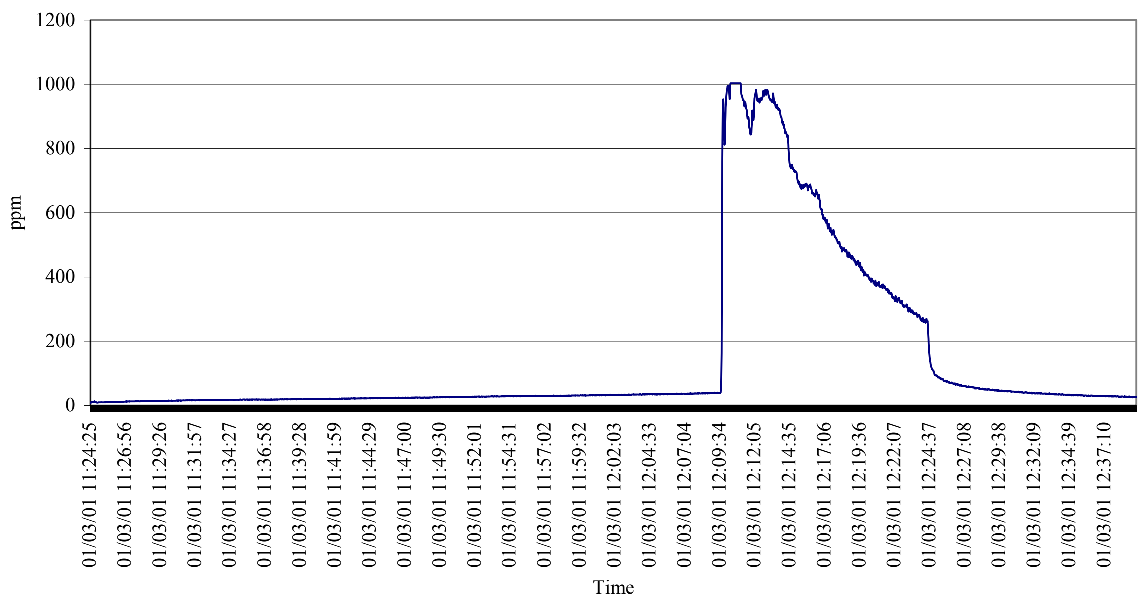

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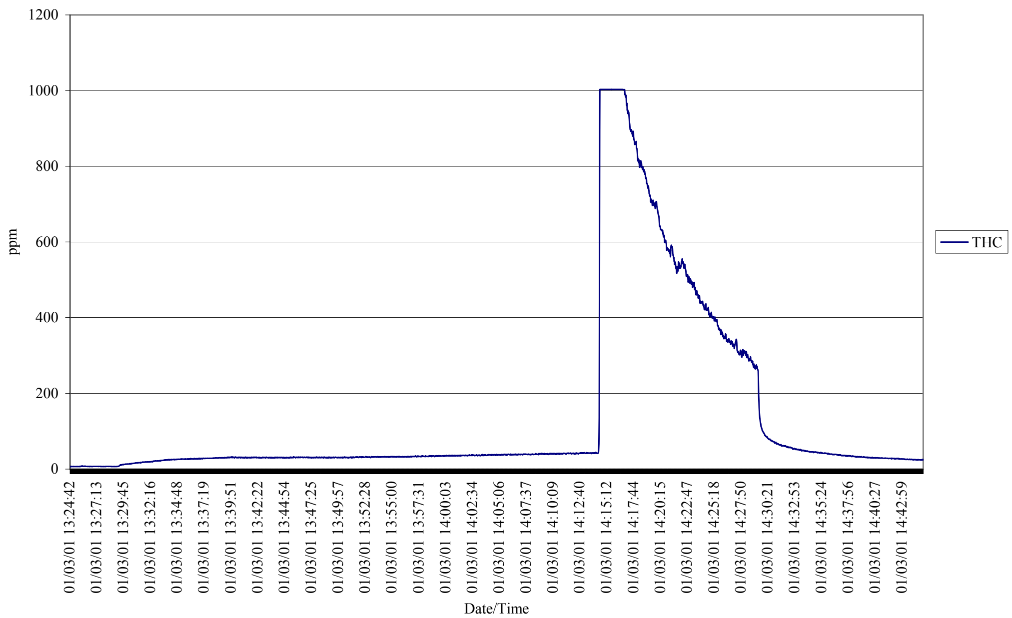
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01/03/01 13:39:51
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01/03/01 13:44:54
01/03/01 13:47:25
01/03/01 13:49:57
01/03/01 13:52:28
01/03/01 13:55:00
01/03/01 13:57:31
01/03/01 14:00:03
01/03/01 14:02:34
01/03/01 14:05:06
01/03/01 14:07:37
01/03/01 14:10:09
01/03/01 14:12:40
01/03/01 14:15:12
01/03/01 14:17:44
01/03/01 14:20:15
01/03/01 14:22:47
01/03/01 14:25:18
01/03/01 14:27:50
01/03/01 14:30:21
01/03/01 14:32:53
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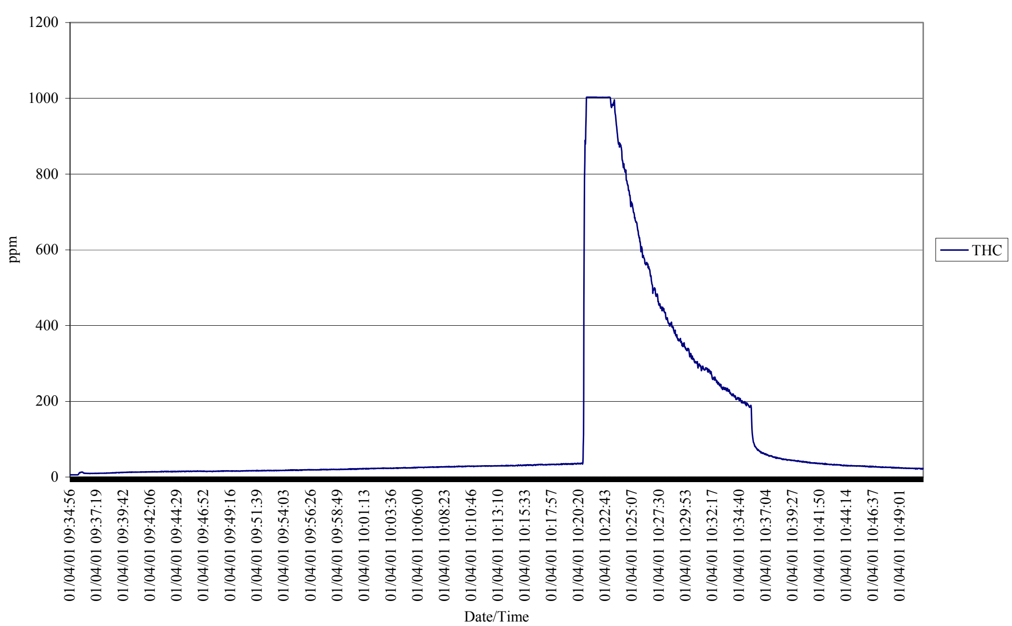
Date/Time

DK003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600
400
200
0
ppm
THC
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01/04/01 09:42:06
01/04/01 09:44:29
01/04/01 09:46:52
01/04/01 09:49:16
01/04/01 09:51:39
01/04/01 09:54:03
01/04/01 09:56:26
01/04/01 09:58:49
01/04/01 10:01:13
01/04/01 10:03:36
01/04/01 10:06:00
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01/04/01 10:10:46
01/04/01 10:13:10
01/04/01 10:15:33
01/04/01 10:17:57
01/04/01 10:20:20
01/04/01 10:22:43
01/04/01 10:25:07
01/04/01 10:27:30
01/04/01 10:29:53
01/04/01 10:32:17
01/04/01 10:34:40
01/04/01 10:37:04
01/04/01 10:39:27
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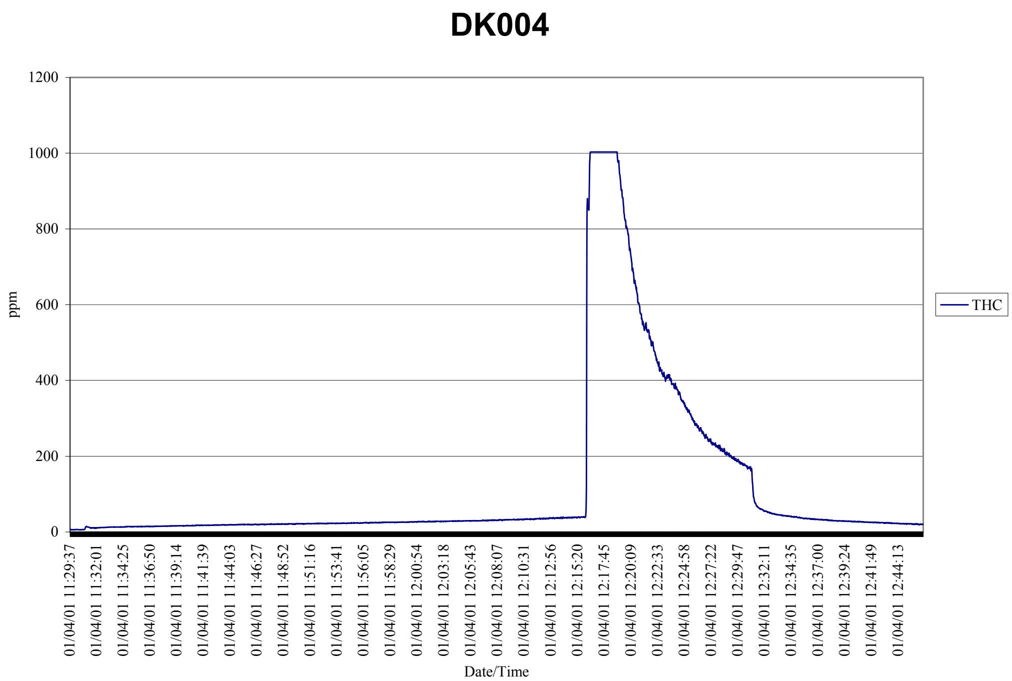
01/04/01 10:46:37
01/04/01 10:49:01
Date/Time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THC
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01/04/01 11:46:27
01/04/01 11:48:52
01/04/01 11:51:16
01/04/01 11:53:41
01/04/01 11:56:05
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01/04/01 12:03:18
01/04/01 12:05:43
01/04/01 12:08:07
01/04/01 12:10:31
01/04/01 12:12:56
01/04/01 12:15:20
01/04/01 12:17:45
01/04/01 12:20:09
01/04/01 12:22:33
01/04/01 12:24:58
01/04/01 12:27:22
01/04/01 12:29:47
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01/04/01 12:34:35
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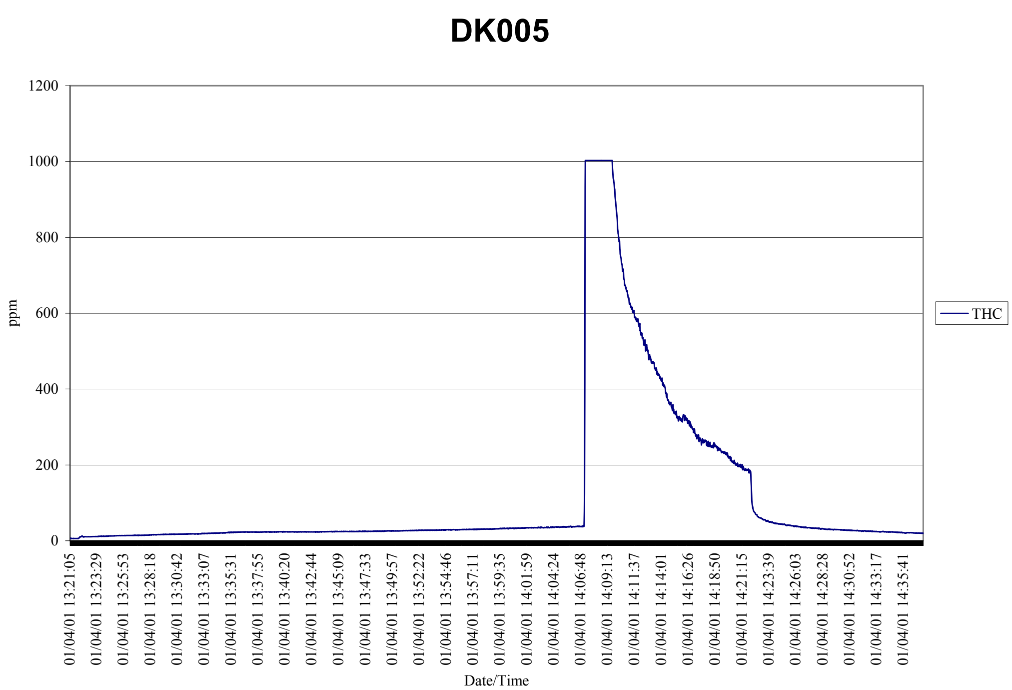
01/04/01 12:41:49
01/04/01 12:44:13
Date/Time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800
600
400
200
0
ppm
THC
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01/04/01 13:23:29
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01/04/01 13:28:18
01/04/01 13:30:42
01/04/01 13:33:07
01/04/01 13:35:31
01/04/01 13:37:55
01/04/01 13:40:20
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01/04/01 13:47:33
01/04/01 13:49:57
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01/04/01 13:57:11
01/04/01 13:59:35
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01/04/01 14:04:24
01/04/01 14:06:48
01/04/01 14:09:13
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01/04/01 14:26:03
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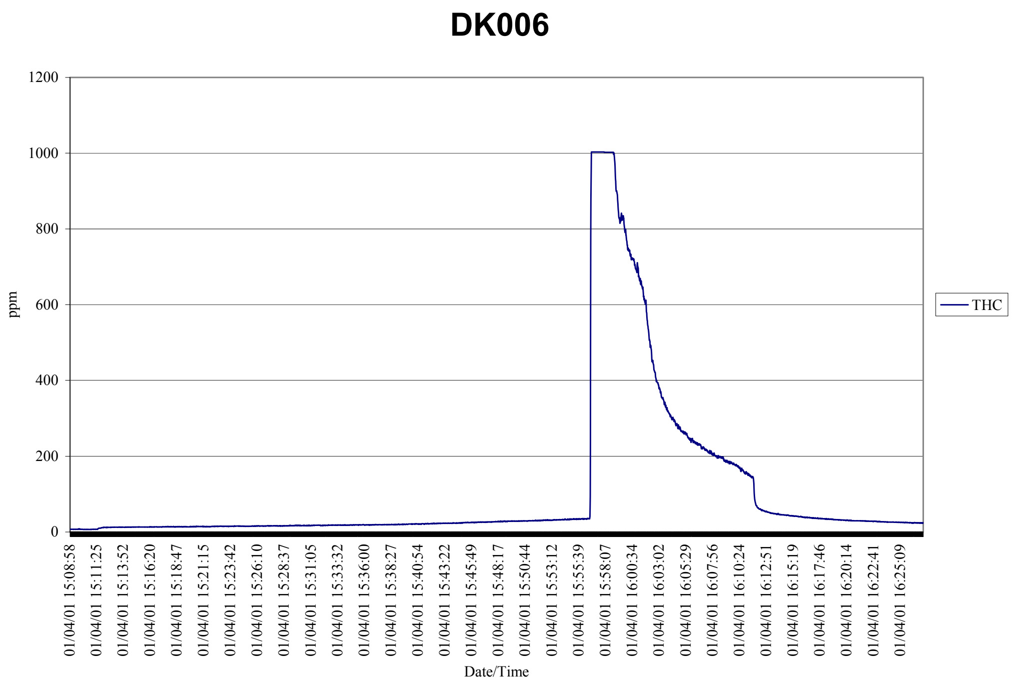
01/04/01 14:33:17
01/04/01 14:35:41
Date/Time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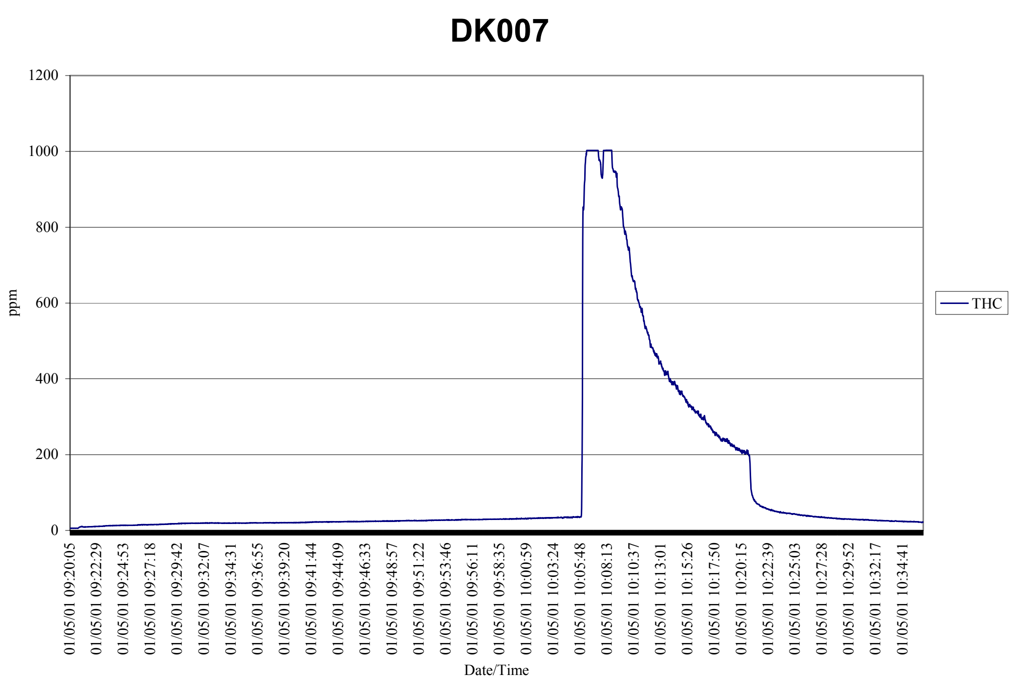
0
ppm
THC
Date/Time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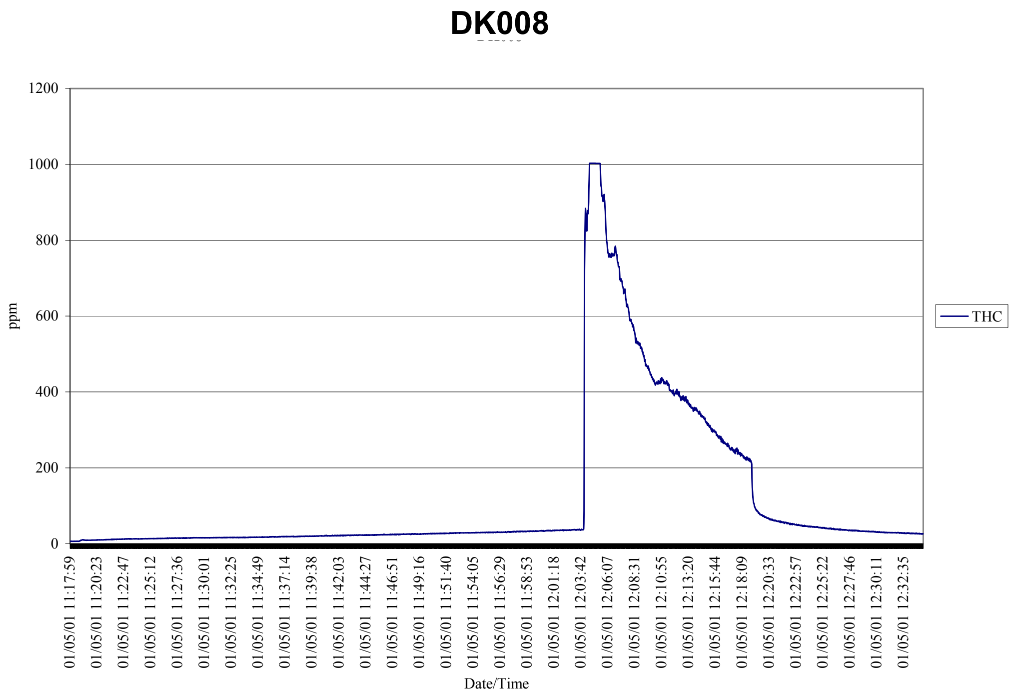
200
0
ppm
THC
Date/Time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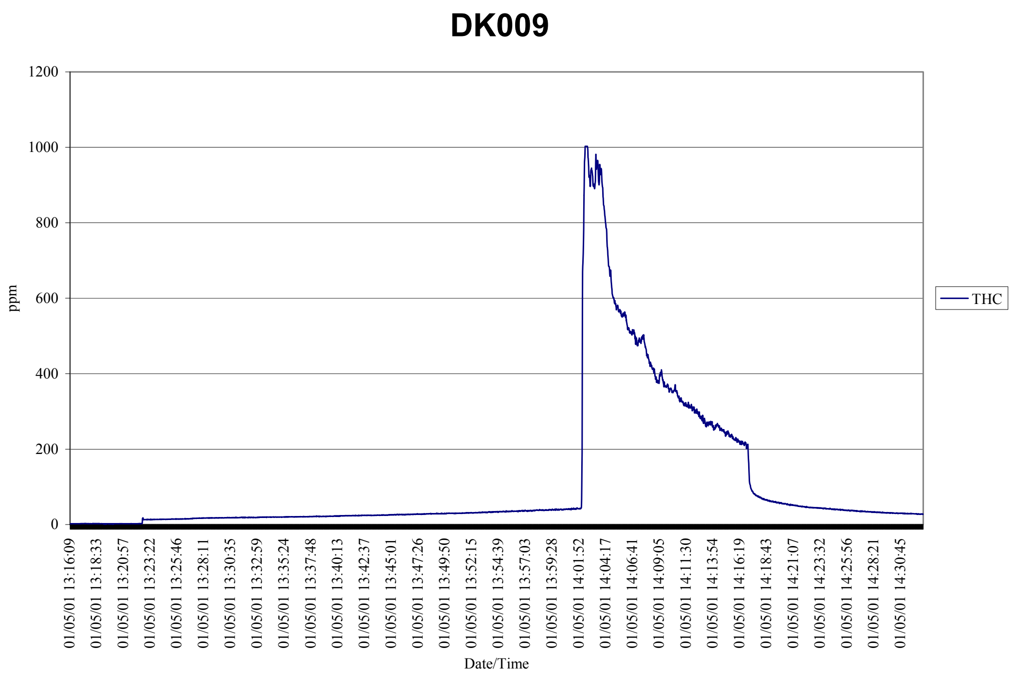
THC
Date/Time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800
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400
200
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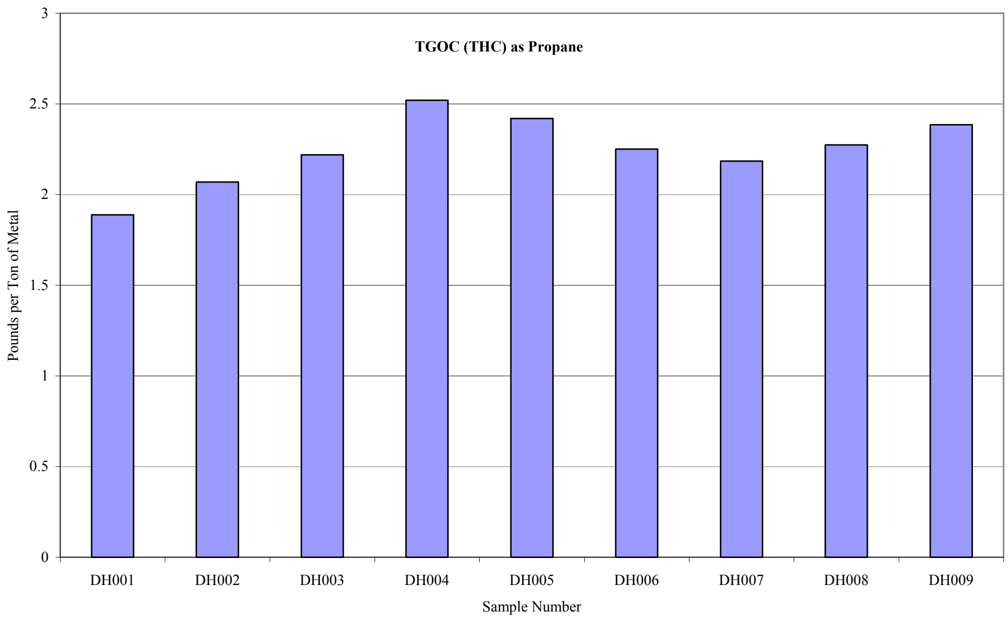
ppm
THC
Date/Time

Test Series DH – TGOC (THC) as Propane



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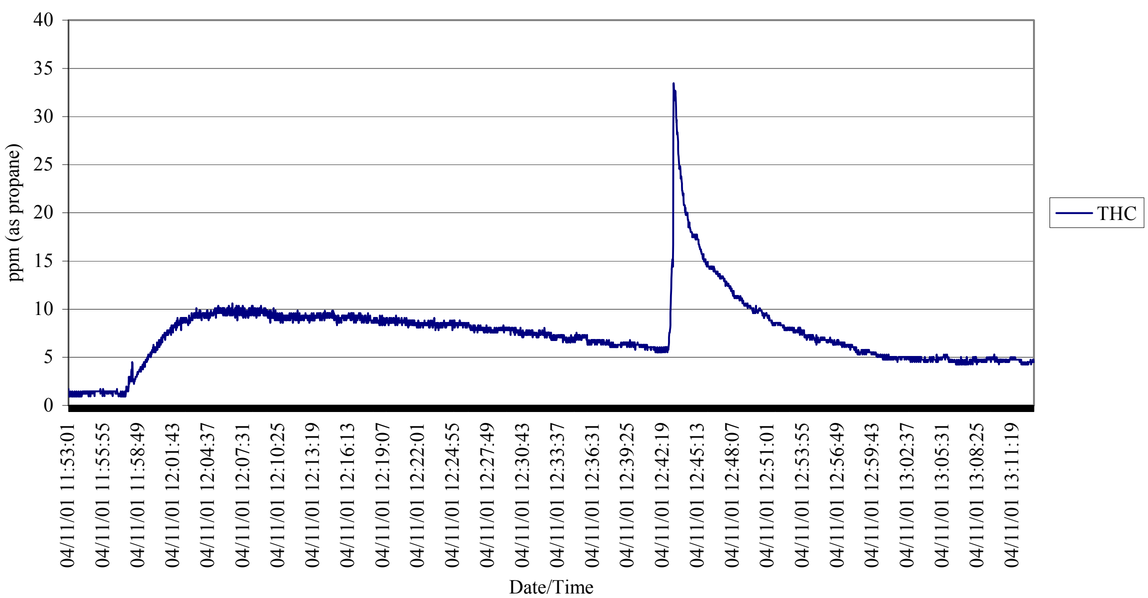
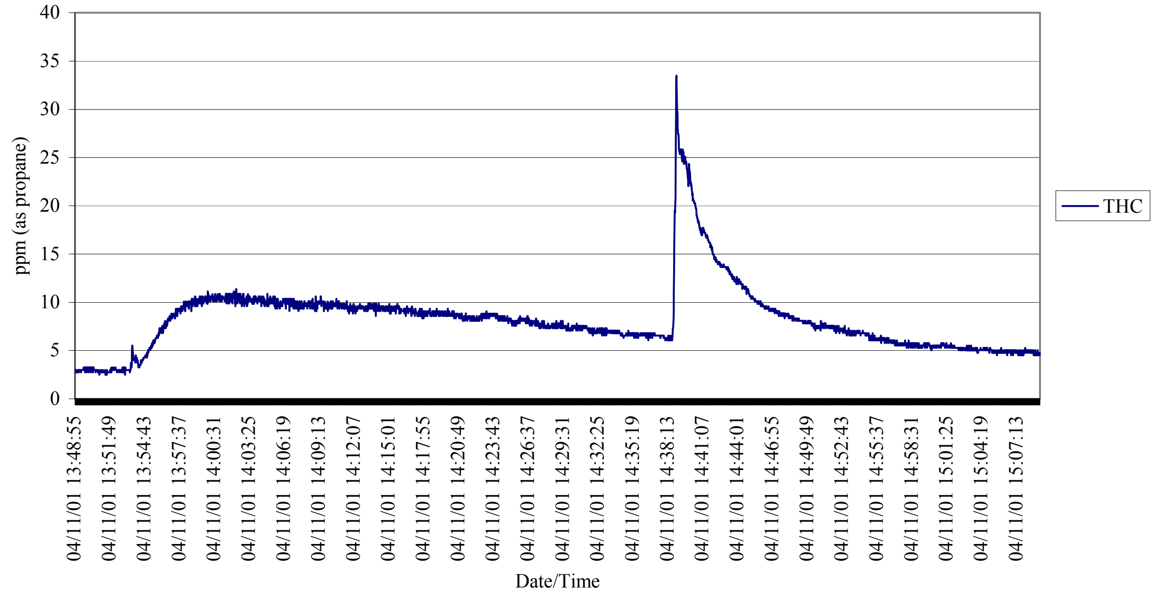


DH002


40
35
30
25
20
15
10
5
0
ppm (as propane)
THC
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04/11/01 13:51:49
04/11/01 13:54:43
04/11/01 13:57:37
04/11/01 14:00:31
04/11/01 14:03:25
04/11/01 14:06:19
04/11/01 14:09:13
04/11/01 14:12:07
04/11/01 14:15:01
04/11/01 14:17:55
04/11/01 14:20:49
04/11/01 14:23:43
04/11/01 14:26:37
04/11/01 14:29:31
04/11/01 14:32:25
04/11/01 14:35:19
04/11/01 14:38:13
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04/11/01 14:44:01
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04/11/01 14:55:37
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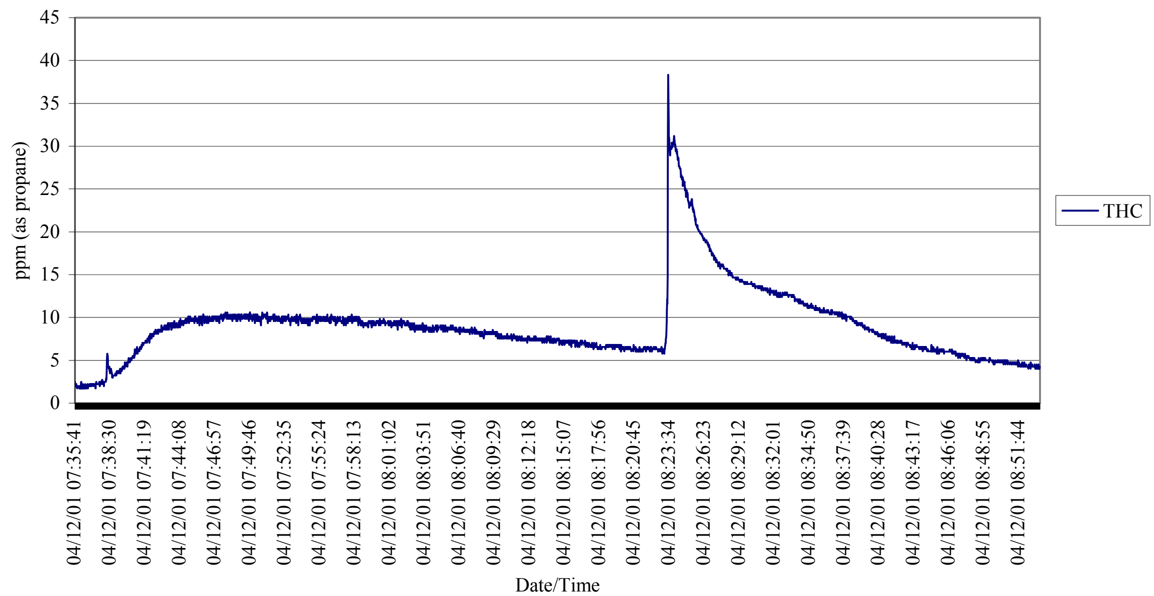
04/11/01 15:04:19
04/11/01 15:07:13
Date/Time

DH003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40
35
30
25
20
15
10
5
0
ppm (as propane)
THC
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04/12/01 07:55:24
04/12/01 07:58:13
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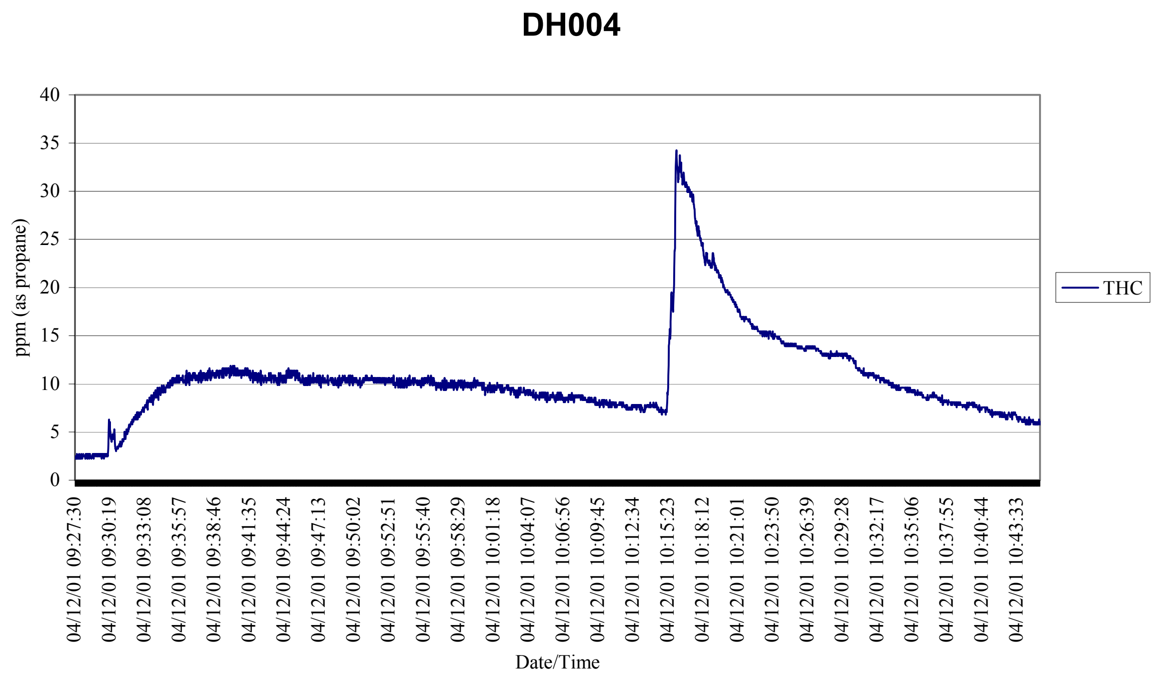
Date/Time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ppm (as propane)
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35
30
25
20
15
10
5
0
THC
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04/12/01 09:30:19
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04/12/01 10:32:17
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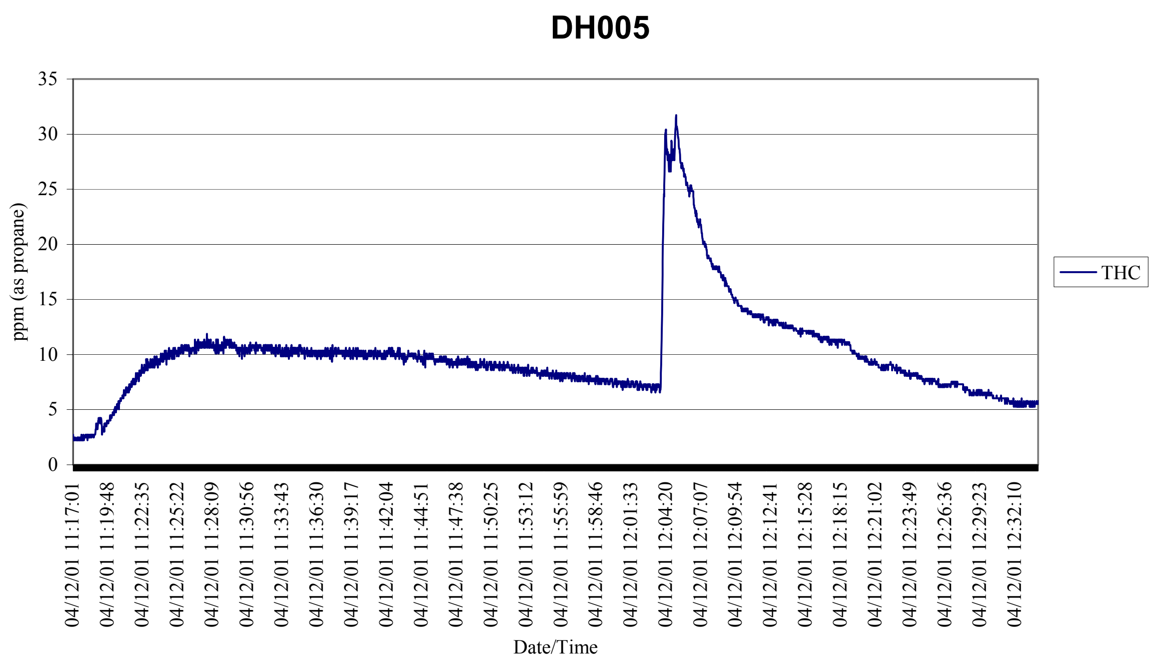
Date/Time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ppm (as propane)
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25
20
15
10
5
0
THC
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04/12/01 12:18:15
04/12/01 12:21:02
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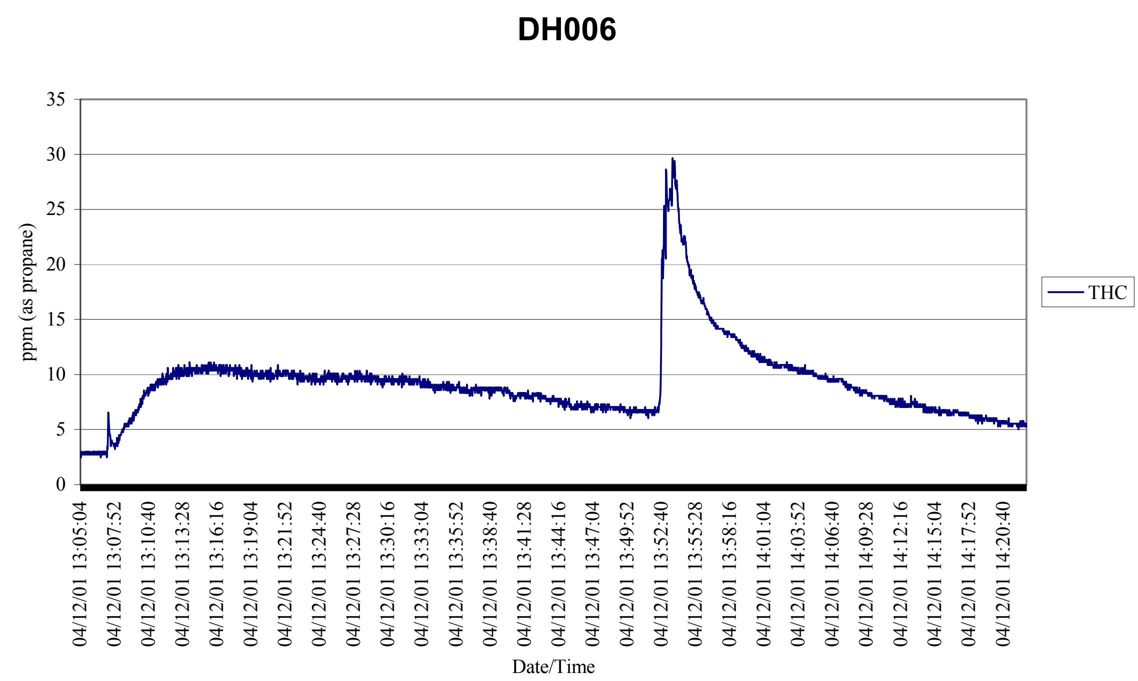
04/12/01 12:29:23
04/12/01 12:32:10
Date/Time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ppm (as propane)
0
5
10
15
20
25
30
35
THC
Date/Time
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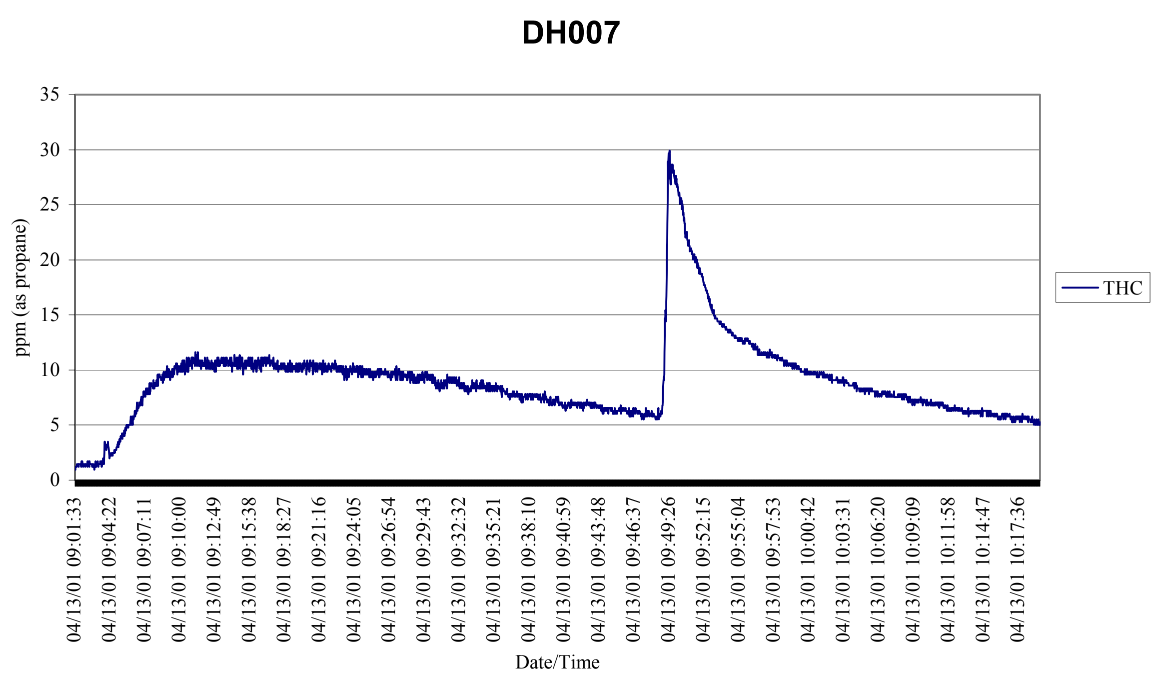
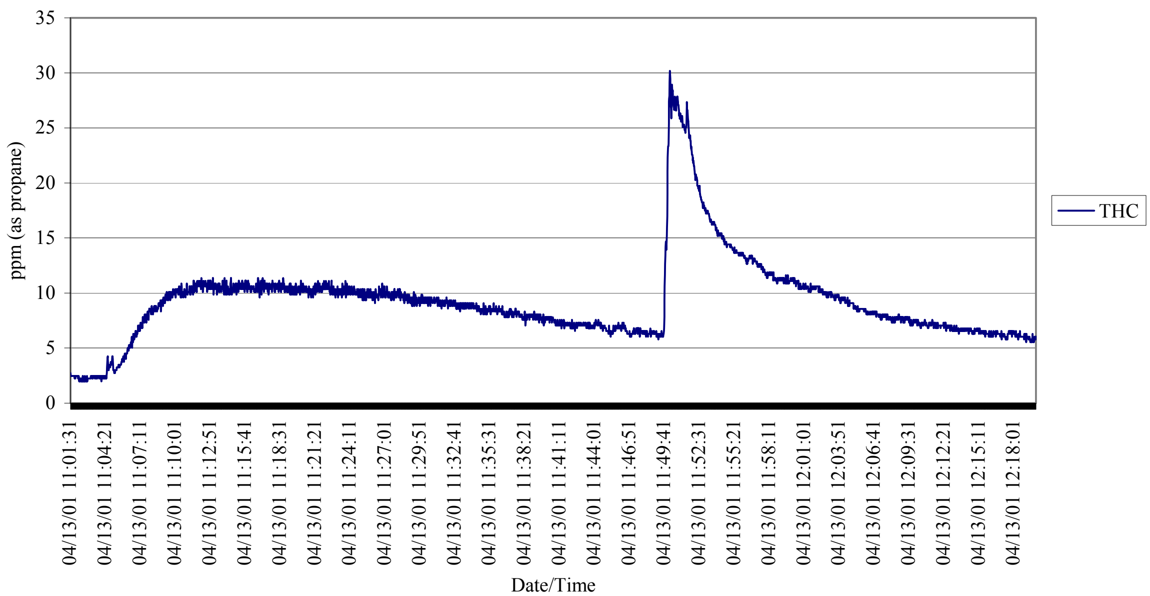
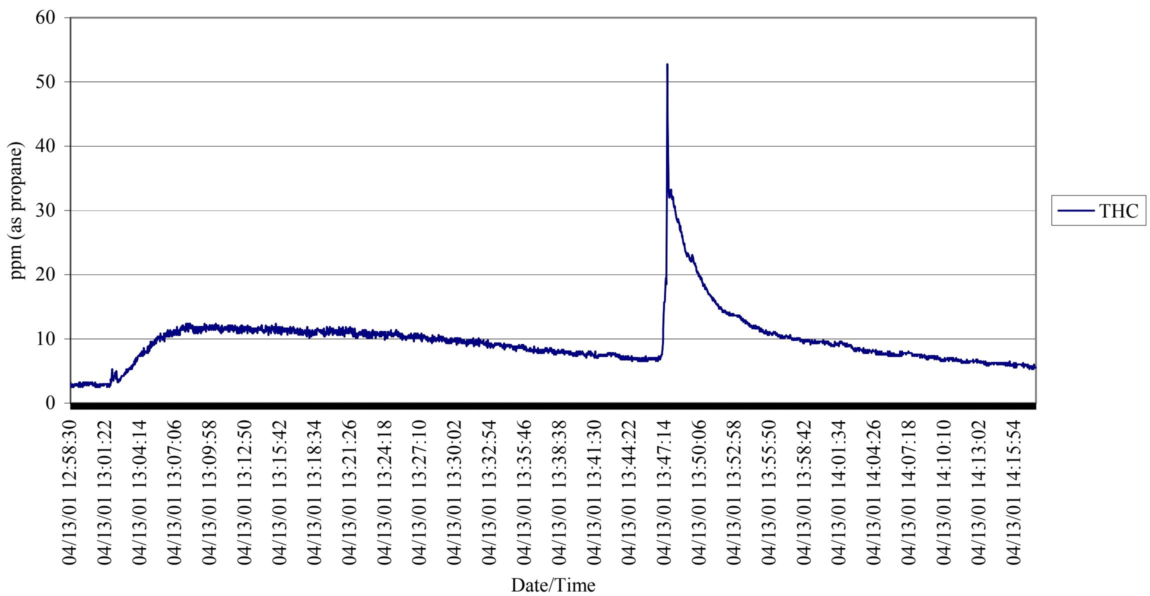
04/12/01 14:06:40
04/12/01 14:09:28
04/12/01 14:12:16
04/12/01 14:15:04
04/12/01 14:17:52
04/12/01 14:20:40


DH007
ppm (as propane)
0
5
10
15
20
25
30
35
THC
Date/Time
04/13/01 09:01:33
04/13/01 09:04:22
04/13/01 09:07:11
04/13/01 09:10:00
04/13/01 09:12:49
04/13/01 09:15:38
04/13/01 09:18:27
04/13/01 09:21:16
04/13/01 09:24:05
04/13/01 09:26:54
04/13/01 09:29:43
04/13/01 09:32:32
04/13/01 09:35:21
04/13/01 09:38:10
04/13/01 09:40:59
04/13/01 09:43:48
04/13/01 09:46:37
04/13/01 09:49:26
04/13/01 09:52:15
04/13/01 09:55:04
04/13/01 09:57:53
04/13/01 10:00:42
04/13/01 10:03:31
04/13/01 10:06:20
04/13/01 10:09:09
04/13/01 10:11:58
04/13/01 10:14:47
04/13/01 10:17:36

DH008



DH009



APPENDIX E LISTING OF SUPPORT DOCUMENTS

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Supporting 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. Technikon Emissions Testing and Analytical Testing Standard Operating Procedures.

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 Data

NT 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.

POM Polycyclic Organic Matter (POM) including Naphthalene and other compounds that contain more than one benzene ring and have a boiling point greater than or equal to 100 degrees Celsius.

LOI Loss of Ignition. LOI represents the change in weight of a sample expressed as % of the original dry weight as a consequence of combustion in air at the test temperature of 1400^{o}F

BO Based on ( ).

BOS Based on Sand.

Binder = Part 1 + Part 2 + Part 3.

Resin = Part 1.

Co-Reactant = Part 2.

Catalyst = Part 3.