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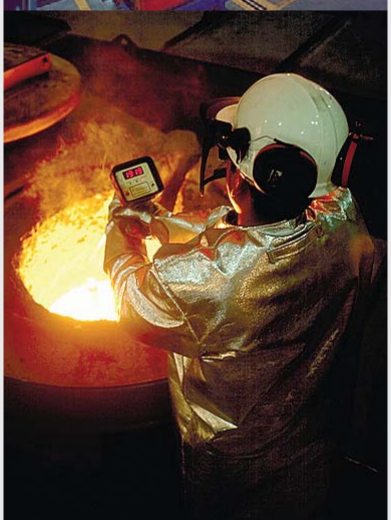

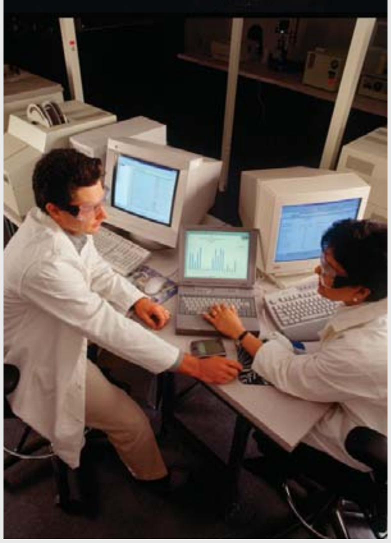

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A Water-Based Phenolic Resin Binder System for Pouring, Cooling, Shakeout Emissions When Poured in Aluminum

1413-113 HP

June 2007
(Revised for public distribution - December 2007)

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A Water-Based Phenolic Resin Binder System for Pouring, Cooling, Shakeout Emissions When Poured in Aluminum

1413-113 HP

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

Director of Measurement Technologies	*//Original Signed//* Sue Anne Sheya, PhD	Date
Vice President	*//Original Signed//* George Crandell	Date

The data contained in this report were developed to assess the relative emissions profile of the product or process being evaluated. You may not obtain the same results in your facility. Data were not collected to assess cost or producibility.

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EXECUTIVE SUMMARY

This report contains the results of Test HP, a quantitative evaluation of the pouring, cooling and shakeout airborne emissions from cores using a water-based phenolic resin coldbox core binder system for aluminum (Ecolotec® 750, Foseco, PLC). Castings were made in greensand molds with no seacoal using the four-cavity step core pattern. Nine molds containing uncoated cores were poured after three initial sand conditioning runs, which used coated cores. Emission results were compared to the phenolic urethane cold box system for aluminum (Sigma Cure® 7227/7707, HA International), which was tested under 1413-112, Test HK.

The core binder used for this test was a single part binder. The concentration was 2.0% total binder based on sand (BOS), per vendor's recommendations. The binder was activated with carbon dioxide (CO_2). The binder for the reference Test HK was a two part binder that contained 1.1% total binder BOS in a 50/50 ratio of Part 1 to Part 2. This binder was activated with triethylamine (TEA).

Molds were poured with aluminum at 1270 ± 10°F. The pouring time of 13-15 seconds was followed by cooling for an elapsed pouring and cooling time of 25 minutes. This was followed by 5 minutes of shakeout, and a post shakeout cooling period of an additional 15 minutes. Emission samples were continuously collected for the total 45 minute period.

The emissions results are reported in both pounds of analyte per pound of binder (lb/lb) and pounds of analyte per ton of metal poured (lb/ton). Emissions are background subtracted to provide accurate reporting of emissions which are a result of the tested process only.

Emission Indicators for lb/ton metal and lb/lb binder for Test HP (see Tables 1a and 1b) show statistically significant decreases on average of approximately 70% for Test HP when compared to Test HK. The biggest single change was in the Sum of Target POMs, which showed a relative decrease of approximately 99%.

Table 1a Average Emission Indicators Summary Table – Lb/Tn Metal

Analyte Name	Reference Test HK	Test HP	Percent Change from Reference
TGOC as Propane	1.10E+00	2.33E-01	**-79**
Non-Methane Hydrocarbons	1.10E+00	2.33E-01	**-79**
Sum of Target Analytes	3.24E-01	1.60E-01	**-51**
Sum of Target HAPs	2.26E-01	1.26E-01	**-44**
Sum of Target POMs	4.66E-02	1.03E-03	**-98**

Table 1b Average Emission Indicators Summary Table – Lb/Lb Binder

Analyte Name	Reference Test HK	Test HP	Percent Change from Reference
TGOC as Propane	7.65E-02	1.04E-02	**-86**
Non-Methane Hydrocarbons	7.65E-02	1.04E-02	**-86**
Sum of Target Analytes	2.25E-02	7.15E-03	**-68**
Sum of Target HAPs	1.57E-02	5.62E-03	**-64**
Sum of Target POMs	3.22E-03	4.59E-05	**-99**

Some target analyte emissions were higher and some were lower when comparing the two binder systems from Test HP and Test HK. The largest decrease of 100% was found for naphthalene, while the largest increase, 676%, was for propionaldehyde. All criteria pollutant and greenhouse gas emissions were less than the practical quantitation limit except for carbon dioxide, which showed an increase of over 300% on a lb/ton basis.

A qualitative assessment was made between the surface quality of castings from Test HP and Test HK. A photographic record was made of the 12 castings produced from cavity 3 of Test HP. Pictures of best, median and worst casting quality are shown in Appendix C. The castings produced from Test HK had a better surface quality than those produced from Test HP. Additionally the core tensile strengths were lower for Test HP than Test HK by 70%.

Emission results from the testing performed and described herein are 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. These measurements 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 point source emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Leadership Council of USCAR, a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC); the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). The US Environmental Protection Agency (US EPA) and the California Air Resources Board (CARB) also have been participants in the CERP program and rely on CERP published reports for regulatory compliance data. All published reports are available on the CERP web site at www.cerp-us.org.

1.2. CERP/TECHNIKON 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 alternative materials and production processes designed to achieve significant air emission reductions. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing facility enables the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. REPORT ORGANIZATION

This report has been written to document the methodology and results of a specific test plan that was used to evaluate the pouring, cooling and shakeout airborne emissions from the single part Foseco Ecolotec® 750 core binder for aluminum applications. Cores were in greensand molds that did not contain seacoal. Binder amounts were at 2.0% BOS for all tests.

Section 2.0 of this report includes a summary of the methodologies used for data collection and analysis, procedures for emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test are summarized in Section 3.0 and detailed data which include the variations appear in the appendices of this report. Section 4.0 of this report contains a discussion of the results.

The raw data for this test series are archived at the Technikon facility.

1.4. SPECIFIC TEST PLAN AND OBJECTIVES

Test HP was designed to evaluate airborne emissions from pouring, cooling and shakeout of a single part water-based phenolic resin core binder on cores. All cores were uncoated and made with Ecolotec® 750, at 2.0 % BOS and cured with CO_2.

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

Table 1-1 Test Plan Summary

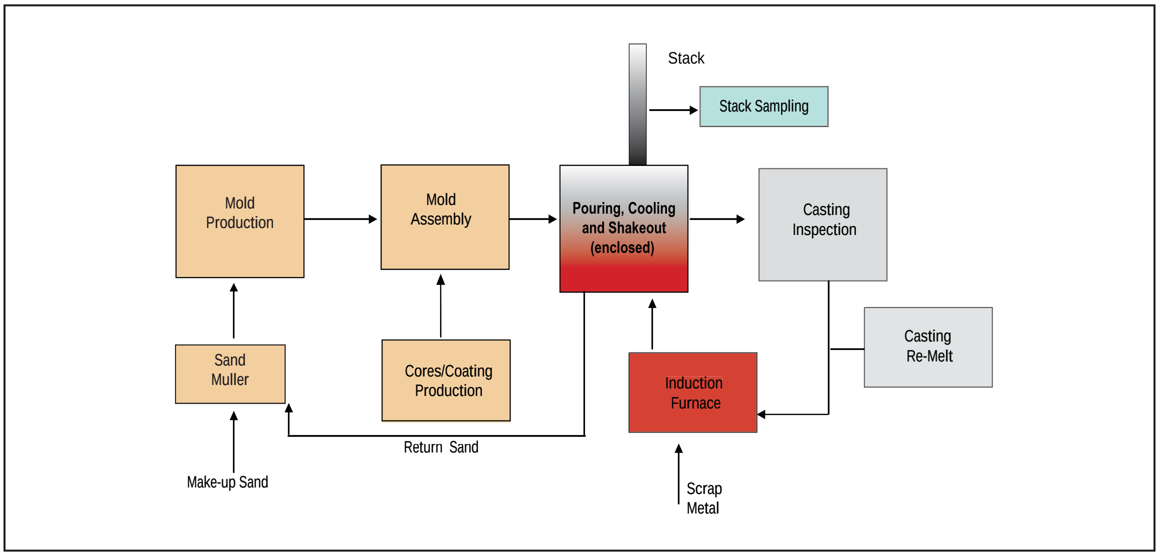
Type of Process Tested	Uncoated phenolic urethane core in greensand, PCS	Uncoated water-based phenolic resin core in greensand, PCS
Test Plan Number	1413-112-HK	1413-113-HP
Metal Poured	Aluminum	Aluminum
Casting Type	4-on step core	4-on step core
Greensand System	Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB clay, no seacoal	Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB clay, no seacoal
Core Binder	1.1% (BOS) HA International Sigma Cure® 7227/7707, 1.1% (BOS) HA International Sigma Cure® EX74522/EX75869, 1.1% (BOS) HA International Sigma Cure® EX76210/EX76211, TEA activated, Wedron 530 sand	2.0% (BOS) Foseco Ecolotec® 750, CO_2 activated, Wedron 530 sand
Core Coating	None	None
Number of Molds Poured	3 conditioning, 6 sampling for 7227/7707, 3 sampling each 74522/75869 and 76210/76211	3 conditioning, 9 sampling
Test Dates	August 21, 2006 through September 15, 2006	December 5, 2006 through December 7, 2006
Emissions Measured	64 Target Analytes	65 Target Analytes
Process Parameters Measured	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate

2.0 TEST METHODS, ASSUMPTIONS AND PROCEDURES

2.1. DESCRIPTION OF PROCESS AND TESTING EQUIPMENT

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

Figure 2-1 Mold/Core Making and Testing Process Diagram



2.2. DESCRIPTION OF TESTING PROGRAM

The testing program encompasses the foundry process and emissions testing, both of which are rigorously controlled. Parameters are monitored and recorded prior to and during the emission tests. Process measurements included the weights of the casting and mold sand, loss on ignition (LOI) values for the mold and core prior to the test, and relevant metallurgical data. Measured source parameters included stack temperature, pressure, volumetric flow rate, and moisture content. All parameters were maintained within prescribed ranges to ensure the reproducibility of the test runs.

Emission testing for organic hydrocarbons included several methods. Method 18 is one of the US Environmental Protection Agency's (EPA) reference methods for volatile organic compound (VOC) analysis. Method 18 is generally used to identify and/or measure as many compounds as possible in order to calculate actual VOC emissions from other measurements (e.g. EPA Method 25 or 25A). The method is a guideline and a system of quality assurance (QA) checks for VOC analysis rather than a rigorous, explicit manual for sampling or analysis.

As described in the method, sampling can be conducted using a Volatile Organic Sampling Train (VOST), which was the technique used for sampling for the tests described herein. A sample gas stream was extracted from the source and then routed using the train through tubes containing adsorbents, which are the collection materials upon which the organic analytes are deposited. Adsorption tube samples were collected and analyzed for sixty-five (65) target compounds using procedures based on approved federal methods, including those of the EPA.

Two methods were employed to measure undifferentiated hydrocarbon emissions as Emission Indicators: TGOC as Propane, performed in accordance with EPA Method 25A, and non-methane hydrocarbons as determined from methane results obtained by EPA CTM-042.

Method 25A is an instrument based method in which the stack gas is introduced directly to a flame ionization detector (FID) without first separating the components. In Method 25A, sampling is accomplished by extracting a gas stream from the stack effluent and transferring it via heated non-reactive tubing to the FID analyzer under very controlled temperature and pressure conditions. The FID measures the quantity of carbon containing molecules, and is calibrated by a gas standard, which in this case is the three carbon alkane, propane (C_3H_8). The FID will give a response relative to the calibration standard and results are expressed in terms of the gas used for calibration. Because the FID responds to all carbon containing compounds, methane (CH_4) and other exempt compounds are included in the total hydrocarbon results.

Methane was analyzed by a separate FID equipped with an oxidizing catalyst (methane cutter) that removes all non-methane hydrocarbons (NMHC). The calibration gas for this FID is methane (CH_4). The two FIDs were run simultaneously, and collected data every second. Average results were calculated over the entire pouring, cooling and shakeout periods for each run. NMHC results were then determined by subtracting the detected methane from the total hydrocarbon value, in a manner similar to that used in EPA Conditional Test Method (CTM) 042.

HC as Hexane was determined as a third method to measure undifferentiated hydrocarbons, and results are reported in Appendix B. This method uses NIOSH methods 1500-1550, and represents the sum of all detected hydrocarbon compounds in the carbon range between C_6 and C_{16}, expressed in terms of the calibration compound, which in this case is the six-carbon alkane, hexane (C_6H_{14}). Results are determined by the summation of all chromatographic peak areas which fall from the elution time of hexane through the elution time of hexadecane ($C_{16}H_{34}$) on the chromatogram. The quantity of hydrocarbons (HC) in this range is determined by dividing the total summed area count by the area of hexane calculated from the initial calibration curve that is derived from a five point calibration.

Continuous on-line monitoring of select criteria pollutant and greenhouse gases such as carbon dioxide (CO_2), carbon monoxide (CO), and nitrogen oxide (NOx) was conducted according to US EPA Methods, 3A, 10, and 7E, respectively.

Mass emission rates for all analytes were calculated using continuous monitoring or laboratory analytical results, measured source data and appropriate process data. Detailed emission results are presented in Appendix B. Individual analyte emissions were calculated in addition to five "Emission Indicators:" TGOC as Propane, NMHC, Sum of Target Analytes, Sum of Target Hazardous Air Pollutants (HAPs), and the Sum of Target Polycyclic Organic Matter (POMs). Full descriptions of these indicators can be found in Section 3.0 of this report.

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

2.2.1. Test Plan Review and Approval

The proposed test plan was reviewed and approved by the Technikon staff and by CERP Working Group Chairs as appropriate.

2.2.2. *Mold and Metal Preparation*

In Technikon's Research foundry, castings were produced individually in discrete manually constructed mold packages, each of which consists of four cavities. The 4-on step core pattern built to evaluate core emissions was used for all runs. The molds and cores (Figure 2-2 and 2-3) were prepared to a standard composition by the Technikon production team. Relevant process data were collected and recorded. The total amount of metal melted was determined from the expected poured weight of the castings and the number of molds to be poured. The weight of metal poured into each mold was recorded.

Figure 2-2 Step Core Pattern

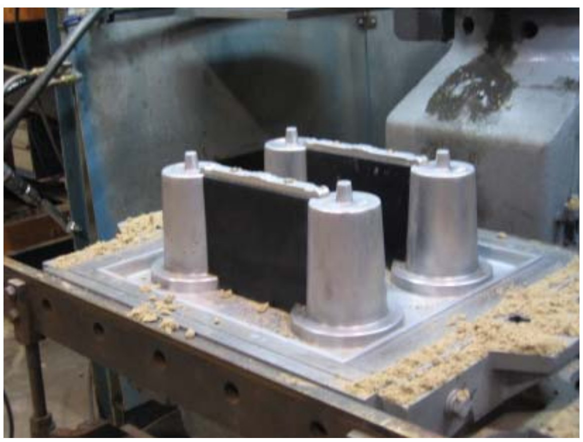
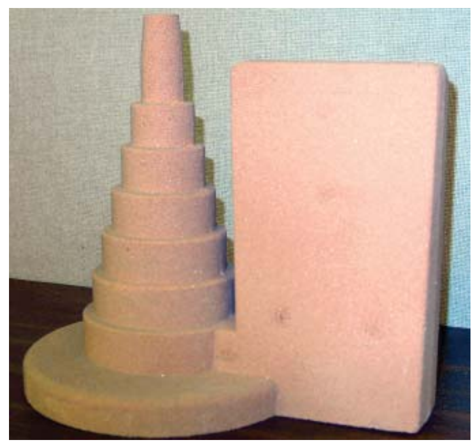


Figure 2-3 Step Core



2.2.3. *Individual Sampling Events*

Test HP was a test to determine emissions from a single part water-based phenolic resin core binder cores poured with aluminum. Prior to pouring and emission sampling for each run in the three tests, a single mold package was placed onto a shake-out table contained within a hooded enclosure designed to meet the requirements of EPA Method 204 for a total temporary enclosure. The enclosed test stand was pre-heated to approximately 85°F. The flow rate of the emission capture air was nominally 600 scfm. Aluminum at approximately 1270°F was then poured through an opening in the top of the emission enclosure into the mold, after which the opening was closed (Figure 2-4).

The emissions generated were transported through an insulated six (6) inch duct or stack located at the top of the enclosure. Heated sample probes inserted into the stack at relevant locations, determined by EPA Method 1, enabled collection of total emissions from all phases of the casting process. One probe provided gases for the VOST (Figure 2-5a). Another probe in the stack was used to continuously draw effluent samples and transport them via a forty-seven (47) ft heated sample line to the FID for methane measurement, and to an emissions console (Figure 2-5b) located in Technikon's laboratory, which contains a battery of gas analyzers. This console, or emissions bench, consists of a total hydrocarbon analyzer for TGOC analysis, two infra-red analyzers (for CO and CO_2) and a chemiluminescence analyzer for NOx.

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

Figure 2-4 Pouring Aluminum into Mold inside Total Enclosure Hood

Figure 2-5 Stack Sampling Equipment

a

b

Table 2-1 Process Equipment and Methods

Process Parameters	Equipment and Method(s)
Mold Weight	Cardinal 748E Platform Scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
Binder Weight	MyWeigh 2600
Core Weight	Mettler SB12001 Digital Scale (Gravimetric)
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold	Denver Instruments XE-100 Analytical Scale (AFS procedure 5100-00-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C Immersion Pyrometer)
Mold Compactability	Dietert 319A Sand Squeezer (AFS Procedure 2221-00-S)
Carbon/Silicon Fusion Temperature	Electro-nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale (Gravimetric)
Carbon Silicon Ratio	Electro-nite DataCast 2000 (thermal arrest)

2.2.4. Process Parameter Measurements

Table 2-1 lists the process parameters that are monitored during each test. The analytical equipment and methods used are also listed.

2.2.5. Air Emissions Analysis

The specific sampling and analytical methods used in the Research Foundry tests are based on federal reference methods shown in Table 2-2. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Standard Operating Procedures.

Table 2-2 Emission Sampling and Analytical Methods

Measurement Parameter	Test Method(s)
Port Location	US EPA Method 1
Number of Traverse Points	US EPA Method 1
Gas Velocity and Temperature	US EPA Method 2
Gas Density and Molecular Weight	US EPA Method 3a
Gas Moisture	US EPA Method 4 (Gravimetric)
Target VOCs and HAPs	US EPA Methods TO17, TO11; NIOSH Methods 1500, 2002, 5523
TGOC	US EPA Method 25A
CO	US EPA Method 10
CO_2	US EPA Method 3A
NOx	US EPA Method 7E
SO_2	OSHA ID 200
CH_4	US EPA CTM 042

Some methods modified to meet specific CERP test objectives.

2.2.6. Data Reduction, Tabulation and Preliminary Report Preparation

Data calculations for determining emission concentrations resulting from the specific test plans outlined in Appendix A are based on process and emission parameters. 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 by 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 or weight of binder to provide emissions data in pounds of analyte per ton of metal or pounds of analyte per pound of binder.

Individual concentration and reporting limit results for each analyte for all sampling runs for all three tests are included in Appendix B of this report. Average results for the tests are given in Section 3.0, Table 3-1a and 3-1b.

2.2.7. *Report Preparation and Review*

The Preliminary Draft Report is created and reviewed by Process Team and Emissions Team members to ensure its completeness, consistency with the test plan, and adherence to QA/QC procedures. Appropriate observations, conclusions and recommendations are added to the report to produce a Draft Report. The Draft Report is then reviewed by senior management and 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" publication. 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 Process Engineer to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Manager of Process Engineering and the Vice President of 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. Senior management of Analytical 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

Average results for the relative pouring, cooling and shakeout airborne emissions for Test HP are presented in Tables 3-1a and 3-1b. Emission results are compared to the phenolic urethane cold box system for aluminum (Sigma Cure® 7227/7707, HA International), which was tested under 1413-112, Test HK. The core binder used for this test was a single part binder. The concentration was 2.0% total binder based on sand (BOS), per the vendor's recommendations. The binder was activated with carbon dioxide (CO_2). The binder for the reference Test HK was a two part binder that contained 1.1% total binder BOS in a 50/50 ratio of Part 1 to Part 2. This binder was activated with triethylamine (TEA).

Table 3-1a Test HP Comparison Summary of Selected Target Analytes, Average Results - Lb/Ton Metal

Analyte Name	Reference Test HK	Test HP	Percent Change from Reference
Emission Indicators			
TGOC as Propane	1.10E+00	2.33E-01	**-79**
Non-Methane Hydrocarbons	1.10E+00	2.33E-01	**-79**
Sum of Target Analytes	3.24E-01	1.60E-01	**-51**
Sum of Target HAPs	2.26E-01	1.26E-01	**-44**
Sum of Target POMs	4.66E-02	1.03E-03	**-98**
Selected Target HAPs and POMs			
Phenol	8.31E-02	2.09E-02	**-75**
Naphthalene	4.04E-02	1.80E-04	**-100**
Cresol, o-	3.34E-02	1.29E-02	**-61**
Aniline	2.06E-02	NT	NA
Acetaldehyde	1.39E-02	3.93E-02	**181**
Benzene	7.09E-03	3.58E-03	**-50**
Toluene	5.26E-03	1.03E-02	**96**
Xylene, mp-	4.03E-03	1.46E-02	**261**
Methylnaphthalene, 2-	3.75E-03	3.74E-04	**-90**
Hexane	3.47E-03	9.29E-04	**-73**
Cresol, mp-	2.47E-03	3.66E-03	**48**
Xylene, o-	1.74E-03	1.34E-03	**-23**
Biphenyl	1.71E-03	≤PQL	NA
Methylnaphthalene, 1-	1.70E-03	1.87E-04	**-89**
Formaldehyde	1.27E-03	3.41E-03	**168**
Propionaldehyde (Propanal)	5.43E-04	4.21E-03	**676**
Acrolein	≤PQL	3.94E-04	NA
Ethylbenzene	NT	7.23E-04	NA
Ethylene Glycol Phenyl Ether	NT	8.67E-03	NA
Additional Selected Target Analytes			
Trimethylbenzene, 1,2,4-	3.09E-02	2.45E-03	**-92**
Dodecane	2.22E-02	≤PQL	NA
Ethyltoluene, 3-	1.02E-02	9.15E-04	**-91**
Diethylbenzene, 1,3-	8.27E-03	≤PQL	NA
Ethyltoluene, 2-	7.03E-03	≤PQL	NA
Dimethylphenol, 2,6-	5.22E-03	3.18E-03	**-39**
Undecane	3.84E-03	≤PQL	NA
Octane	3.03E-03	≤PQL	NA
Propylbenzene, n-	2.83E-03	≤PQL	NA
Tetradecane	2.58E-03	≤PQL	NA
2-Butanone (MEK)	1.75E-03	8.06E-04	**-54**
Butyraldehyde/Methacrolein	≤PQL	6.88E-03	NA
Dimethylphenol, 2,4-	≤PQL	4.31E-03	NA
Heptane	≤PQL	9.56E-04	NA
Pentanal (Valeraldehyde)	≤PQL	4.34E-04	NA
Trimethylbenzene, 1,3,5-	≤PQL	9.00E-03	NA
Butyl Carbitol	NT	5.32E-03	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	6.03E-01	2.57E+00	**326**
Carbon Monoxide	≤PQL	9.27E-02	NA
Methane	≤PQL	≤PQL	NA
Nitrogen Oxides	≤PQL	≤PQL	NA
Sulfur Dioxide	≤PQL	≤PQL	NA

NA= Not Applicable

I=Invalidated Data

≤PQL= Less than or equal to the Practical Quantitation Limit

Bold numbers indicate those compounds whose calculated t-statistic is significant at alpha=0.05

Table 3-1b Test HP Comparison Summary of Selected Target Analytes, Average Results - Lb/Lb Binder

Analyte Name	Reference Test HK	Test HP	Percent Change from Reference
Emission Indicators			
TGOC as Propane	7.65E-02	1.04E-02	-86
Non-Methane Hydrocarbons	7.65E-02	1.04E-02	-86
Sum of Target Analytes	2.25E-02	7.15E-03	**-68**
Sum of Target HAPs	1.57E-02	5.62E-03	**-64**
Sum of Target POMs	3.22E-03	4.59E-05	**-99**
Selected Target HAPs and POMs			
Phenol	5.75E-03	9.30E-04	**-84**
Naphthalene	2.79E-03	8.14E-06	**-100**
Cresol, o-	2.31E-03	5.76E-04	**-75**
Aniline	1.43E-03	NT	NA
Acetaldehyde	9.65E-04	1.75E-03	**81**
Benzene	4.89E-04	1.60E-04	**-67**
Toluene	3.64E-04	4.61E-04	**27**
Xylene, mp-	2.79E-04	6.50E-04	**133**
Methylnaphthalene, 2-	2.59E-04	1.66E-05	**-94**
Hexane	2.39E-04	4.13E-05	**-83**
Cresol, mp-	1.94E-04	1.63E-04	-16
Biphenyl	1.49E-04	≤PQL	NA
Xylene, o-	1.20E-04	5.95E-05	**-50**
Methylnaphthalene, 1-	1.18E-04	8.37E-06	**-93**
Formaldehyde	8.81E-05	1.52E-04	**73**
Ethylbenzene	5.44E-05	3.23E-05	**-41**
Propionaldehyde (Propanal)	3.76E-05	1.88E-04	**399**
Acrolein	≤PQL	1.77E-05	NA
Ethylene Glycol Phenyl Ether	NT	3.86E-04	NA
Additional Selected Target Analytes			
Trimethylbenzene, 1,2,4-	2.14E-03	1.09E-04	**-95**
Dodecane	1.54E-03	≤PQL	NA
Ethyltoluene, 3-	7.07E-04	4.08E-05	**-94**
Diethylbenzene, 1,3-	5.71E-04	≤PQL	NA
Ethyltoluene, 2-	4.86E-04	≤PQL	NA
Dimethylphenol, 2,6-	3.61E-04	1.42E-04	**-61**
Undecane	2.65E-04	≤PQL	NA
Octane	2.10E-04	≤PQL	NA
Propylbenzene, n-	1.95E-04	≤PQL	NA
Tetradecane	1.78E-04	≤PQL	NA
2-Butanone (MEK)	1.21E-04	3.60E-05	**-70**
Butyraldehyde/Methacrolein	≤PQL	3.07E-04	NA
Dimethylphenol, 2,4-	≤PQL	1.91E-04	NA
Heptane	≤PQL	4.23E-05	NA
Pentanal (Valeraldehyde)	≤PQL	1.93E-05	NA
Trimethylbenzene, 1,3,5-	≤PQL	4.01E-04	NA
Butyl Carbitol	NT	2.37E-04	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	4.18E-02	1.16E-01	177
Carbon Monoxide	≤PQL	4.16E-03	NA
Methane	≤PQL	≤PQL	NA
Nitrogen Oxides	≤PQL	≤PQL	NA
Sulfur Dioxide	≤PQL	≤PQL	NA

NA= Not Applicable
I=Invalidated Data
≤PQL=Less than or equal to the Practical Quantitation Limit

Compounds which were chosen for analysis from PCS emissions that are based on chemical and operational parameters are termed “target analytes” (TA). The emissions indicator called the “Sum of Target Analytes” is the sum of the individual analytes that were targeted for collection and analysis, and detected at a level above the practical quantitation limit. For less complex samples with fewer individual analytes contributing to emissions, the target analyte sum would theoretically closely match the results for total hydrocarbons obtained by Method 25A, excluding exempt compounds such as methane, and including compounds such as formaldehyde, which are less responsive in the FID. For the results reported here, the Sum of Target Analytes averages 69% of adjusted TGOC as Propane results.

The target analyte sum includes targeted compounds that may also be defined as HAPs and POMs. By definition, HAPs are specific compounds listed in the Clean Air Act Amendments of 1990. The term POM defines not one compound, but a broad class of compounds based on chemical structure and boiling point. POMs as a class are a listed HAP. A subset of organic compounds from the current list of EPA HAPs was targeted for collection and analysis. These individual target HAPs (which may also be POMs by nature of their chemical properties) detected in the samples are summed together and defined as the “Sum of Target HAPs,” while the “Sum of Target POMs” only sums those organic HAPs that are also defined as POMs.

Also included in the tables are the “Sum of Target Analytes,” the “Sum of Target HAPs,” and the “Sum of Target POMs.” These three analyte sums are part of the group termed “Emission Indicators.” Also included in this group and reported in the first section of the tables are “TGOC as Propane” as determined by Method 25A, and non-method hydrocarbon (NMHC) as determined by CTM-042. The second section of the table includes average emission results for select individual target analytes. In addition, average values for selected criteria and greenhouse gases including CO, CO_2, CH_4, SO_2, and NO_x are given in the third section of the tables. Individual isomers are reported in the tables, and have not been summed and reported as a group. If the reader chooses, isomers which have been targeted and analyzed may be summed using the information located in these tables and in Appendix B.

Speciated results presented in the tables of this report, including those gases measured continuously on-line in real time at Technikon during both Test HP and Test HK, have been background corrected. When sample measurements are made, the observed result includes the contribution of the analyte in the sample, plus a response due to the background contribution found from the blank. The net analyte sample concentration is therefore the amount of the analyte, if any, found in the blank subtracted from the amount of analyte found in the sample. Background correcting the data allows determination of the emissions resulting only from the specific materials tested, and not those that may be present in the ambient air of the research foundry during the testing period.

The tables also include the relative percent change in emissions from the reference Test HK to Test HP. The relative percent change in this case is defined as the difference in concentrations between the current test and reference test, divided by the reference test concentration and expressed as a percentage.

Emissions data that have been determined to be below the practical quantitation limit (PQL) after data validation and verification are substituted with the numerical value used for the PQL, rather than with the value of zero. If an analyte has calculated concentrations above the PQL for some runs, but values for other runs fall below the PQL, the PQL value is included when calculating analyte averages and sums. However, if an analyte has a concentration that is below the PQL for all runs in a test, the test average is indicated by ≤ PQL (less than or equal to the PQL) in the Tables and Figures of this report, and no runs are included in any summations or averages. Omitting these less-than-reporting-limit analytes in calculations ensures that only those targeted compounds which contribute to emissions are included in emission sums.

Examination of measured process parameters indicated that Test HP was run within acceptable ranges and limits. The principal causes and secondary influences on emissions were fixed between the reference test and the comparative test for each individual run, so that for pouring, cooling, and shakeout, the emissions reflect only the difference in the materials being tested. A statistical determination is made to verify the effectiveness of controlling these influences. This is done by determining whether the means of emissions of the baseline reference test and the comparative subtests were different through calculating a T-test at a 95% significance level (α=0.05). Results at this significance level indicate that there is a 95% probability that the mean values for the comparison tests are not equivalent to those of the reference test. It may therefore be said that the differences in the average emission values are real differences, and not due to test, sampling, or analysis methodologies. This difference is indicated in Tables 3-1a and 3-1b in the column labeled "Percent Change from Reference." Values in this column presented in **bold font** indicate a greater than 95% probability that the two tests are statistically different.

3.1. DISCUSSION OF RESULTS

The individual chemical compounds from airborne emissions targeted for collection and analyses for this test were chosen based on the chemistry of the binder under investigation as well as analytes historically targeted. The analyte lists were identical for all the subtests under Test HP.

Figures 3-1a to 3-3b graphically present the data from Tables 3-1a and 3-1b for Test HP for the five emissions indicators, selected individual HAP, target analyte, and criteria pollutant and greenhouse gas emissions as both lb/ton of metal and lb/lb of binder.

Figure 3-1a Comparison of Emissions Indicators of Test HP to Reference Test HK, Average Results – Lb/Tn Metal

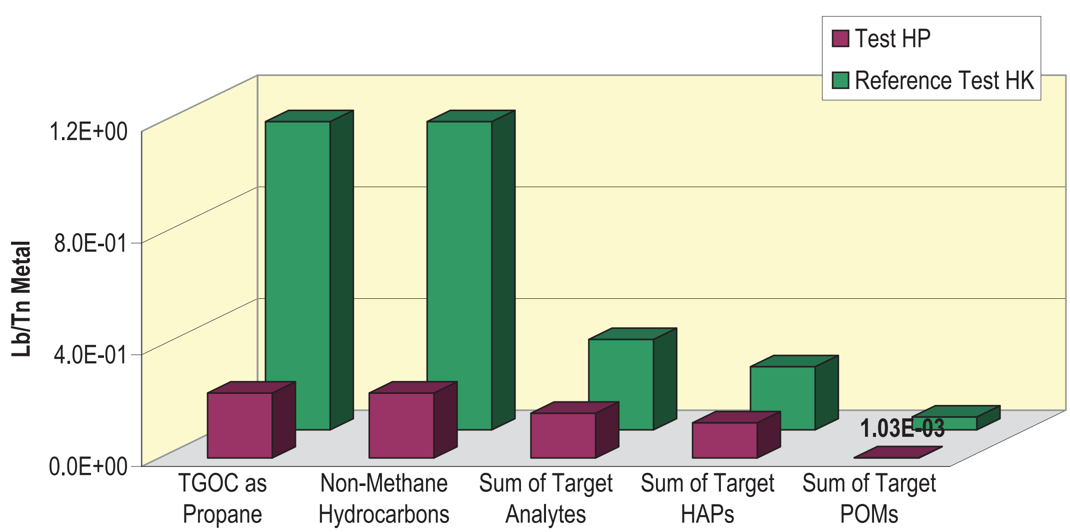


Figure 3-1b Comparison of Emissions Indicators of Test HP to Reference Test HK, Average Results – Lb/Lb Binder

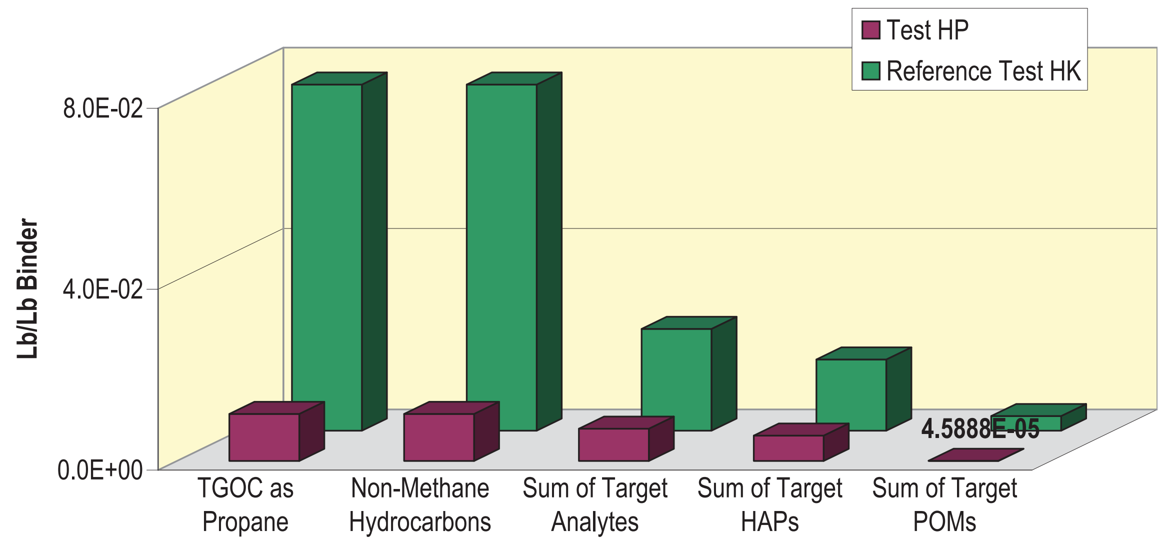


Figure 3-2a Comparison of Selected HAP and POM Emissions of Test HP to Reference Test HK, Average Results – Lb/Tn Metal

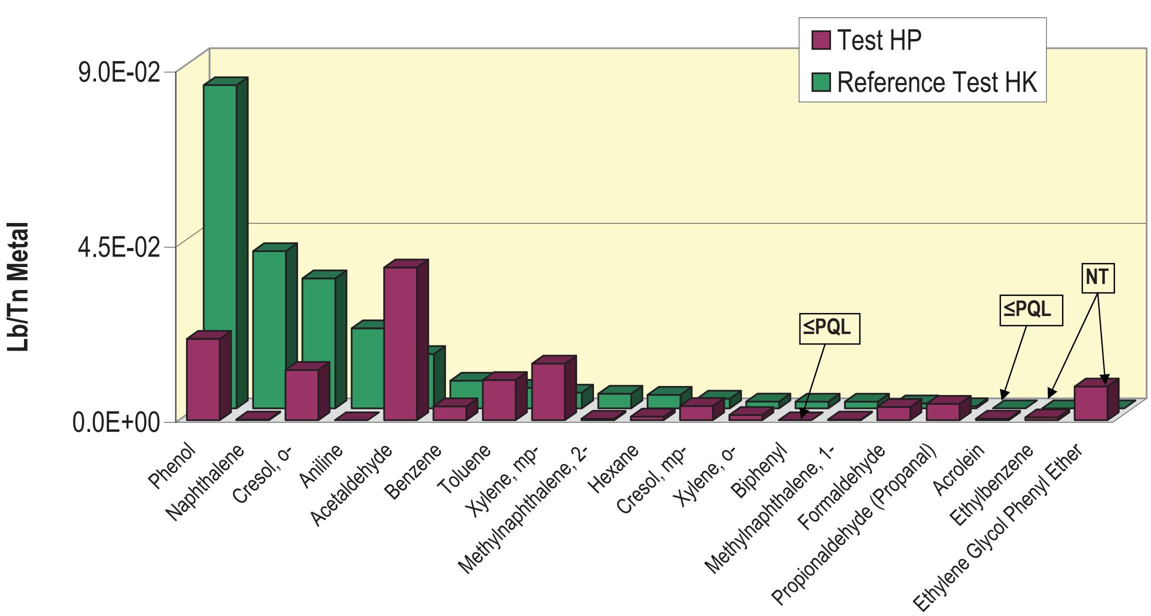


Figure 3-2b Comparison of Selected HAP and POM Emissions of Test HP to Reference Test HK, Average Results – Lb/Lb Binder

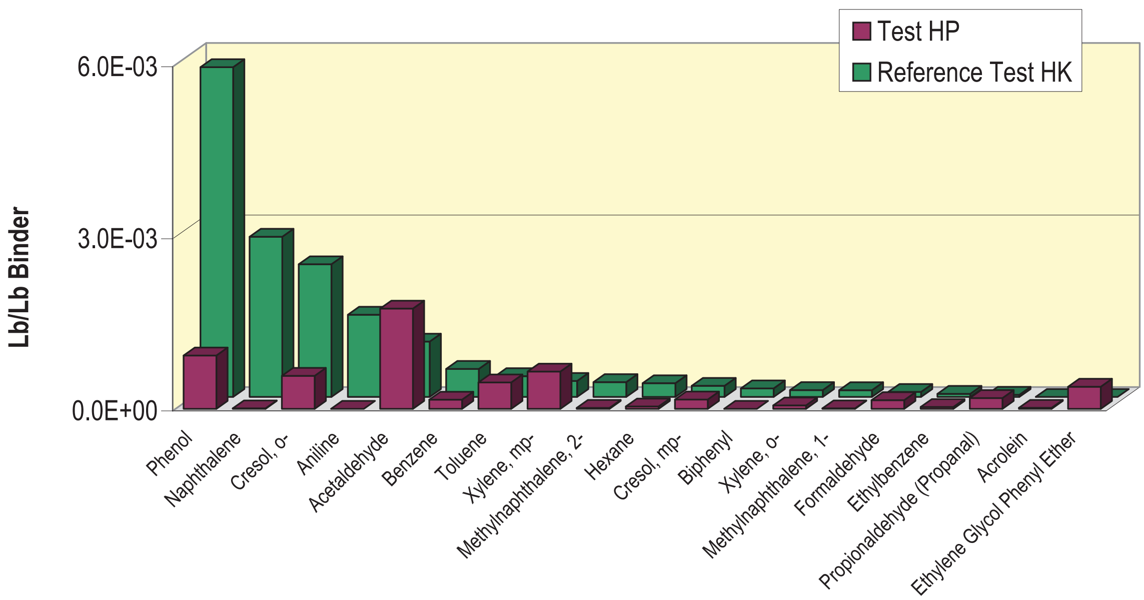


Figure 3-3a Comparison of Criteria Pollutants and Greenhouse Gases of Test HP to Reference Test HK, Average Results – Lb/Tn Metal

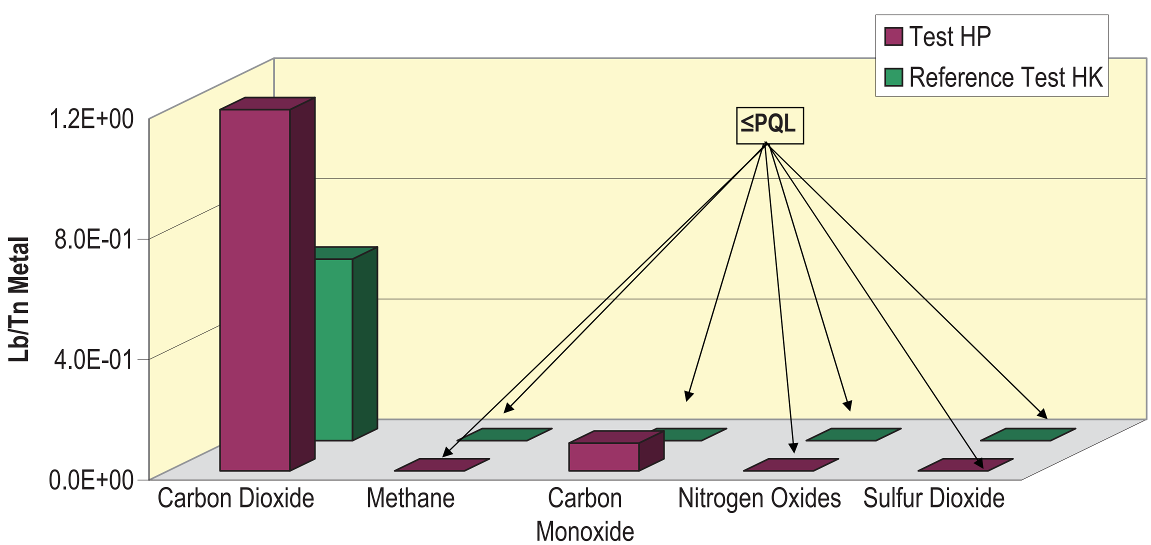
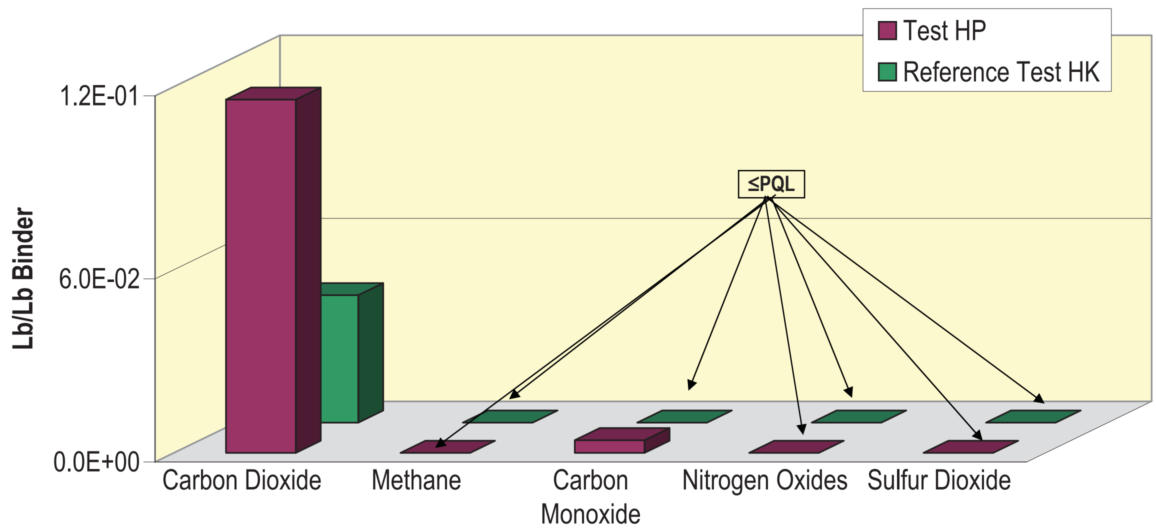


Figure 3-3b Comparison of Criteria Pollutants and Greenhouse Gases of Test HP to Reference Test HK, Average Results – Lb/Lb Binder



Emission Indicators for both lb/ton metal and lb/lb binder for Test HP show statistically significant decreases on average of approximately 70% for Test HP when compared to Test HK. The biggest single change was in the Sum of Target POMs, which showed a relative decrease of approximately 99%.

Some target analyte emissions were higher and some were lower when comparing the two binder systems from Test HP and Test HK. The largest decrease of 100% was found for naphthalene, while the largest increase, 676%, was for propionaldehyde. All criteria pollutant and greenhouse gas emissions were less than the practical quantitation limit except for carbon dioxide, which showed an increase of over 300% on a lb/ton basis.

Of the 65 Target Analytes from Test HP (including criteria pollutants and greenhouse gases), only 31 contributed to emissions above the PQL. Of the 34 HAPs targeted for analysis, 19 contributed to emissions above the PQL. Acetaldehyde, phenol and mp-xylene accounted for approximately 50% of the measured emissions at 24%, 13% and 9%, respectively. For reference Test HK phenol, naphthalene and o-cresol accounted for approximately 50% of the measured emissions at 26%, 12%, and 10% respectively.

The top non-HAP contributors for Test HP were 1,3,5-Trimethylbenzene, butyraldehyde, and butyl carbitol at 6%, 4% and 3%. For Test HK, the top three non-HAP contributors were 1,2,4- trimethylbenzene at 10%, dodecane at 7%, and 3-ethyltoluene at 3%.

A comparison was made between the surface qualities of the castings from Test HP. These castings were also compared to the best, median, and worst castings from Test HK. The comparison consisted initially of a visual examination of minor surface defects such as penetration. Castings were first ranked according to those defects. To further differentiate surface quality among castings, the finish was tested by touch for smoothness. The smoothest casting with the fewest visual surface defects received the highest ranking.

Three benchmark visual casting quality rankings consisting of the best, the median, and the worst casting are assigned to three of the castings from each test. The "best" designation means that the internal surface of a casting is the best appearing of the lot of 12, and is given an in-series rank of 1. The "median" designation, given an in-series rank of 6 means that five castings are better in appearance and six are worse. The "worst" designation is assigned to that casting which is of the poorest quality, and is assigned an in-series rank of 12. The remaining castings are then compared to these three benchmarks and ranked accordingly.

Twelve castings chosen from cavity 3 from Test HP were selected for comparison. The castings were very similar in quality and showed very little difference from one casting to another. Casting rankings of the castings from test HP compared to the castings from test HK are reported in Table 3-2.

Table 3-2 Rank Order of Casting Appearance

Rank Order of Appearance Overall Best Casting to Overall Worst Casting

	Emissions Mold number	Cavity Number	Test HK Baseline	Test HP Comparative
Rank 1	HK012	2	Best	
Rank 2	HK012	3	Median	
Rank 3	HK011	1	Worst	
Rank 4	HP001	3		Best
Rank 5	HP012	3		
Rank 6	HP004	3		
Rank 7	HP002	3		
Rank 8	HP003	3		
Rank 9	HP005	3		Median
Rank 10	HP006	3		
Rank 11	HP009	3		
Rank 12	HP007	3		
Rank 13	HP010	3		
Rank 14	HP011	3		
Rank 15	HP008	3		Worst

The best, median, and worst castings from Test HK were also compared with the castings from Test HP. The castings from Test HK were made with cores made with HA International SigmaCure® 76210/76211, a phenolic urethane binder. The castings from Test HK had much better surface quality than those from Test HP. Even the worst ranked casting from Test HK was ranked higher than the best casting from Test HP. Additionally, the Test HP binder system had lower tensile strengths than traditional cold box cores (Test HK). This may be an issue for some thin section cores.

The average process parameters are reported in Table 3-3 and Appendix C.

Table 3-3 Summary of Test Plan Average Process Parameters

Greensand PCS

Test HP	Ecolotec® 750	Sigma Cure® 7227/7707
Test Dates	**12/5/06-12/7/06**	**8/29/06-8/31/06**
Cast weight, lbs.	46.33	43.87
Pouring time, sec.	14	14
Pouring temp ,°F	1274	1278
Pour hood process air temp at start of pour, °F	86	86
Mixer auto dispensed sand weight, lbs	49.87	50.10
Core binder weight part 1, g	453.8	125.3
Core binder weight part 2, g	0.0	125.3
Core binder weight, g	453.8	250.6
% core binder (BOS)	2.01	1.10
% core binder, actual	1.97	1.09
Total core weight in mold, lbs.	26.32	29.05
Total binder weight in mold, lbs.	0.52	0.32
Core LOI, %	0.94	0.86
2 hour core dogbone tensile, psi	88.9	283.9
Core age when poured, hrs.	58.7	62.0
Muller batch weight, lbs.	899	902
GS mold sand weight, lbs.	648.85	636
Mold temperature, °F	69	84
Average green compression , psi	18.35	19.26
GS compactability, %	38	39
GS moisture content, %	1.71	1.80
GS MB clay content, %	6.9	7.1
MB clay reagent, ml	36.3	36.8
1500°F LOI - mold sand, %	0.86	0.96
900°F volatiles , %	0.43	0.42
Permeability index	235	225
Sand temperature, °F	73	86

The four appendices in this report contain detailed information regarding testing, sampling, data collection and results for each sampling event. Appendix A contains test plans, instructions and the sampling plans for Test HK and Test HP. Appendix B contains detailed emissions data and average results for all targeted analytes. Target analyte practical quantitation limits expressed in both lb/lb binder and lb/ton metal are also shown in Appendix B. Appendix C contains detailed process data and the pictorial casting record. Appendix D contains continuous monitor charts. The charts are presented to show TGOC, carbon monoxide, carbon dioxide, methane, and oxides of nitrogen time-dependent emissions profiles for each individual emissions test pour. Charts have not been background corrected. Appendix E contains acronyms and abbreviations.

Appendix A Test & Sample Plans and Process Instructions

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TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1413 **TASK NUMBER** 112 **SERIES** HK
- **SITE:** Research Foundry
- **TEST TYPE:** PCS of phenolic urethane cores in greensand, no seacoal
- **METAL TYPE:** Aluminum
- **MOLD TYPE:** 4-on step core
- **NUMBER OF MOLDS:** 3 molds, conditioning/casting quality, 6 molds with cores made of Sigma Cure® 7227/7707, 3 with cores made from Sigma Cure® EX74522/75869, and 3 molds with cores made from Sigma Cure® EX76210/EX76211
- **CORE TYPE:** Step; Wedron 530 sand; 1.1% (BOS) HA International binder P1/P2 in a 50/50 ratio, TEA activated.
- **CORE COATING:** None
- **SAMPLE EVENTS:** 12
- **TEST DATE(S):** **START:** 8/21/06
  FINISH: 9/15/06

TEST OBJECTIVES:

Measure selected PCS HAP & VOC emissions, CO, CO_2, NOx, CH_4 and TGOC from pouring cooling and shakeout of phenolic urethane cores in greensand no seacoal. Results will be calculated in lbs of emissions per ton of metal poured and lbs of emissions per pound of binder. Results will be compared to those of test DN.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB Clay, no seacoal, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 70-90°F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with aluminum at 1270±10°F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes.

BRIEF OVERVIEW:

These greensand molds will be produced on mechanically assisted Osborne molding machines. (Ref. CERP test FH). The 4-on step-core standard mold is a 24 x 24 x 10/10 inch 4-on array of standard AFS, drag only, step core castings against which other binder systems can be compared. The cores will be manufactured at Technikon.

Special Conditions:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially a 1200 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with Wedron 530 silica sand. The cores shall be bagged in plastic. Coated and dried cores will be bagged as soon as sufficiently cooled. The cores will be approximately 1-4 days old when tested.

Process Engineering Manager (Technikon)	Date
V.P. Measurement Technology (Technikon)	Date
V.P. Operations (Technikon)	Date

TECHNIKON TEST PLAN

> **CONTRACT NUMBER:** 1413 **TASK NUMBER** 113 **SERIES** HP

> **SITE:** Research Foundry

> **TEST TYPE:** Emissions testing of the pouring, cooling, and shakeout of Ecolotec® cores in Aluminum

> **METAL TYPE:** A356 Aluminum poured at 1270±10°F

> **MOLD TYPE:** 4-on, step core, Wexford 450 lake sand with western and southern bentonite in a 5:2 ratio to yield 7.0 ± 0.5% methylene blue clay, no seacoal

> **NUMBER OF MOLDS:** 12 (3 conditioning + 9 sampling)

> **CORE TYPE:** Step, water-based phenolic resin, CO_2 activated, Foseco ECOLOTEC® 750 at 2 .0 % binder (BOS), Wedron 530 sand

> **CORE COATING:** None

> **SAMPLE EVENTS:** 9

> **TEST DATE(S):** **START:** 12/4/06
> **FINISH:** 12/7/06

TEST OBJECTIVES:

Measure selected PCS HAP & VOC emissions, CO, CO_2, NOx, CH_4 and TGOC from pouring cooling and shakeout of Foseco Ecolotec cores in greensand, with no seacoal. Results will be calculated in lbs of emissions per ton of metal poured and lbs of emissions per pound of binder. Compare results to test HK.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB Clay, no seacoal, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 70-90°F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with aluminum at 1270±10°F. Mold cooling will be 20 minutes followed by 5 minutes of shakeout, or until no more material remains to be shaken out, followed by 20 minutes additional sampling for a total of 75 minutes.

BRIEF OVERVIEW:

These greensand molds will be produced on mechanically assisted Osborne molding machines. (Ref. CERP test FH). The 4-on step-core standard mold is a 24 x 24 x 10/10 inch 4-on array of standard AFS, drag only, step core castings against which other binder systems can be compared. The cores will be manufactured at Technikon.

Special Conditions:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially a 1200 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with Wedron 530 silica sand. The cores shall be bagged in plastic. Coated and dried cores will be bagged as soon as sufficiently cooled. The cores will be approximately 2-4 days old when tested.

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/29/2006											
CONDITIONING - 1											
THC, CH_4, CO, CO_2 & NOx	HK CR-1	X									TOTAL

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/29/2006											
CONDITIONING - 2											
THC, CH4, CO, CO_2 & NOx	HK CR-2	X									TOTAL

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/29/2006											
CONDITIONING - 3											
THC, CH_4, CO, CO_2 & NOx	HK CR-3	X									TOTAL

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
9/30/2006											
THC, CH_4, CO, CO_2 & NOx	HK001	X									TOTAL
TO-17	HK00101		1						100	1	Carbopak charcoal
TO-17	HK00102				1				0		Carbopak charcoal
	Excess								100	2	BLOCKED
	Excess								100	3	BLOCKED
NIOSH 2002	HK00103		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HK00104				1				0		150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00105		1						500	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HK00106				1				0		100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00107		1						500	6	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HK00108			1					500	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HK00109				1				0		150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HK00110		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HK00111				1				0		100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HK00112		1						1700	10	DNPH Silica Gel (SKC 226-119)
TO11	HK00113				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1700	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
9/30/2006											
THC, CH_4, CO, CO_2 & NOx	HK002	X									TOTAL
TO-17	HK00201		1						100	1	Carbopak charcoal
TO-17	HK00202			1					100	2	Carbopak charcoal
	Excess								100	3	BLOCKED
NIOSH 2002	HK00203		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HK00204			1					500	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00205		1						500	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00206		1						500	7	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HK00207		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HK00208			1					1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HK00209		1						1700	10	DNPH Silica Gel (SKC 226-119)
TO11	HK00210			1					1700	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
9/30/2006											
THC, CH_4, CO, CO_2 & NOx	HK003	X									TOTAL
TO-17	HK00301		1						100	1	Carbopak charcoal
TO-17 MS	HK00302		1						100	2	Carbopak charcoal
TO-17 MS	HK00303			1					100	3	Carbopak charcoal
NIOSH 2002	HK00304		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00305		1						500	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HK00306			1					500	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00307		1						500	7	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HK00308		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HK00309		1						1700	10	DNPH Silica Gel (SKC 226-119)
	Excess								1700	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/31/2006											
THC, CH_4, CO, CO_2 & NOx	HK004	X									TOTAL
TO-17	HK00401		1						100	1	Carbopak charcoal
TO-17	HK00402					1			100	1	Carbopak charcoal
	Excess								100	2	BLOCKED
	Excess								100	3	BLOCKED
NIOSH 2002	HK00403		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00404		1						500	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00405		1						500	6	150/75 mg Silica Gel (SKC 226-10)
	Excess								500	7	BLOCKED
OSHA ID200	HK00406		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HK00407		1						1700	10	DNPH Silica Gel (SKC 226-119)
	Excess								1700	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/31/2006											
THC, CH_4, CO, CO_2 & NOx	HK005	X									TOTAL
TO-17	HK00501		1						100	1	Carbopak charcoal
	Excess								100	2	BLOCKED
	Excess								100	3	BLOCKED
NIOSH 2002	HK00502		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00503		1						500	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00504		1						500	6	150/75 mg Silica Gel (SKC 226-10)
	Excess								500	7	BLOCKED
OSHA ID200	HK00505		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HK00506		1						1700	10	DNPH Silica Gel (SKC 226-119)
	Excess								1700	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 7277/7707 Binder System
8/31/2006											
THC, CH_4, CO, CO_2 & NOx	HK006	X									TOTAL
TO-17	HK00601		1						100	1	Carbopak charcoal
	Excess								100	2	BLOCKED
	Excess								100	3	BLOCKED
NIOSH 2002	HK00602		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK00603		1						500	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK00604		1						500	6	150/75 mg Silica Gel (SKC 226-10)
	Excess								500	7	BLOCKED
OSHA ID200	HK00605		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HK00606		1						1700	10	DNPH Silica Gel (SKC 226-119)
	Excess								1700	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HK - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: 74522/75869 Binder System
9/6/2006											
THC, CH_4, CO, CO_2 & NOx	HK020	X									TOTAL
TO-17	HK02001		1						100	1	Carbopak charcoal
TO-17	HK02002					1			100	1	Carbopak charcoal
TO-17 MS	HK02003		1						100	2	Carbopak charcoal
TO-17 MS	HK02004			1					100	3	Carbopak charcoal
NIOSH 2002	HK02005		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HK02006			1					500	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HK02007		1						500	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HK02008		1						500	7	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HK02009		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HK02010			1					1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HK02011		1						1700	10	DNPH Silica Gel (SKC 226-119)
TO11	HK02012			1					1700	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/5/2006											**HP CONDITIONING - RUN 1**
HP CR-1											
THC, CO, CO2, Nox and CH4	HP CR-1	X									

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/5/2006											**HP CONDITIONING - RUN 2**
HP CR-2											
THC, CO, CO2, Nox and CH4	HP CR-2	X									

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/5/2006											**HP CONDITIONING - RUN 3**
HP CR-3											
THC, CO, CO2, Nox and CH4	HP CR-3	X									
TO-17	HP CR-301		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP CR-302		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP CR-303		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP CR-304		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP CR-305		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	Excess
TO11	HP CR-306		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess		1						1500	11	Excess
	Excess								500	12	TOTAL
	Moisture		1						5000	13	Excess
	Excess										

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/5/2006											
RUN 1											
THC, CO, CO2, Nox and CH4	HP001	X									TOTAL
TO-17	HP00101		1						200	1	Carbopak charcoal
TO-17	HP00102				1				0		Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00103		1						800	4	XAD-7 OVS (100/200 mg sorbent)
NIOSH 5523	HP00104				1				0		XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00105		1						1000	6	100/50 mg Charcoal (SKC 226-01)

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/6/2006											
RUN 5											
THC, CO, CO2, Nox and CH4	HP005	X									TOTAL
TO-17	HP00501		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00502		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00503		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP00504		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP00505		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	Excess
TO11	HP00506		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess								1500	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/7/2006											
RUN 6											
THC, CO, CO2, Nox and CH4	HP006	X									TOTAL
TO-17	HP00601		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00602		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00603		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP00604		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP00605		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	Excess
TO11	HP00606		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess								1500	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/7/2006											
RUN 7											
THC, CO, CO2, Nox and CH4	HP007	X									TOTAL
TO-17	HP00701		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00702		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00703		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP00704		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP00705		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	Excess
TO11	HP00706		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess								1500	11	Excess

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/7/2006											
RUN 8											
THC, CO, CO2, Nox and CH4	HP008	X									TOTAL
TO-17	HP00801		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00802		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00803		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP00804		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP00805		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess		1						1000	9	Excess
TO11	HP00806		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess								1500	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/7/2006											
RUN 9											
THC, CO, CO2, Nox and CH4	HP009	X									TOTAL
TO-17	HP00901		1						200	1	Carbopak charcoal
	Excess								200	2	Excess
	Excess								200	3	Excess
NIOSH 5523	HP00902		1						800	4	XAD-7 OVS (100/200 mg sorbent)
	Excess								800	5	Excess
NIOSH 1500	HP00903		1						1000	6	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	HP00904		1						1000	7	100/50 mg Charcoal (SKC 226-01)
OSHA ID 200	HP00905		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	Excess
TO11	HP00906		1						1500	10	DNPH Silica HPI (SKC 226-119)
	Excess								1500	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

1413-1.1.2-HK

PCS Product Test: Greensand Uncoated Cores Made with HA International Sigma Cure® 7227/7707, EX74522/EX75869, and EX76210/EX76211 TEA Catalyzed& Mechanized Molding

Process Instructions

A Experiment:

1 Product emissions measurement from greensand molds made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5 % MB Clay, & no seacoal. 9 molds will have cores made with HA International 7227/7707 cores, 3 with 74522/75869 cores and 3 with 76210/76211 cores. The molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand.

B Materials:

1 Mold sand:

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

2 Core:

a Uncoated step core made with virgin Wedron 530 silica sand

1) 1.1% (BOS) HA International Sigma Cure® 7227/7707 (9molds)

2) 1.1% (BOS) HA International Sigma Cure® EX74522/EX75869 (3 molds)

3) 1.1% (BOS) HA International Sigma Cure® EX76210/EX76211 (3 molds)

3 Core coating:

a None

4 Metal:

a 356 Aluminum poured at 1270 +/- 10°F.

5 Pattern release:

a Black Diamond, hand wiped.

6 20 pores per inch (ppi) 2 x 2 x 0.5 ceramic foam filter.

C Briefing:

1 The Process Engineer, Emissions Engineer, and the area Supervisor will brief the operating personnel on the requirements of the test at least one (1) day prior to the test.

Caution

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

D HA International 7227/7707 coldbox cores:

1 Klein vibratory core sand mixer.

a The binder components should be 75-85°F.

b Calibrate the Klein mixer sand batch size.

1) Calibrate sand.

a) Turn the AUTO/MAN switch to MANUAL on main control panel.

b) Zero a container on the scale.

c) Put the same container below the mixing bowl to catch the sand.

d) Open a few bags of WEDRON 530 sand into the sand hopper and manually fill batch hopper using max. and min. proximity switches.

e) Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.

f) Repeat 3 times to determine the weight variation. The sand should be 75-85°F.

c Pre-weigh 50% of 1.1% (BOS) of the part 1 into a non-absorbing container for addition to the mixer.

d Pre-weigh 50% of 1.1% (BOS) of the part 2 into a non-absorbing container for addition to the mixer.

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

f Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. As soon as the sand enters the mixer chamber pour the pre-weighed binder through the open top front half of the mixing chamber.

g Make three (3) batches to start the Redford Carver core machine.

h Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.

i Clean the mixer bowl when done.

j Clean the sand chute and core box.

k Repeat for both the 74522/75869 binder and the 76210/76211

Caution:

Do not make more sand than sand magazine will hold plus one (1) batch. If too much sand is made it will shorten the sand bench life

2 Redford/Carver core machine.
   a Mount the Step-Core core box on the Carver/Redford core machine.
   b Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
   c Set up the core machine in the warm box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
      1) Core process setup
         a) Set the core box heaters to 300°F
         b) Set the blow pressure to 50+/-2 psi for 3 seconds (R/C).
         c) Set the gas time to 0 seconds.
         d) Set the purge for 210 seconds(R/C).
         e) Total cycle time approximately 4 minutes.

   d Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. Make five (5) additional 50 pound sand batches and run the sand out making core.
      1) For 7227/7707 a minimum of 45 cores are required
      2) For 74522/75869 and 76210/76211 a minimum of 15 cores are required

   e The sand lab will sample one (1) core from the core rack for each mold produced just prior to the emission test to represent the four (4) cores placed in that mold. Those cores will be tested for LOI using the standard 1800 °F core LOI test method and reported out associated with the test mold it is to represent.

3 Dog Bone Manufacture
   a Set the parameters per the AFS Procedure
   b Use the Kitchen Aid® mixer
      1) Add 5 pounds of Wedron 530 to the running mixer.
      2) Slowly pour 1.1% BOS (50% Part 1/50% part 2) of binder into the sand. Distribute the resin as it is poured. Avoid pouring the resin on the plows or walls of the mixer or in one location or resin balling will occur preventing proper mixing.
      3) Mix for three minutes after the resin is all in.

   c Fill the sand head with sand and place it under the blow head
   d Compress the sand head with the lever and hit the blow button
   e Gas the samples in the same manner until hardened
   f Immediately put the samples in a desiccator for 5 minutes and take them to the green room and tensile test them.
   g Make 30 dog bones per binder set.
   h In addition, make another 90 dog bones for 3 standard tests 2 hr, 24 hr, and 24 hr humidity.

E Sand preparation

1 Start up batch: make 1, HKER1.

a Thoroughly clean the pre-production muller elevator and molding hoppers.

b Weigh and add 1130 +/-10 pounds of new Wexford W450 lake sand, per the recipe, to the running pre-production muller to make a 1200 batch.

c Add 5 pounds of potable water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.

d Add the clays slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.

e Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.

f Temper the sand-clay mixture slowly, with potable water, to allow for distribution.

g After about 16 pounds of water have been added allow 30 seconds of mixing then start taking compactability test samples.

h Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability, as would be measured at the mold, is in the range 40-45%.

i Discharge the sand into the mold station elevator.

j Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge into the mold. The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, Permeability 1500°F loss on ignition (LOI), and 900°F volatiles. Each volatile test requires a separate 50 gram sample from the collected sand. Each LOI test requires 3 separate 30 gram samples from the collected sand.

k Empty the extra greensand from the mold hopper into a clean empty dump hopper whose tare weight is known. Set this sand aside to be used to maintain the recycled batch at 900+/-10 pounds

2 Re-mulling: HKER2

a Add to the sand recovered from poured mold HKER1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.

b Return the sand to the muller and dry blend for about one minute.

c Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.

d Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.

e Follow the above procedure beginning at E.1.f.

3 Re-mulling: HKER3, HK001-HK015

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

b Return the sand to the muller and dry blend for about one minute.

c Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.

d Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.

e Follow the above procedure beginning at E.1.f.

F Molding:

1 Step core pattern preparation:

a Inspect and tighten all loose pattern and gating pieces.

b Repair any damaged pattern or gating parts.

2 Making the green sand mold.

a Mount the drag pattern on one Osborne Whisper Ram molding machine and mount the cope pattern on the other Osborne machine.

b Lightly rub parting oil from a damp oil rag on the pattern particularly in the corners and recesses.

Caution:
Do not pour gross amounts of parting oil on the pattern to be blown off with air. This practice will leave sufficient oil at the parting line to be adsorbed by the sand weakening it and the burning oil will be detected by the emission samplers.

c Use the overhead crane to place the pre-weighed drag/cope flask on the mold machine table, parting line surface down.

d Locate a 24 x 24 x 4 inch deep wood upset on top of the flask.

e Make the green sand mold cope or drag on the Osborn Whisper Ram Jolt-Squeeze mold machine.

WARNING
Only properly trained personnel may operate this machine.
Proper personal protective equipment must be worn at all times while operating this equipment, including safety glasses with side shields and a properly fitting hard hat. Industrial type boots are highly recommended.

WARNING
Stand clear of the mold machine table and swinging head during the following operation or serious injury or death could result.

f Open the air supply to the mold machine.

WARNING
The squeeze head may suddenly swing to the outboard side or forward.
Do not stand in the outer corners of the molding enclosure.

g On the operator's panel turn the POWER switch to ON.
h Turn the RAM-JOLT-SQUEEZE switch to ON.
i Turn the DRAW UP switch to AUTO.
j Set the PRE-JOLT timer to 4-5 seconds.
k Set the squeeze timer to 8 seconds.
l Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
m Manually spread one to two inches or so of sand over the pattern using a shovel. Source the sand from the overhead mold sand hopper by actuating the hopper gate valve with the lever located under the operators panel.
n Fill the center potion of the flask.
o Manually move sand from the center portion to the outboard areas and hand tuck the sand.
p Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
q Grab a sufficient sample of sand to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
r Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.
s The operator will grab a sand sample for the Lab. The sand technician will quickly measure the sand temperature and compactability and record the results.
t Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.
u Remove the upset and set it aside.

WARNING
Failure to stand clear of the molding table and flasks in the following operations could result in serious injury as this equipment is about to move up and down with great force.

WARNING
Stand clear of the entire mold machine during the following operations.
Several of the machine parts will be moving.
Failure to stand clear could result in severe injury even death.

v Using both hands initiate the automatic machine sequence by simultaneously pressing, holding for 2-3 seconds, and releasing the green push buttons on either side of the operators panel. The machine will squeeze and jolt the sand in the flask and then move the squeeze head to the side.

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

w Screed the bottom of the drag mold flat to the bottom of the flask if required.
x Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
y Use the overhead crane to lift the mold half and remove it from the machine. If the mold half is a drag, roll it parting line side up, set it on the floor, blow it out.
z Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.
aa Set four (4) step cores that have been weighed and logged into the drag. Verify that the cores are fully set and flush with the parting line and insert foam filter into its receiver.
bb Close the cope over the drag being careful not to crush anything.
cc Clamp the flask halves together.
dd Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the uncoated cores, and the sand weight by difference.
ee Measure and record the sand temperature.
ff Deliver the mold to the previously cleaned shakeout to be poured.
gg Cover the mold with the emission hood.

G Emission hood:
1 Loading.
2 Hoist the mold onto the shakeout deck within the emission hood.
3 Close, seal, and lock the emission hood.
4 Adjust the ambient air heater control so that the measured temperature of the blended air within the hood is 85-90°F at the start of the test run.

H Shakeout.
1 After the 45 minute cooling time prescribed in the emission sample plan has elapsed turn on the shakeout unit and run for it the 15 minutes prescribed in the emission sample plan or until the sand has all fallen through the grating.
2 Turn off the shakeout.
3 Sample the emissions for 30 minutes after the start of shakeout, a total of 75 minutes.
a When the emission sampling is completed remove the flask, with casting, and

recover the sand from the hopper and surrounding floor.

4 Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.
5 Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

I Melting:

1 Initial charge:
   a Use the 75 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°F.
   f Slag the furnace and cover it.
   g Hold the furnace at 1250-1300°F until near ready to tap.
   h When ready to tap adjust the temperature to 1400-1425°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 40 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 F.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.

J Pouring:

1 Heat the metal to 1400 +/- 20°F.
2 Tap 180 pounds, more or less, of Aluminum into the ladle.
3 Cover the ladle to conserve heat.
4 Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 1270 +/- 10 °F.
5 Commence pouring keeping the sprue full.
6 Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.

K Rank order evaluation.

1. The supervisor shall select a group of up to five persons to make a collective subjective judgment of the casting relative surface appearance.
2. The rank order evaluation for cored castings shall be done on castings from the Engineering/ conditioning runs HKER1-3.
3. Review the general appearance of the interior of the castings and select specific casting features to compare.
4. For each cavity 1-4 :
   - a Place each casting initially in sequential mold number and cavity number order.
   - b Beginning with the casting from mold HKER1 cavity 1, compare it to castings from mold HKER1 cavity 2.
   - c Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   - d Repeat this procedure with HKER1 cavity 1 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HKER1 cavity 1 and the next casting farther down the line is inferior.
   - e Repeat this comparison to next neighbors for each casting number.
   - f When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
   - g Repeat this comparison until all concur with the ranking order.
5. Record mold number by rank-order series for this cavity.
6. Compare the castings to the best, median, and worst rated castings for test DN.
7. Repeat for both the binder sets 74522/75869 and 76210/76211

Thomas J Fennell Jr.
Process Engineer

1413-113-HP

PCS: Uncoated Foseco ECOLOTEC® 750 Core in Greensand with Clay and No Coal, Mechanized Molding, Aluminum

Process Instructions

A Experiment:

1 Comparative test of uncoated organic cores in conventional greensand without seacoal. Measure emissions from greensand molds made with all virgin Wexford W450 lakesand, bonded with western & southern bentonite in a 5:2 ratio to yield 7.00 ± 0.5 % MB Clay. The molds shall be tempered with potable water to 45-50% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned materials after each casting cycle and compensating for core sand dilution.

B Materials:

1 Mold sand:

a Virgin mix of Wexford W450 Lakesand sand, Western & Southern Bentonite in a 5:2 ration for a total of 7 % and potable water per recipe. No seacoal will be used.

2 Core:

a Step core made from Wedron 530 sand and 2 % (BOS) Foseco ECOLOTEC® 750 single part binder, CO_2 gas cured.

3 Core Coating:

a None.

4 Metal:

a A356 Aluminum poured at 1270 +/- 10°F.

5 Pattern Spray:

a Black Diamond, hand wiped.

Caution

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

6 The following test shall be conducted:
  a Sand batch:
    1) Single sand batch to be used for all HP molds.

  b The recycled sand heap shall be maintained at 900+-10 pounds
  c The first three (3) runs will be conditioning runs numbered HPCR1-3 and will be monitored by TGOC, CO, CO2, & NOx.
  d Emission sampling will begin on the 4th turn. Nine (9) satisfactory sampling runs numbered HP001-009 will be conducted monitored by TGOC, CO, CO2, NOx, and sorption tubes. Should a run HP00X need to be repeated the run will be numbered HP00Xa, b, or c etc. The shop supervisor will monitor to assure the numbering consistency of the process data.
  e The shop supervisor and the sampling team technician will coordinate the numbering between the two groups.
  f HPCR1:
    1) Virgin mix as described above, vented mold.

  g HPCR2, HPCR3, and HP001-HP009:
    1) Re-cycled, re-mulled, reconstituted greensand, potable water, vented molds.

C Sand preparation
1 Start up batch:
  a make 1, HPCR1.
  b Thoroughly clean the pre-production muller elevator and molding hoppers.
  c Weigh and add 1225 +/-10 pounds of new Wexford W450 sand, per the recipe, to the foundry muller to make a 1300 batch.
  d Add 5 pounds of potable water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
  e Add the clays and organics slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.
  f Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
  g Temper the sand-clay mixture slowly, with potable water, to allow for distribution.
  h After about 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
  i Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 45-50%. Discharge the sand into the mold station elevator.
  j Grab sufficient sample from the mold hopper discharge to fill a quart zip-lock

bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis

- k Record the total sand mixed in the batch, the total of each type of clay and other material added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at charge and discharge.
- l The sand lab will be immediately characterized for Methylene Blue Clay, Moisture content, Compactability, Green Compression strength, and Green permeability. 1500ºF loss on ignition (LOI), and 900°F volatiles will be run at a convenient time. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.
- m Empty the extra greensand from the mold hopper into a clean empty dump hopper whose tare weight is known. Set this sand aside to be used to maintain the recycled batch at 900+/-10 pounds

2 Re-mulling:

- a HPCR2
- b Add to the sand recovered from poured mold HPCR1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.
- c Return the sand to the muller and dry blend for about one minute.
- d Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
- e Follow the above procedure beginning at B.1.f.

3 Re-mulling:

- a HPCR3, HP001-HP009
- b Add to the sand recovered from the previous poured mold, mold machine spill sand, the residual mold hopper sand and sufficient pre-blended sand to total 900 +/- 10 pounds.
- c Return the sand to the muller and dry blend for about one minute.
- d Add the clays and other materials, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.
- e Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
- f Follow the above procedure beginning at B.1.f.

D ECOLOTEC® Step Cores:

1 Klein vibratory core sand mixer.
2 a. The binder components should be 75-85ºF.
3 b. Calibrate the Klein mixer sand batch size.

1) Remove the mixing bowl skirt to gain access to the binder injection tubes and the bottom side of the batch hopper outlet gate.

2) Calibrate sand.
   a) Turn the AUTO/MAN switch to MANUAL on main control panel.
   b) Place one bucket of preheated raw sand, of at least fifty-two (52) pounds net weight, into the sand hopper and manually fill batch hopper using max. and min. proximity switches.
   c) Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.
   d) Repeat 3 times to determine the weight variation. The sand should be 75-85ºF.

3) Turn off the mixer and replace the mixing bowl skirt.

a Pre-weigh 2.0% (BOS) of the single part binder into a non-absorbing container for addition to the mixer.
b Turn on the mixer and turn the AUTO/MAN switch to AUTO.
c Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. As soon as the sand enters the mixer chamber pour the pre-weighed binder through a top opening.
d Make three (3) batches to start the Redford Carver core machine.
e Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.
f Clean the mixer bowl when done.

Caution:
Do not make more sand than sand magazine will hold plus one (1) batch. If too much sand is made the sand will be exposed to captured CO_2 and significantly shorten the sand bench life

4 Making cores:
a Redford/Carver core machine.
b Mount the Step-Core core box on the Carver/Redford core machine.
c Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
d Set up the core machine in the cold box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
e Core process setup
   1) Remove the TEA gas line form the gassing head and install the client supplied CO_2 vaporizer equipment to the gas head.
   2) Set the gas timer to 30 seconds.
   3) Set the after gas delay to zero (0) seconds.
   4) Set the purge timer to zero (0) seconds.

5) Total cycle time approximately 1-2 minutes.

f Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. A minimum of 60 cores are required.

g The sand lab will sample one (1) core from the core rack for each mold produced just prior to the emission test to represent the four (4) cores placed in that mold. Those cores will be tested for LOI using the standard 1500ºF core LOI test method and reported out associated with the test mold it is to represent.

h Seal the cores in a Zip-lock bag.

E Molding:

1 4-on step core pattern.

2 Pattern preparation:

a Inspect and tighten all loose pattern and gating pieces.

b Repair any damaged pattern or gating parts.

c Hand wipe liquid parting on the pattern once each run.

3 Mount the drag 4-on step drag pattern into the north mold machine bolster and bolt it down tightly.

4 Mount the cope pattern with sprue on the south mold machine.

5 Use the overhead crane to place the pre-weighed drag/cope flask on the mold machine table, parting line surface down.

6 On the drag pattern hang a "double chicken foot gagger" from the flask bottom support bar and center between the gating and casting cavities.

7 Locate a 24 x 24 x4 inch deep wood upset on top of the flask.

8 Make the green sand mold on the Osborn Whisper Ram Jolt-Squeeze mold machine

WARNING
Only properly trained personnel may operate this machine.
Proper personal protective equipment must be worn at all times while operating this equipment, including safety glasses with side shields and a properly fitting hard hat. Industrial type boots are highly recommended.

WARNING
Stand clear of the mold machine table and swinging head during the following operation or serious injury or death could result.

a Open the air supply to the mold machine.

WARNING
The squeeze head may suddenly swing to the outboard side or forward.
Do not stand in the outer corners of the molding enclosure.

b On the operator's panel turn the POWER switch to ON.
c Turn the RAM-JOLT-SQUEEZE switch to ON.
d Turn the DRAW UP switch to AUTO
e Set the PRE-JOLT timer to 4-5 seconds.
f Set the squeeze timer to 8 seconds.
g Hang a "double chicken foot gagger" on the flask bottom support.
h Fill the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
i Manually level sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.

WARNING
Failure to stand clear of the molding table and flasks in the following operations could result in serious injury as this equipment is about to move up and down with great force.

j Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.

WARNING
Stand clear of the entire mold machine during the following operations.
Several of the machine parts will be moving.
Failure to stand clear could result in severe injury even death.

k Using both hands initiate the automatic machine sequence by simultaneously pressing and releasing the green push buttons on either side of the operators panel. The machine will squeeze and jolt the sand in the flask and then move the squeeze head to the side.

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

l Remove the upset and set it aside.
m Screed the bottom of the mold flat if required.
n Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.

- o Use the overhead crane to lift the mold half and remove it from the machine.
- p Finally, press and release the draw down pushbutton to cause the draw frame to return to the start position.

9 If the mold half is a drag, roll it parting line side up, set it on the floor, blow it out, and cover it to keep it clean.
10 Set the pre-weighed core in the drag mold half. Record the core ID number on the molding log.
11 Set the gating filter in place.
12 Close the cope over the drag being careful not to crush anything.
13 Clamp the flask halves together.
14 Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, and the sand weight by difference
15 Deliver the mold to the previously cleaned shakeout to be poured.
16 Cover the mold with the emission hood.

F Shakeout.

1 After the cooling time prescribed in the test plan turn on the shakeout unit and run it until the greensand has passed into the hopper below. Turn off the shakeout.
2 When the emission sampling is competed remove the flask with casting, and recover the sand from the hopper and surrounding floor.
3 Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper.
4 Add the un-used pre-mixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

G Melting:

1 Initial charge:

- a Use the 75 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°F.
- f Slag the furnace and cover it.
- g Hold the furnace at 1250-1300°F until near ready to tap.
- h When ready to tap adjust the temperature to 1400-1425°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 40 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 F.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.

H Pouring:
1 Preheat the ladle.
2 Heat the metal to 1400 +/- 20°F.
3 Tap 180 pounds, more or less, of Aluminum into the ladle.
4 Cover the ladle to conserve heat.
5 Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 1270 +/- 10 °F.
6 Commence pouring keeping the sprue full.
7 Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.

I Casting cleaning
1 Sand Blasting
   a Castings should be cleaned by sandblasting to remove any core material.

J Rank order evaluation.
1 The supervisor shall select a group of five persons to make a collective subjective judgment of the casting relative surface appearance.
2 Review the general appearance of the castings and select specific casting features to compare.
3 For each cavity:
   a Place each casting initially in sequential mold number order.
   b Beginning with castings from mold HP001, compare it to castings from mold HP002.
   c Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   d Repeat this procedure with HP001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HP001 and the next casting farther down the line is inferior.
   e Repeat this comparison to next neighbors for each casting number.
   f When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the

castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.

g Repeat this comparison until all concur with the ranking order.

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

Tom Fennell
Process Engineer

APPENDIX B DETAILED EMISSION RESULTS AND QUANTITATION LIMITS

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Test HK - Detailed Emission Results - Lb/Tn Metal - Runs 1 through 6 (Sigma Cure® 7227/7707)

TA	POM	HAP		HK001	HK002	HK003	HK004	HK005	HK006	Average	Standard Deviation
			Test Dates	**30-Aug-06**	**30-Aug-06**	**30-Aug-06**	**31-Aug-06**	**31-Aug-06**	**31-Aug-06**	—	—
Emission Indicators											
			TGOC as Propane	1.32E+00	1.35E+00	1.38E+00	1.32E+00	1.29E+00	1.23E+00	1.32E+00	4.93E-02
			HC as n-Hexane	6.81E-01	7.93E-01	8.44E-01	7.30E-01	6.99E-01	6.32E-01	7.30E-01	7.74E-02
			Sum of Target Analytes	2.74E-01	2.99E-01	3.38E-01	3.77E-01	3.50E-01	2.86E-01	3.24E-01	4.06E-02
			Sum of Target HAPs	1.62E-01	2.07E-01	2.26E-01	2.70E-01	2.61E-01	2.12E-01	2.26E-01	3.93E-02
			Sum of Target POMs	5.35E-02	4.64E-02	5.34E-02	4.95E-02	4.18E-02	3.50E-02	4.66E-02	7.20E-03
Selected Target HAPs and POMs											
TA		H	Phenol	4.49E-02	6.66E-02	7.69E-02	1.16E-01	1.09E-01	8.56E-02	8.31E-02	2.64E-02
TA	P	H	Naphthalene	4.59E-02	3.99E-02	4.66E-02	4.29E-02	3.66E-02	3.05E-02	4.04E-02	6.10E-03
TA		H	Cresol, o-	2.27E-02	2.88E-02	3.49E-02	3.92E-02	4.07E-02	3.41E-02	3.34E-02	6.69E-03
TA		H	Aniline	I	2.07E-02	2.27E-02	1.91E-02	2.02E-02	2.02E-02	2.06E-02	1.30E-03
TA		H	Acetaldehyde	1.35E-02	1.30E-02	1.34E-02	1.55E-02	1.37E-02	1.45E-02	1.39E-02	9.33E-04
TA		H	Benzene	1.02E-02	8.48E-03	5.69E-03	6.90E-03	6.65E-03	4.63E-03	7.09E-03	1.99E-03
TA		H	Toluene	5.53E-03	5.32E-03	5.13E-03	6.15E-03	5.66E-03	3.80E-03	5.26E-03	7.97E-04
TA		H	Xylene, mp-	3.60E-03	4.06E-03	3.93E-03	4.60E-03	4.58E-03	3.43E-03	4.03E-03	4.86E-04
TA	P	H	Methylnaphthalene, 2-	4.82E-03	3.92E-03	3.81E-03	3.90E-03	3.22E-03	2.84E-03	3.75E-03	6.78E-04
TA		H	Hexane	1.01E-03	6.62E-03	8.19E-04	3.67E-03	7.13E-03	1.58E-03	3.47E-03	2.83E-03
TA		H	Cresol, mp-	≤PQL	2.27E-03	2.85E-03	≤PQL	3.88E-03	3.29E-03	2.47E-03	1.07E-03
TA		H	Xylene, o-	1.59E-03	1.68E-03	1.58E-03	2.09E-03	1.98E-03	1.50E-03	1.74E-03	2.41E-04
TA		H	Biphenyl	≤PQL	≤PQL	1.85E-03	2.56E-03	2.07E-03	≤PQL	1.71E-03	5.43E-04
TA	P	H	Methylnaphthalene, 1-	1.84E-03	1.66E-03	1.87E-03	1.98E-03	1.52E-03	1.35E-03	1.70E-03	2.39E-04
TA		H	Formaldehyde	1.28E-03	9.31E-04	1.29E-03	1.47E-03	1.21E-03	1.45E-03	1.27E-03	1.97E-04
TA		H	Ethylbenzene	6.36E-04	6.10E-04	6.41E-04	1.09E-03	1.04E-03	7.09E-04	7.88E-04	2.18E-04
TA	P	H	Dimethylnaphthalene, 1,3-	9.23E-04	9.38E-04	1.08E-03	7.43E-04	3.96E-04	≤PQL	7.21E-04	3.29E-04
TA		H	Propionaldehyde (Propanal)	4.61E-04	4.98E-04	5.26E-04	6.08E-04	5.40E-04	6.25E-04	5.43E-04	6.32E-05
TA		H	Styrene	5.61E-04	≤PQL	≤PQL	4.87E-04	8.17E-04	≤PQL	4.37E-04	2.30E-04
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Tn Metal - Runs 1 through 6 (Sigma Cure® 7227/7707)

TA	POM	HAP		HK001	HK002	HK003	HK004	HK005	HK006	Average	Standard Deviation
			Test Dates	**30-Aug-06**	**30-Aug-06**	**30-Aug-06**	**31-Aug-06**	**31-Aug-06**	**31-Aug-06**	—	—
Additional Selected Target Analytes											
TA			Trimethylbenzene, 1,2,4-	3.82E-02	3.38E-02	3.61E-02	3.08E-02	2.58E-02	2.06E-02	3.09E-02	6.64E-03
TA			Dodecane	2.70E-02	1.54E-02	2.88E-02	2.46E-02	1.96E-02	1.79E-02	2.22E-02	5.37E-03
TA			Ethyltoluene, 3-	1.17E-02	1.05E-02	1.12E-02	1.12E-02	9.44E-03	7.35E-03	1.02E-02	1.62E-03
TA			Diethylbenzene, 1,3-	9.13E-03	7.99E-03	8.93E-03	9.44E-03	7.95E-03	6.16E-03	8.27E-03	1.20E-03
TA			Ethyltoluene, 2-	8.34E-03	7.33E-03	7.97E-03	7.27E-03	6.25E-03	4.99E-03	7.03E-03	1.23E-03
TA			Dimethylphenol, 2,6-	4.18E-03	3.87E-03	4.68E-03	7.56E-03	6.03E-03	4.99E-03	5.22E-03	1.37E-03
TA			Undecane	4.07E-03	3.73E-03	4.31E-03	4.31E-03	3.63E-03	3.00E-03	3.84E-03	5.00E-04
TA			Octane	2.60E-03	2.36E-03	2.85E-03	3.65E-03	3.77E-03	2.95E-03	3.03E-03	5.67E-04
TA			Propylbenzene, n-	2.97E-03	2.91E-03	3.17E-03	3.20E-03	2.66E-03	2.06E-03	2.83E-03	4.24E-04
TA			Tetradecane	2.20E-03	2.03E-03	2.69E-03	3.51E-03	2.75E-03	2.31E-03	2.58E-03	5.35E-04
TA			2-Butanone (MEK)	1.57E-03	1.68E-03	1.78E-03	1.80E-03	1.73E-03	1.93E-03	1.75E-03	1.21E-04
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	I	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases											
			Carbon Monoxide	2.33E+00	2.51E+00	2.42E+00	2.51E+00	2.53E+00	2.43E+00	2.46E+00	7.63E-02
			Carbon Dioxide	≤PQL	1.35E+00	1.38E+00	1.32E+00	1.29E+00	1.23E+00	1.14E+00	4.38E-01
			Methane	1.54E-01	1.50E-01	1.38E-01	2.62E-01	2.03E-01	1.78E-01	1.81E-01	4.60E-02
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Sulfur Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Tn Metal - Runs 7 through 9 (Sigma Cure® EX74522/EX75869)

TA	POM	HAP		HK020	HK021	HK022	Average	Standard Deviation
			Test Dates	**6-Sep-06**	**6-Sep-06**	**6-Sep-06**	**—**	**—**
Emission Indicators								
			TGOC as Propane	1.24E+00	1.21E+00	1.35E+00	1.27E+00	7.47E-02
			HC as n-Hexane	5.08E-01	5.27E-01	5.40E-01	5.25E-01	1.62E-02
			Sum of Target Analytes	4.77E-01	4.66E-01	5.68E-01	5.04E-01	5.63E-02
			Sum of Target HAPs	3.73E-01	3.67E-01	4.63E-01	4.01E-01	5.38E-02
			Sum of Target POMs	1.70E-01	1.75E-01	2.27E-01	1.90E-01	3.15E-02
Selected Target HAPs and POMs								
TA	P	H	Methylnaphthalene, 2-	7.80E-02	8.14E-02	1.06E-01	8.84E-02	1.51E-02
TA		H	Phenol	7.57E-02	8.13E-02	1.06E-01	8.77E-02	1.62E-02
TA	P	H	Methylnaphthalene, 1-	3.76E-02	3.91E-02	5.07E-02	4.25E-02	7.13E-03
TA		H	Biphenyl	3.12E-02	3.05E-02	3.66E-02	3.28E-02	3.35E-03
TA		H	Cresol, o-	2.31E-02	2.35E-02	2.73E-02	2.46E-02	2.32E-03
TA		H	Acetaldehyde	1.98E-02	1.89E-02	2.08E-02	1.98E-02	9.37E-04
TA	P	H	Dimethylnaphthalene, 1,3-	1.37E-02	1.44E-02	1.95E-02	1.59E-02	3.19E-03
TA	P	H	Dimethylnaphthalene, 2,6-	1.14E-02	1.19E-02	1.57E-02	1.30E-02	2.35E-03
TA	P	H	Naphthalene	1.10E-02	9.67E-03	1.14E-02	1.07E-02	8.99E-04
TA		H	Toluene	9.55E-03	8.75E-03	9.43E-03	9.24E-03	4.33E-04
TA		H	Hexane	1.87E-02	2.86E-03	5.96E-03	9.16E-03	8.37E-03
TA		H	Xylene, mp-	7.57E-03	8.32E-03	9.22E-03	8.37E-03	8.28E-04
TA	P	H	Dimethylnaphthalene, 1,6-	6.49E-03	7.02E-03	8.90E-03	7.47E-03	1.27E-03
TA		H	Benzene	6.78E-03	6.81E-03	7.13E-03	6.91E-03	1.95E-04
TA	P	H	Dimethylnaphthalene, 2,3-	5.72E-03	5.73E-03	7.48E-03	6.31E-03	1.01E-03
TA		H	Xylene, o-	4.22E-03	4.39E-03	4.80E-03	4.47E-03	3.00E-04
TA	P	H	Dimethylnaphthalene, 1,2-	3.29E-03	3.26E-03	4.50E-03	3.68E-03	7.04E-04
TA		H	Cresol, mp-	2.73E-03	3.31E-03	3.36E-03	3.13E-03	3.52E-04
TA	P	H	Dimethylnaphthalene, 1,5-	2.27E-03	2.26E-03	2.81E-03	2.45E-03	3.11E-04
TA		H	Ethylbenzene	1.82E-03	1.92E-03	2.26E-03	2.00E-03	2.31E-04
TA		H	Formaldehyde	1.21E-03	1.36E-03	1.91E-03	1.50E-03	3.72E-04
TA		H	Propionaldehyde (Propanal)	6.32E-04	6.08E-04	8.48E-04	6.96E-04	1.32E-04
TA		H	Styrene	4.04E-04	≤PQL	8.82E-04	5.02E-04	3.42E-04
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Aniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Tn Metal - Runs 7 through 9 (Sigma Cure® EX74522/EX75869)

TA	POM	HAP		HK020	HK021	HK022	Average	Standard Deviation
			Test Dates	**6-Sep-06**	**6-Sep-06**	**6-Sep-06**	—	—
Additional Selected Target Analytes								
TA			Trimethylbenzene, 1,2,4-	4.02E-02	3.79E-02	3.87E-02	3.89E-02	1.17E-03
TA			Ethyltoluene, 3-	1.88E-02	1.77E-02	1.70E-02	1.78E-02	9.08E-04
TA			Ethyltoluene, 2-	1.02E-02	9.47E-03	9.60E-03	9.76E-03	3.86E-04
TA			Dodecane	5.49E-03	5.13E-03	8.56E-03	6.39E-03	1.88E-03
TA			Propylbenzene, n-	5.67E-03	5.37E-03	5.96E-03	5.67E-03	2.93E-04
TA			Tetradecane	4.94E-03	4.73E-03	5.43E-03	5.03E-03	3.59E-04
TA			Dimethylphenol, 2,4-	4.31E-03	4.15E-03	3.79E-03	4.09E-03	2.65E-04
TA			Diethylbenzene, 1,3-	3.94E-03	3.68E-03	4.12E-03	3.91E-03	2.18E-04
TA			Octane	2.31E-03	2.36E-03	3.00E-03	2.56E-03	3.82E-04
TA			Undecane	1.64E-03	1.70E-03	3.51E-03	2.28E-03	1.06E-03
TA			Dimethylphenol, 2,6-	3.06E-03	2.68E-03	≤PQL	2.28E-03	1.04E-03
TA			Decane	2.00E-03	1.95E-03	1.99E-03	1.98E-03	2.47E-05
TA			2-Butanone (MEK)	1.11E-03	1.15E-03	1.63E-03	1.30E-03	2.86E-04
TA			Hexaldehyde	≤PQL	≤PQL	5.94E-04	3.58E-04	2.04E-04
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases								
			Carbon Monoxide	2.68E+00	2.45E+00	2.53E+00	2.56E+00	1.18E-01
			Methane	2.29E-01	2.00E-01	2.05E-01	2.11E-01	1.55E-02
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Carbon Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Sulfur Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Tn Metal - Runs 10 through 12 (Sigma Cure® EX76210/76211)

TA	POM	HAP		HK030	HK031	HK032	Average	Standard Deviation
			Test Dates	**7-Sep-06**	**7-Sep-06**	**7-Sep-06**	—	—
Emission Indicators								
			TGOC as Propane	1.28E+00	1.40E+00	1.28E+00	1.32E+00	6.92E-02
			HC as n-Hexane	5.52E-01	6.52E-01	5.42E-01	5.82E-01	6.09E-02
			Sum of Target Analytes	4.51E-01	5.27E-01	5.35E-01	5.05E-01	4.65E-02
			Sum of Target HAPs	3.30E-01	3.97E-01	4.15E-01	3.81E-01	4.50E-02
			Sum of Target POMs	1.52E-01	1.69E-01	1.93E-01	1.71E-01	2.05E-02
Selected Target HAPs and POMs								
TA		H	Phenol	7.47E-02	1.07E-01	1.02E-01	9.45E-02	1.73E-02
TA	P	H	Methylnaphthalene, 2-	6.76E-02	7.54E-02	8.43E-02	7.57E-02	8.34E-03
TA	P	H	Methylnaphthalene, 1-	3.13E-02	3.45E-02	3.85E-02	3.47E-02	3.60E-03
TA		H	Cresol, o-	2.16E-02	3.03E-02	3.08E-02	2.76E-02	5.17E-03
TA		H	Acetaldehyde	2.23E-02	2.24E-02	2.27E-02	2.25E-02	1.67E-04
TA	P	H	Dimethylnaphthalene, 1,3-	1.32E-02	1.46E-02	1.79E-02	1.52E-02	2.44E-03
TA	P	H	Naphthalene	1.24E-02	1.50E-02	1.48E-02	1.41E-02	1.45E-03
TA		H	Aniline	≤PQL	1.59E-02	1.50E-02	1.33E-02	3.77E-03
TA	P	H	Dimethylnaphthalene, 2,6-	1.09E-02	1.20E-02	1.49E-02	1.26E-02	2.07E-03
TA		H	Xylene, mp-	1.05E-02	1.14E-02	1.16E-02	1.12E-02	5.73E-04
TA		H	Toluene	1.06E-02	1.06E-02	9.77E-03	1.03E-02	4.69E-04
TA	P	H	Dimethylnaphthalene, 1,6-	6.22E-03	6.83E-03	8.34E-03	7.13E-03	1.09E-03
TA		H	Benzene	7.01E-03	7.35E-03	6.92E-03	7.09E-03	2.30E-04
TA	P	H	Dimethylnaphthalene, 2,3-	5.22E-03	5.74E-03	7.21E-03	6.06E-03	1.03E-03
TA		H	Xylene, o-	5.24E-03	5.66E-03	5.64E-03	5.51E-03	2.39E-04
TA		H	Biphenyl	5.40E-03	5.27E-03	5.71E-03	5.46E-03	2.23E-04
TA	P	H	Dimethylnaphthalene, 1,2-	3.11E-03	3.19E-03	4.10E-03	3.47E-03	5.47E-04
TA		H	Cresol, mp-	2.27E-03	3.76E-03	4.26E-03	3.43E-03	1.04E-03
TA		H	Hexane	4.20E-03	2.56E-03	2.55E-03	3.11E-03	9.49E-04
TA		H	Ethylbenzene	2.45E-03	2.74E-03	2.82E-03	2.67E-03	1.95E-04
TA	P	H	Dimethylnaphthalene, 1,5-	1.93E-03	2.15E-03	2.69E-03	2.26E-03	3.89E-04
TA		H	Formaldehyde	1.47E-03	1.91E-03	1.60E-03	1.66E-03	2.29E-04
TA		H	Propionaldehyde (Propanal)	6.75E-04	7.15E-04	7.78E-04	7.23E-04	5.20E-05
TA		H	Styrene	3.95E-04	4.27E-04	≤PQL	3.46E-04	1.14E-04
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Lb Binder - Runs 1 through 6 (Sigma Cure® 7227/7707)

TA	POM	HAP		HK001	HK002	HK003	HK004	HK005	HK006	Average	Standard Deviation
			Test Dates	**30-Aug-06**	**30-Aug-06**	**30-Aug-06**	**31-Aug-06**	**31-Aug-06**	**31-Aug-06**	—	—
Emission Indicators											
			TGOC as Propane	8.85E-02	9.34E-02	9.87E-02	8.87E-02	8.97E-02	8.76E-02	9.11E-02	4.23E-03
			HC as n-Hexane	4.57E-02	5.49E-02	6.04E-02	4.90E-02	4.85E-02	4.48E-02	5.06E-02	5.99E-03
			Sum of Target Analytes	1.85E-02	2.08E-02	2.42E-02	2.54E-02	2.43E-02	2.04E-02	2.25E-02	2.74E-03
			Sum of Target HAPs	1.10E-02	1.44E-02	1.62E-02	1.82E-02	1.81E-02	1.51E-02	1.57E-02	2.68E-03
			Sum of Target POMs	3.59E-03	3.21E-03	3.82E-03	3.32E-03	2.90E-03	2.49E-03	3.22E-03	4.35E-04
Selected Target HAPs and POMs											
TA		H	Phenol	3.01E-03	4.61E-03	5.50E-03	7.76E-03	7.55E-03	6.07E-03	5.75E-03	1.80E-03
TA	P	H	Naphthalene	3.08E-03	2.76E-03	3.34E-03	2.88E-03	2.54E-03	2.17E-03	2.79E-03	4.10E-04
TA		H	Cresol, o-	1.53E-03	1.99E-03	2.50E-03	2.63E-03	2.82E-03	2.42E-03	2.31E-03	4.75E-04
TA		H	Aniline	—	1.43E-03	1.62E-03	1.28E-03	1.40E-03	1.43E-03	1.43E-03	1.21E-04
TA		H	Acetaldehyde	9.06E-04	8.98E-04	9.63E-04	1.04E-03	9.50E-04	1.03E-03	9.65E-04	6.12E-05
TA		H	Benzene	6.84E-04	5.87E-04	4.08E-04	4.64E-04	4.61E-04	3.29E-04	4.89E-04	1.27E-04
TA		H	Toluene	3.71E-04	3.68E-04	3.67E-04	4.13E-04	3.93E-04	2.70E-04	3.64E-04	4.93E-05
TA		H	Xylene, mp-	2.42E-04	2.81E-04	2.82E-04	3.09E-04	3.18E-04	2.43E-04	2.79E-04	3.18E-05
TA	P	H	Methylnaphthalene, 2-	3.23E-04	2.71E-04	2.73E-04	2.62E-04	2.24E-04	2.02E-04	2.59E-04	4.25E-05
TA		H	Hexane	6.75E-05	4.58E-04	5.86E-05	2.46E-04	4.94E-04	1.12E-04	2.39E-04	1.96E-04
TA		H	Cresol, mp-	≤PQL	1.57E-04	2.04E-04	≤PQL	2.69E-04	2.33E-04	1.94E-04	5.03E-05
TA		H	Biphenyl	≤PQL	≤PQL	1.32E-04	1.72E-04	1.44E-04	≤PQL	1.49E-04	1.28E-05
TA		H	Xylene, o-	1.07E-04	1.16E-04	1.13E-04	1.41E-04	1.37E-04	1.07E-04	1.20E-04	1.51E-05
TA	P	H	Methylnaphthalene, 1-	1.24E-04	1.15E-04	1.34E-04	1.33E-04	1.05E-04	9.56E-05	1.18E-04	1.53E-05
TA		H	Formaldehyde	8.61E-05	6.45E-05	9.26E-05	9.88E-05	8.37E-05	1.03E-04	8.81E-05	1.37E-05
TA		H	Ethylbenzene	4.27E-05	4.22E-05	4.59E-05	7.30E-05	7.23E-05	5.03E-05	5.44E-05	1.44E-05
TA	P	H	Dimethylnaphthalene, 1,3-	6.19E-05	6.49E-05	7.71E-05	4.99E-05	2.74E-05	≤PQL	5.19E-05	2.00E-05
TA		H	Propionaldehyde (Propanal)	3.09E-05	3.45E-05	3.77E-05	4.08E-05	3.75E-05	4.43E-05	3.76E-05	4.69E-06
TA		H	Styrene	3.76E-05	≤PQL	≤PQL	3.27E-05	5.67E-05	≤PQL	3.61E-05	1.05E-05
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HK - Detailed Emission Results - Lb/Lb Binder - Runs 1 through 6 (Sigma Cure® 7227/7707)

TA	POM	HAP		HK001	HK002	HK003	HK004	HK005	HK006	Average	Standard Deviation
			Test Dates	**30-Aug-06**	**30-Aug-06**	**30-Aug-06**	**31-Aug-06**	**31-Aug-06**	**31-Aug-06**	—	—
Additional Selected Target Analytes											
TA			Trimethylbenzene, 1,2,4-	2.56E-03	2.34E-03	2.59E-03	2.07E-03	1.79E-03	1.46E-03	2.14E-03	4.48E-04
TA			Dodecane	1.81E-03	1.07E-03	2.06E-03	1.65E-03	1.36E-03	1.27E-03	1.54E-03	3.71E-04
TA			Ethyltoluene, 3-	7.87E-04	7.26E-04	8.00E-04	7.53E-04	6.54E-04	5.22E-04	7.07E-04	1.05E-04
TA			Diethylbenzene, 1,3-	6.13E-04	5.53E-04	6.40E-04	6.34E-04	5.51E-04	4.37E-04	5.71E-04	7.62E-05
TA			Ethyltoluene, 2-	5.60E-04	5.08E-04	5.71E-04	4.88E-04	4.33E-04	3.54E-04	4.86E-04	8.16E-05
TA			Dimethylphenol, 2,6-	2.81E-04	2.68E-04	3.35E-04	5.08E-04	4.18E-04	3.54E-04	3.61E-04	9.02E-05
TA			Undecane	2.73E-04	2.58E-04	3.08E-04	2.89E-04	2.52E-04	2.13E-04	2.65E-04	3.30E-05
TA			Octane	1.75E-04	1.63E-04	2.04E-04	2.45E-04	2.62E-04	2.09E-04	2.10E-04	3.84E-05
TA			Propylbenzene, n-	1.99E-04	2.02E-04	2.27E-04	2.15E-04	1.84E-04	1.46E-04	1.95E-04	2.82E-05
TA			Tetradecane	1.47E-04	1.40E-04	1.92E-04	2.36E-04	1.91E-04	1.64E-04	1.78E-04	3.53E-05
TA			2-Butanone (MEK)	1.05E-04	1.17E-04	1.27E-04	1.21E-04	1.20E-04	1.37E-04	1.21E-04	1.06E-05
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	I	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases											
			Carbon Monoxide	1.57E-01	1.74E-01	1.73E-01	1.69E-01	1.76E-01	1.72E-01	1.70E-01	6.95E-03
			Carbon Dioxide	≤PQL	1.64E-01	≤PQL	≤PQL	≤PQL	≤PQL	4.16E-02	5.97E-02
			Methane	1.04E-02	1.04E-02	9.88E-03	1.76E-02	1.41E-02	1.27E-02	1.25E-02	2.98E-03
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Sulfur Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HP - Detailed Emission Results - Lb/Tn Metal

TA	POM	HAP		HP001	HP002	HP003	HP004	HP005	HP006	HP007	HP008	HP009	Average	Standard Deviation
			Test Dates	**5-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	—	—
Emission Indicators														
			TGOC as Propane	2.01E-01	1.86E-01	2.17E-01	2.54E-01	2.31E-01	2.34E-01	2.54E-01	2.86E-01	I	2.33E-01	3.21E-02
			Non-Methane Hydrocarbons	2.01E-01	1.86E-01	2.17E-01	2.54E-01	2.31E-01	2.34E-01	2.54E-01	2.86E-01	NA	2.33E-01	3.21E-02
			Sum of Target Analytes	1.37E-01	1.23E-01	1.39E-01	1.66E-01	1.63E-01	1.77E-01	1.70E-01	1.78E-01	1.81E-01	1.60E-01	2.10E-02
			Sum of Target HAPs	1.06E-01	9.76E-02	1.10E-01	1.31E-01	1.28E-01	1.41E-01	1.35E-01	1.43E-01	1.44E-01	1.26E-01	1.73E-02
			Sum of Target POMs	7.31E-04	6.59E-04	1.01E-03	7.55E-04	1.04E-03	9.78E-04	9.28E-04	1.05E-03	9.68E-04	1.03E-03	1.47E-04
Selected Target HAPs and POMs														
TA		H	Acetaldehyde	3.24E-02	3.31E-02	3.59E-02	4.00E-02	3.66E-02	4.39E-02	4.33E-02	4.42E-02	4.39E-02	3.93E-02	4.83E-03
TA		H	Phenol	1.51E-02	1.35E-02	1.67E-02	2.27E-02	1.83E-02	2.62E-02	2.43E-02	2.69E-02	2.47E-02	2.09E-02	5.08E-03
TA		H	Xylene, mp-	1.35E-02	1.12E-02	1.35E-02	1.53E-02	1.59E-02	1.47E-02	1.49E-02	1.57E-02	1.64E-02	1.46E-02	1.61E-03
TA		H	Cresol, o-	1.10E-02	9.53E-03	9.96E-03	1.44E-02	1.35E-02	1.47E-02	1.36E-02	1.48E-02	1.49E-02	1.29E-02	2.17E-03
TA		H	Toluene	9.63E-03	7.54E-03	9.44E-03	1.11E-02	1.19E-02	1.03E-02	1.03E-02	1.10E-02	1.17E-02	1.03E-02	1.34E-03
TA		H	Ethylene glycol phenyl ether	7.15E-03	7.71E-03	7.14E-03	7.10E-03	1.10E-02	1.05E-02	8.88E-03	8.14E-03	1.04E-02	8.67E-03	1.59E-03
TA		H	Propionaldehyde (Propanal)	3.85E-03	3.74E-03	3.98E-03	4.28E-03	4.08E-03	4.53E-03	4.41E-03	4.56E-03	4.49E-03	4.21E-03	3.11E-04
TA		H	Cresol, mp-	2.82E-03	2.52E-03	2.33E-03	4.01E-03	4.10E-03	4.23E-03	3.96E-03	4.40E-03	4.56E-03	3.66E-03	8.57E-04
TA		H	Benzene	2.93E-03	2.67E-03	3.77E-03	3.71E-03	3.81E-03	3.71E-03	3.61E-03	3.97E-03	4.05E-03	3.58E-03	4.66E-04
TA		H	Formaldehyde	3.13E-03	3.11E-03	3.33E-03	4.01E-03	3.32E-03	3.64E-03	3.40E-03	3.59E-03	3.18E-03	3.41E-03	2.92E-04
TA		H	Xylene, o-	9.79E-04	8.56E-04	1.26E-03	1.24E-03	1.31E-03	1.61E-03	1.53E-03	1.73E-03	1.50E-03	1.34E-03	2.90E-04
TA		H	Hexane	1.30E-03	5.14E-04	3.61E-04	1.04E-03	1.28E-03	1.02E-03	7.25E-04	1.03E-03	1.10E-03	9.29E-04	3.27E-04
TA		H	Ethylbenzene	7.33E-04	4.07E-04	5.82E-04	8.61E-04	8.93E-04	5.73E-04	6.44E-04	8.12E-04	9.99E-04	7.23E-04	1.87E-04
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	4.47E-04	≤PQL	≤PQL	≤PQL	3.91E-04	≤PQL	3.94E-04	2.00E-05
TA	P	H	Methylnaphthalene, 2-	I	I	3.79E-04	I	3.75E-04	3.77E-04	3.59E-04	3.82E-04	3.72E-04	3.74E-04	8.16E-06
TA	P	H	Dimethylnaphthalene, 1,3-	2.69E-04	2.89E-04	2.85E-04	3.41E-04	2.81E-04	2.88E-04	2.62E-04	3.04E-04	2.48E-04	2.85E-04	2.66E-05
TA		H	Styrene	2.05E-04	≤PQL	2.36E-04	2.93E-04	3.00E-04	≤PQL	2.42E-04	3.59E-04	3.89E-04	2.57E-04	8.60E-05
TA	P	H	Methylnaphthalene, 1-	2.30E-04	2.22E-04	1.85E-04	1.94E-04	1.72E-04	1.68E-04	1.62E-04	1.88E-04	1.66E-04	1.87E-04	2.42E-05
TA	P	H	Naphthalene	2.32E-04	1.49E-04	1.64E-04	2.20E-04	2.07E-04	≤PQL	≤PQL	1.79E-04	1.82E-04	1.80E-04	3.30E-05
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Biphenyl	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Ethylene Glycol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HP - Detailed Emission Results - Lb/Tn Metal

TA	POM	HAP		HP001	HP002	HP003	HP004	HP005	HP006	HP007	HP008	HP009	Average	Standard Deviation
			Test Dates	**5-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	—	—
Additional Selected Target Analytes														
TA			# THCs as n-Hexane	8.59E-02	6.63E-02	8.07E-02	9.95E-02	1.00E-01	9.28E-02	9.61E-02	1.11E-01	1.16E-01	9.43E-02	1.53E-02
TA			Trimethylbenzene, 1,3,5-	9.26E-03	7.97E-03	9.14E-03	9.20E-03	9.89E-03	8.86E-03	8.99E-03	8.34E-03	9.34E-03	9.00E-03	5.67E-04
TA			Butyraldehyde/Methacrolein	6.01E-03	5.99E-03	6.55E-03	6.87E-03	6.69E-03	7.49E-03	7.10E-03	7.65E-03	7.54E-03	6.88E-03	6.26E-04
TA			Butyl Carbitol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	5.66E-03	5.32E-03	1.29E-04
TA			Dimethylphenol, 2,4-	3.32E-03	I	I	4.12E-03	4.50E-03	4.71E-03	4.36E-03	4.61E-03	4.57E-03	4.31E-03	4.80E-04
TA			Dimethylphenol, 2,6-	2.74E-03	2.52E-03	2.95E-03	3.47E-03	3.22E-03	3.70E-03	3.41E-03	3.33E-03	3.29E-03	3.18E-03	3.75E-04
TA			Trimethylbenzene, 1,2,4-	1.87E-03	1.48E-03	2.05E-03	2.63E-03	2.66E-03	2.49E-03	2.49E-03	3.00E-03	3.42E-03	2.45E-03	5.87E-04
TA			Heptane	≤PQL	≤PQL	8.84E-04	≤PQL	≤PQL	1.09E-03	9.99E-04	1.38E-03	1.34E-03	9.56E-04	2.64E-04
TA			Ethyltoluene, 3-	8.58E-04	≤PQL	7.88E-04	1.01E-03	1.05E-03	7.95E-04	8.42E-04	1.01E-03	1.15E-03	9.15E-04	1.45E-04
TA			2-Butanone (MEK)	8.33E-04	7.13E-04	8.27E-04	8.57E-04	7.45E-04	7.47E-04	7.47E-04	7.96E-04	9.89E-04	8.06E-04	8.42E-05
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	4.38E-04	4.26E-04	4.38E-04	4.61E-04	4.21E-04	4.70E-04	4.78E-04	4.34E-04	3.29E-05
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Dioxide	5.65E+00	1.49E+00	2.82E+00	4.11E+00	4.35E+00	≤PQL	5.96E-01	2.18E+00	1.75E+00	2.57E+00	1.83E+00
			Carbon Monoxide	I	1.17E-01	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	9.27E-02	9.74E-03
			Methane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Sulfur Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

#: THCs as n-hexane not included in Emission Indicator Target Analyte Sums

Test HP - Detailed Emission Results - Lb/Lb Binder

TA	POM	HAP		HP001	HP002	HP003	HP004	HP005	HP006	HP007	HP008	HP009	Average	Standard Deviation
			Test Dates	**5-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**6-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	**7-Dec-06**	—	—
Emission Indicators														
			THC as Propane	8.74E-03	8.55E-03	9.99E-03	1.15E-02	1.08E-02	9.62E-03	1.10E-02	1.31E-02	I	1.04E-02	1.50E-03
			Non-Methane Hydrocarbons	8.74E-03	8.55E-03	9.99E-03	1.15E-02	1.08E-02	9.62E-03	1.10E-02	1.31E-02	NA	1.04E-02	1.50E-03
			Sum of Target Analytes	5.97E-03	5.67E-03	6.39E-03	7.49E-03	7.58E-03	7.29E-03	7.34E-03	8.16E-03	8.00E-03	7.15E-03	8.82E-04
			Sum of Target HAPs	4.60E-03	4.49E-03	5.07E-03	5.93E-03	5.95E-03	5.81E-03	5.84E-03	6.52E-03	6.33E-03	5.62E-03	7.27E-04
			Sum of Target POMs	3.18E-05	3.03E-05	4.67E-05	3.41E-05	4.82E-05	4.08E-05	4.03E-05	4.82E-05	4.27E-05	4.59E-05	6.91E-06
Selected Target HAPs and POMs														
TA		H	Acetaldehyde	1.41E-03	1.52E-03	1.66E-03	1.81E-03	1.71E-03	1.80E-03	1.87E-03	2.02E-03	1.93E-03	1.75E-03	1.96E-04
TA		H	Phenol	6.55E-04	6.21E-04	7.71E-04	1.03E-03	8.51E-04	1.08E-03	1.05E-03	1.23E-03	1.09E-03	9.30E-04	2.13E-04
TA		H	Xylene, mp-	5.86E-04	5.17E-04	6.21E-04	6.91E-04	7.41E-04	6.05E-04	6.44E-04	7.16E-04	7.24E-04	6.50E-04	7.46E-05
TA		H	Cresol, o-	4.78E-04	4.39E-04	4.59E-04	6.51E-04	6.28E-04	6.05E-04	5.86E-04	6.77E-04	6.57E-04	5.76E-04	9.23E-05
TA		H	Toluene	4.19E-04	3.47E-04	4.35E-04	5.00E-04	5.54E-04	4.23E-04	4.47E-04	5.03E-04	5.17E-04	4.61E-04	6.33E-05
TA		H	Ethylene glycol phenyl ether	3.11E-04	3.55E-04	3.29E-04	3.21E-04	5.13E-04	4.31E-04	3.84E-04	3.72E-04	4.60E-04	3.86E-04	6.89E-05
TA		H	Propionaldehyde (Propanal)	1.67E-04	1.72E-04	1.83E-04	1.93E-04	1.90E-04	1.87E-04	1.91E-04	2.09E-04	1.98E-04	1.88E-04	1.26E-05
TA		H	Cresol, mp-	1.22E-04	1.16E-04	1.08E-04	1.81E-04	1.91E-04	1.74E-04	1.71E-04	2.01E-04	2.01E-04	1.63E-04	3.74E-05
TA		H	Benzene	1.27E-04	1.23E-04	1.74E-04	1.68E-04	1.78E-04	1.53E-04	1.56E-04	1.81E-04	1.78E-04	1.60E-04	2.20E-05
TA		H	Formaldehyde	1.36E-04	1.43E-04	1.53E-04	1.81E-04	1.54E-04	1.50E-04	1.47E-04	1.64E-04	1.40E-04	1.52E-04	1.38E-05
TA		H	Xylene, o-	4.26E-05	3.94E-05	5.83E-05	5.60E-05	6.12E-05	6.64E-05	6.63E-05	7.92E-05	6.60E-05	5.95E-05	1.24E-05
TA		H	Hexane	5.65E-05	2.36E-05	1.67E-05	4.68E-05	5.95E-05	4.19E-05	3.13E-05	4.72E-05	4.84E-05	4.13E-05	1.46E-05
TA		H	Ethylbenzene	3.19E-05	1.87E-05	2.68E-05	3.89E-05	4.16E-05	2.36E-05	2.78E-05	3.71E-05	4.40E-05	3.23E-05	8.66E-06
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	2.02E-05	≤PQL	≤PQL	≤PQL	1.79E-05	≤PQL	1.77E-05	9.85E-07
TA	P	H	Methylnaphthalene, 2-	I	I	1.75E-05	I	1.75E-05	1.55E-05	1.55E-05	1.75E-05	1.64E-05	1.66E-05	9.73E-07
TA	P	H	Dimethylnaphthalene, 1,3-	1.17E-05	1.33E-05	1.32E-05	1.54E-05	1.31E-05	1.19E-05	1.13E-05	1.39E-05	1.09E-05	1.27E-05	1.42E-06
TA		H	Styrene	8.90E-06	≤PQL	1.09E-05	1.32E-05	1.40E-05	≤PQL	1.05E-05	1.64E-05	1.71E-05	1.16E-05	3.93E-06
TA	P	H	Methylnaphthalene, 1-	9.98E-06	1.02E-05	8.54E-06	8.75E-06	8.02E-06	6.92E-06	7.00E-06	8.61E-06	7.34E-06	8.37E-06	1.19E-06
TA	P	H	Naphthalene	1.01E-05	6.83E-06	7.54E-06	9.96E-06	9.64E-06	≤PQL	≤PQL	8.18E-06	8.01E-06	8.14E-06	1.45E-06
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Biphenyl	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Ethylene Glycol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HP - Detailed Emission Results - Lb/Lb Binder

TA	POM	HAP		HP001	HP002	HP003	HP004	HP005	HP006	HP007	HP008	HP009	Average	Standard Deviation
			Test Dates	5-Dec-06	6-Dec-06	6-Dec-06	6-Dec-06	6-Dec-06	7-Dec-06	7-Dec-06	7-Dec-06	7-Dec-06	—	—
Additional Selected Target Analytes														
TA			# THCs as n-Hexane	3.74E-03	3.05E-03	3.72E-03	4.50E-03	4.66E-03	3.82E-03	4.15E-03	5.09E-03	5.12E-03	4.20E-03	6.91E-04
TA			Trimethylbenzene, 1,3,5-	4.03E-04	3.67E-04	4.22E-04	4.16E-04	4.61E-04	3.64E-04	3.89E-04	3.81E-04	4.12E-04	4.01E-04	3.04E-05
TA			Butyraldehyde/Methacrolein	2.62E-04	2.76E-04	3.02E-04	3.10E-04	3.12E-04	3.08E-04	3.07E-04	3.50E-04	3.32E-04	3.07E-04	2.64E-05
TA			Butyl Carbitol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	2.50E-04	2.37E-04	4.79E-06
TA			Dimethylphenol, 2,4-	1.44E-04	I	I	1.86E-04	2.10E-04	1.94E-04	1.88E-04	2.11E-04	2.02E-04	1.91E-04	2.27E-05
TA			Dimethylphenol, 2,6-	1.19E-04	1.16E-04	1.36E-04	1.57E-04	1.50E-04	1.52E-04	1.47E-04	1.52E-04	1.45E-04	1.42E-04	1.48E-05
TA			Trimethylbenzene, 1,2,4-	8.15E-05	6.79E-05	9.46E-05	1.19E-04	1.24E-04	1.03E-04	1.08E-04	1.37E-04	1.51E-04	1.09E-04	2.63E-05
TA			Heptane	≤PQL	≤PQL	4.08E-05	≤PQL	≤PQL	4.48E-05	4.32E-05	6.31E-05	5.90E-05	4.23E-05	1.18E-05
TA			Ethyltoluene, 3-	3.73E-05	≤PQL	3.63E-05	4.56E-05	4.90E-05	3.27E-05	3.64E-05	4.63E-05	5.07E-05	4.08E-05	7.12E-06
TA			2-Butanone (MEK)	3.62E-05	3.28E-05	3.81E-05	3.87E-05	3.47E-05	3.08E-05	3.23E-05	3.64E-05	4.36E-05	3.60E-05	3.92E-06
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	2.02E-05	1.93E-05	2.04E-05	1.90E-05	1.82E-05	2.15E-05	2.11E-05	1.93E-05	1.57E-06
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Dioxide	2.46E-01	6.86E-02	1.30E-01	1.86E-01	2.03E-01	≤PQL	2.58E-02	9.98E-02	7.70E-02	1.16E-01	7.72E-02
			Carbon Monoxide	I	5.38E-03	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	4.16E-03	4.62E-04
			Methane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Sulfur Dioxide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
			#: THCs as n-hexane not includ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Practical Reporting Limit -Test HK- Runs 1 through 6 (7277/7707 Binder System)

Analyte	lb/ton Metal	Analyte	lb/ton Metal
Carbon Monoxide	1.59E-01	Ethylbenzene	2.52E-04
Methane	9.06E-02	Ethyltoluene, 2-	2.52E-04
Carbon Dioxide	2.49E-01	Ethyltoluene, 3-	1.26E-03
Nitrogen Oxides	1.70E-01	Formaldehyde	2.33E-04
THC as Propane	2.49E-01	Heptane	1.26E-03
2-Butanone (MEK)	2.33E-04	Hexaldehyde	2.33E-04
Acenaphthalene	1.26E-03	Hexane	2.52E-04
Acetaldehyde	2.33E-04	Indan	1.26E-03
Acrolein	2.33E-04	Indene	1.26E-03
Aniline	9.03E-03	Methylnaphthalene, 1-	2.52E-04
Benzaldehyde	2.33E-04	Methylnaphthalene, 2-	2.52E-04
Benzene	2.52E-04	Naphthalene	2.52E-04
Biphenyl	1.26E-03	Nonane	1.26E-03
Butyraldehyde/Methacrolein	3.89E-04	o,m,p-Tolualdehyde	6.22E-04
Cresol, mp-	1.26E-03	Octane	1.26E-03
Cresol, o-	1.26E-03	Pentanal (Valeraldehyde)	2.33E-04
Crotonaldehyde	2.33E-04	Phenol	1.26E-03
Cyclohexane	1.26E-03	Propionaldehyde (Propanal)	2.33E-04
Decane	1.26E-03	Propylbenzene, n-	1.26E-03
Diethylbenzene, 1,3-	1.26E-03	Styrene	2.52E-04
Dimethylaniline	1.58E-02	Sulfur Dioxide	4.63E-03
Dimethylnaphthalene, 1,2-	1.26E-03	Tetradecane	1.26E-03
Dimethylnaphthalene, 1,3-	2.52E-04	THCs as n-Hexane	2.20E-02
Dimethylnaphthalene, 1,5-	1.26E-03	Toluene	2.52E-04
Dimethylnaphthalene, 1,6-	1.26E-03	Triethylamine	2.22E-03
Dimethylnaphthalene, 1,8-	1.26E-03	Trimethylbenzene, 1,2,3-	2.52E-04
Dimethylnaphthalene, 2,3-	1.26E-03	Trimethylbenzene, 1,2,4-	2.52E-04
Dimethylnaphthalene, 2,6-	1.26E-03	Trimethylbenzene, 1,3,5-	2.52E-04
Dimethylnaphthalene, 2,7-	1.26E-03	Trimethylnaphthalene, 2,3,5-	1.26E-03
Dimethylphenol, 2,4-	1.26E-03	Undecane	2.52E-04
Dimethylphenol, 2,6-	1.26E-03	Xylene, mp-	2.52E-04
Dodecane	1.26E-03	Xylene, o-	2.52E-04

Analyte	lb/lb Binder	Analyte	lb/lb Binder
Carbon Monoxide	1.10E-02	Ethylbenzene	2.99E-05
Methane	6.27E-03	Ethyltoluene, 2-	2.99E-05
Carbon Dioxide	1.73E-02	Ethyltoluene, 3-	1.49E-04
Nitrogen Oxides	1.18E-02	Formaldehyde	2.76E-05
THC as Propane	1.73E-02	Heptane	1.49E-04
Acenaphthalene	1.49E-04	Hexaldehyde	2.76E-05
Acetaldehyde	2.76E-05	Hexane	2.99E-05
Acrolein	2.76E-05	Indan	1.49E-04
Aniline	1.07E-03	Indene	1.49E-04
Benzaldehyde	2.76E-05	Methylnaphthalene, 1-	2.99E-05
Benzene	2.99E-05	Methylnaphthalene, 2-	2.99E-05
Biphenyl	1.49E-04	Naphthalene	2.99E-05
Butyraldehyde/Methacrolein	4.60E-05	Nonane	1.49E-04
Cresol, mp-	1.49E-04	o,m,p-Tolualdehyde	7.36E-05
Cresol, o-	1.49E-04	Octane	1.49E-04
Crotonaldehyde	2.76E-05	Pentanal (Valeraldehyde)	2.76E-05
Cyclohexane	1.49E-04	Phenol	1.49E-04
Decane	1.49E-04	Propionaldehyde (Propanal)	2.76E-05
Diethylbenzene, 1,3-	1.49E-04	Propylbenzene, n-	1.49E-04
Dimethylaniline	1.87E-03	Styrene	2.99E-05
Dimethylnaphthalene, 1,2-	1.49E-04	Sulfur Dioxide	5.48E-04
Dimethylnaphthalene, 1,3-	2.99E-05	Tetradecane	1.49E-04
Dimethylnaphthalene, 1,5-	1.49E-04	THCs as n-Hexane	2.61E-03
Dimethylnaphthalene, 1,6-	1.49E-04	Toluene	2.99E-05
Dimethylnaphthalene, 1,8-	1.49E-04	Triethylamine	2.63E-04
Dimethylnaphthalene, 2,3-	1.49E-04	Trimethylbenzene, 1,2,3-	2.99E-05
Dimethylnaphthalene, 2,6-	1.49E-04	Trimethylbenzene, 1,2,4-	2.99E-05
Dimethylnaphthalene, 2,7-	1.49E-04	Trimethylbenzene, 1,3,5-	2.99E-05
Dimethylphenol, 2,4-	1.49E-04	Trimethylnaphthalene, 2,3,5-	1.49E-04
Dimethylphenol, 2,6-	1.49E-04	Undecane	2.99E-05
Dodecane	1.49E-04	Xylene, mp-	2.99E-05
		Xylene, o-	2.99E-05

Practical Reporting Limits - Test HP

Analyte	lb/ton Metal	Analyte	lb/ton Metal
Carbon Dioxide	1.40E-01	Dodecane	7.27E-04
Carbon Monoxide	8.93E-02	Ethylbenzene	1.45E-04
Methane	5.10E-02	Ethylene Glycol	4.13E-02
Nitrogen Oxides	9.57E-02	Ethylene glycol phenyl ether	3.52E-03
Sulfur Dioxide	7.36E-03	Ethyltoluene, 2-	1.45E-04
THC as Propane	1.40E-01	Ethyltoluene, 3-	7.27E-04
2-Butanone (MEK)	3.87E-04	Formaldehyde	3.87E-04
Acenaphthalene	7.27E-04	Heptane	7.27E-04
Acetaldehyde	3.87E-04	Hexaldehyde	3.87E-04
Acrolein	3.87E-04	Hexane	1.45E-04
Benzaldehyde	3.87E-04	Indan	7.27E-04
Benzene	1.45E-04	Indene	7.27E-04
Biphenyl	7.27E-04	Methylnaphthalene, 1-	1.45E-04
Butyl Carbitol	5.27E-03	Methylnaphthalene, 2-	1.45E-04
Butyraldehyde/Methacrolein	6.45E-04	Naphthalene	1.45E-04
Cresol, mp-	7.27E-04	Nonane	7.27E-04
Cresol, o-	7.27E-04	o,m,p-Tolualdehyde	1.03E-03
Crotonaldehyde	3.87E-04	Octane	7.27E-04
Cumene	3.55E-03	Pentanal (Valeraldehyde)	3.87E-04
Cyclohexane	7.27E-04	Phenol	7.27E-04
Decane	7.27E-04	Propionaldehyde (Propanal)	3.87E-04
Diethylbenzene, 1,3-	7.27E-04	Propylbenzene, n-	7.27E-04
Dimethylnaphthalene, 1,2-	7.27E-04	Styrene	1.45E-04
Dimethylnaphthalene, 1,3-	1.45E-04	Tetradecane	7.27E-04
Dimethylnaphthalene, 1,5-	7.27E-04	Toluene	1.45E-04
Dimethylnaphthalene, 1,6-	7.27E-04	Trimethylbenzene, 1,2,3-	1.45E-04
Dimethylnaphthalene, 1,8-	7.27E-04	Trimethylbenzene, 1,2,4-	1.45E-04
Dimethylnaphthalene, 2,3-	7.27E-04	Trimethylbenzene, 1,3,5-	1.45E-04
Dimethylnaphthalene, 2,6-	7.27E-04	Trimethylnaphthalene, 2,3,5-	7.27E-04
Dimethylnaphthalene, 2,7-	7.27E-04	Undecane	1.45E-04
Dimethylphenol, 2,4-	7.27E-04	Xylene, mp-	1.45E-04
Dimethylphenol, 2,6-	7.27E-04	Xylene, o-	1.45E-04

Analyte	lb/lb Binder	Analyte	lb/lb Binder
Carbon Dioxide	6.26E-03	Dodecane	3.24E-05
Carbon Monoxide	3.98E-03	Ethylbenzene	6.49E-06
Methane	2.27E-03	Ethylene Glycol	1.84E-03
Nitrogen Oxides	4.27E-03	Ethylene glycol phenyl ether	1.57E-04
Sulfur Dioxide	3.28E-04	Ethyltoluene, 2-	6.49E-06
THC as Propane	6.26E-03	Ethyltoluene, 3-	3.24E-05
2-Butanone (MEK)	1.73E-05	Formaldehyde	1.73E-05
Acenaphthalene	3.24E-05	Heptane	3.24E-05
Acetaldehyde	1.73E-05	Hexaldehyde	1.73E-05
Acrolein	1.73E-05	Hexane	6.49E-06
Benzaldehyde	1.73E-05	Indan	3.24E-05
Benzene	6.49E-06	Indene	3.24E-05
Biphenyl	3.24E-05	Methylnaphthalene, 1-	6.49E-06
Butyl Carbitol	2.35E-04	Methylnaphthalene, 2-	6.49E-06
Butyraldehyde/Methacrolein	2.88E-05	Naphthalene	6.49E-06
Cresol, mp-	3.24E-05	Nonane	3.24E-05
Cresol, o-	3.24E-05	o,m,p-Tolualdehyde	4.60E-05
Crotonaldehyde	1.73E-05	Octane	3.24E-05
Cumene	1.58E-04	Pentanal (Valeraldehyde)	1.73E-05
Cyclohexane	3.24E-05	Phenol	3.24E-05
Decane	3.24E-05	Propionaldehyde (Propanal)	1.73E-05
Diethylbenzene, 1,3-	3.24E-05	Propylbenzene, n-	3.24E-05
Dimethylnaphthalene, 1,2-	3.24E-05	Styrene	6.49E-06
Dimethylnaphthalene, 1,3-	6.49E-06	Tetradecane	3.24E-05
Dimethylnaphthalene, 1,5-	3.24E-05	Toluene	6.49E-06
Dimethylnaphthalene, 1,6-	3.24E-05	Trimethylbenzene, 1,2,3-	6.49E-06
Dimethylnaphthalene, 1,8-	3.24E-05	Trimethylbenzene, 1,2,4-	6.49E-06
Dimethylnaphthalene, 2,3-	3.24E-05	Trimethylbenzene, 1,3,5-	6.49E-06
Dimethylnaphthalene, 2,6-	3.24E-05	Trimethylnaphthalene, 2,3,5-	3.24E-05
Dimethylnaphthalene, 2,7-	3.24E-05	Undecane	6.49E-06
Dimethylphenol, 2,4-	3.24E-05	Xylene, mp-	6.49E-06
Dimethylphenol, 2,6-	3.24E-05	Xylene, o-	6.49E-06

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APPENDIX C DETAILED PROCESS DATA AND CASTING QUALITY PHOTOS

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Detailed Process Data - Test HK

	HA International Sigma Cure® 7227/7707									
Test Dates	**08/29/06**	**08/29/06**	**08/29/06**	**08/30/06**	**08/30/06**	**08/30/06**	**08/31/06**	**08/31/06**	**08/31/06**	**Averages**
Emissions Sample #	**HKCR1**	**HKCR2**	**HKCR3**	**HK001**	**HK002**	**HK003**	**HK004**	**HK005**	**HK006**	
Production Sample #	**HK001**	**HK002**	**HK003**	**HK004**	**HK005**	**HK006**	**HK007**	**HK008**	**HK009**	
Cast weight, lbs.	44.20	42.45	43.30	42.40	43.90	45.10	42.70	44.25	44.85	43.87
Pouring time, sec.	ND	ND	13	17	13	12	15	14	14	14.2
Pouring temp ,°F	ND	ND	1275	**1280**	1277	1279	1279	1275	1280	1278
Pour hood process air temp at start of pour, °F	ND	ND	90	87	86	86	85	86	87	86
Mixer auto dispensed sand weight, lbs	50.10	50.10	50.10	50.10	50.10	50.10	50.10	50.10	50.10	50.10
Core binder weight part 1, g	124.9	125.4	125.4	126.1	124.6	125.2	125.2	125.0	125.6	125.3
Core binder weight part 2, g	125.4	125.6	125.2	125.2	125.3	125.2	125.8	125.2	125.1	125.3
Core binder weight, g	250.3	251.0	250.6	251.3	249.9	250.4	251.0	250.2	250.7	250.6
% core binder (BOS)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
% core binder, actual	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Total core weight in mold, lbs.	29.31	29.28	29.13	28.87	29.12	28.93	29.10	29.32	28.97	29.05
Total binder weight in mold, lbs.	0.319	0.320	0.318	0.316	0.317	0.315	0.318	0.319	0.316	0.317
Core LOI, %	ND	ND	ND	0.87	0.87	0.87	0.87	0.85	0.85	0.86
2 hour core dogbone tensile, psi	283.9	283.9	283.9	283.9	283.9	283.9	283.9	283.9	283.9	283.9
Core age when poured, hrs.	24	26	27	47	50	52	72	74	76	62.0
Muller batch weight, lbs.	1100	907	900	894	900	908	911	897	900	902
GS mold sand weight, lbs.	646	647	639	648	641	627	645	635	620	636
Mold temperature, °F	82	94	81	82	85	84	83	84	85	84
Average green compression , psi	16.49	18.39	18.48	18.69	18.55	19.41	19.35	19.11	20.47	19.26
GS compactability, %	46	43	40	41	41	42	35	37	39	39
GS moisture content, %	1.96	1.88	1.90	2.02	1.80	1.88	1.68	1.62	1.78	1.80
GS MB clay content, %	7.29	7.19	7.29	7.19	6.90	6.90	6.90	7.19	7.29	7.06
MB clay reagent, ml	38.0	37.5	38.0	37.5	36.0	36.0	36.0	37.5	38.0	36.8
1500°F LOI - mold sand, %	0.86	0.92	0.93	0.91	1.01	0.93	0.97	0.98	0.95	0.96
900°F volatiles , %	0.44	0.44	0.42	0.38	0.50	0.36	0.36	0.46	0.44	0.42
Permeability index	225	218	215	219	222	224	228	229	229	225
Sand temperature, °F	ND	83	82	83	86	87	83	87	90	86

Notes:
HK001/HK004 the pour tempertaure was taken in the ladle immediately after the pour.
2. Dogbones were made with the same binder content as the cores and mixed, blown, and tested on a different date from the core making

Test HP - Detailed Process Data

	1413-113-HP Ecolotec® 750 Cores in Aluminum												
Test Dates	**12/05/06**	**12/05/06**	**12/05/06**	**12/05/06**	**12/06/06**	**12/06/06**	**12/06/06**	**12/06/06**	**12/07/06**	**12/07/06**	**12/07/06**	**12/07/06**	**Averages**
Emissions sample #	**HPCR1**	**HPCR2**	**HPCR3**	**HP001**	**HP002**	**HP003**	**HP004**	**HP005**	**HP006**	**HP007**	**HP008**	**HP009**	
Production sample #	**HP001**	**HP002**	**HP003**	**HP004**	**HP005**	**HP006**	**HP007**	**HP008**	**HP009**	**HP010**	**HP011**	**HP012**	
Cast weight, lbs.	44.95	43.70	46.85	45.40	47.95	47.05	45.10	48.25	44.20	46.15	45.55	45.40	46.33
Pouring time, sec.	12	15	15	14	12	15	14	13	13	12	12	12	13.5
Pouring temp ,°F	1268	1281	1284	1262	1277	1275	1276	1277	1275	1275	1280	1267	1274
Pour hood process air temp at start of pour, °F	84	84	86	85	86	86	88	87	87	88	86	88	86
Mixer auto dispensed sand weight, lbs	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87
Core binder weight part 1, g	451.2	452.7	449.7	453.4	455.6	452.6	452.6	455.4	453.2	453.7	454.2	453.4	453.8
Core binder weight part 2, g	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Core binder weight, g	451.2	452.7	449.7	453.4	455.6	452.6	452.6	455.4	453.2	453.7	454.2	453.4	453.8
% core binder (BOS)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
% core binder, actual	1.96	1.96	1.95	1.96	1.97	1.96	1.96	1.97	1.96	1.97	1.97	1.96	1.97
Total core weight in mold, lbs.	26.42	26.64	26.63	26.55	26.37	25.99	25.42	26.24	27.32	27.14	25.29	26.20	26.32
Total binder weight in mold, lbs.	0.517	0.523	0.519	0.522	0.521	0.510	0.499	0.518	0.537	0.534	0.498	0.515	0.518
Core LOI, %	0.9031	0.9141	0.9022	0.9140	0.9269	0.9236	0.9698	0.9733	0.9083	0.9388	0.9557	0.9432	0.94
2 hour core dogbone tensile, psi	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9
Core age when poured, hrs.	30.85	32.10	33.87	36.86	56.49	58.36	60.10	61.67	78.83	81.04	82.40	84.02	58.7
Muller batch weight, lbs.	1100	901	898	899	902	897	894	901	902	901	933	906	899
GS mold sand weight, lbs.	650.1	658.9	634.9	654.9	654.1	654.0	640.6	646.3	643.2	634.4	634.2	628.8	649
Mold temperature, °F	62	70	68	70	66	67	71	74	67	73	67	70	69
Average green compression , psi	12.67	15.04	16.95	17.37	18.25	18.37	19.51	17.97	18.64	19.73	18.24	17.82	18.35
GS compactability, %	56	55	41	38	33	35	40	43	37	36	46	53	38
GS moisture content, %	2.48	1.98	1.86	1.68	1.88	1.60	1.64	1.74	1.72	1.56	1.84	1.86	1.71
GS MB clay content, %	7.1	7.1	7.0	7.0	7.0	6.9	7.0	6.6	6.6	7.0	6.8	6.7	6.86
MB clay reagent, ml	37.5	37.5	37.0	37.0	37.0	36.5	37.0	35.0	35.0	37.0	36.0	35.5	36.3
1500°F LOI - mold sand, %	0.9337	0.9525	0.8511	0.8816	0.9139	0.8826	0.8204	0.8391	0.8522	0.7947	0.8894	0.9103	0.86
900°F volatiles , %	0.44	0.44	0.36	0.46	0.48	0.44	0.40	0.40	0.40	0.30	0.44	0.48	0.43
Permeability index	236	244	239	247	218	225	249	239	233	230	244	250	235
Sand temperature, °F	63	72	73	73	76	73	74	76	68	74	75	75	73

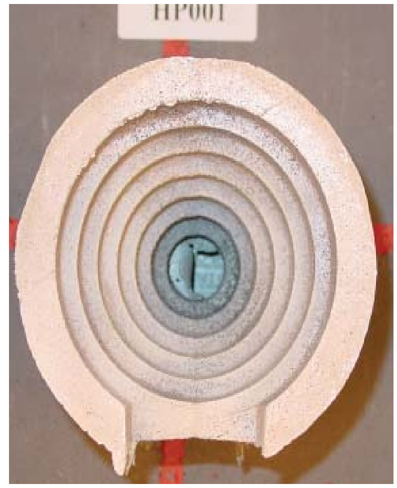
Notes:

2 hour core dogbone tensile, psi data is the same for all runs. One 30 dog bone test batch was made a 2.0% BOS Ecolotec binder with wedron 530 sand was made to represent the cores in the mold.

Casting Quality Photos

Best

HK012-2



HP001-3

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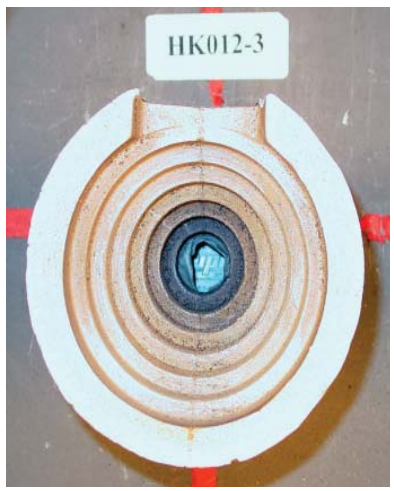
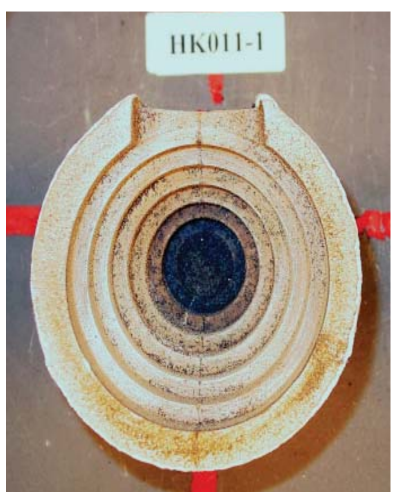


HK012-3

HP005-3

Worst



HK011-1

HP008-3

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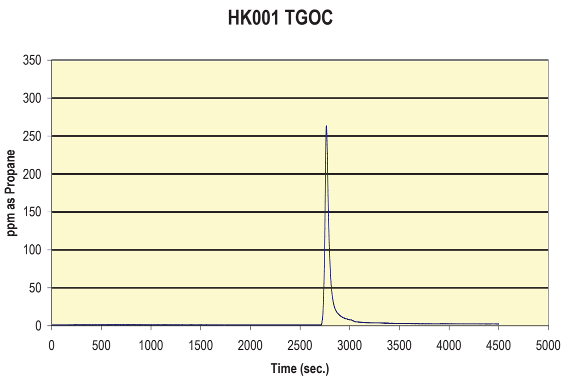
Appendix D Continuous Emission Charts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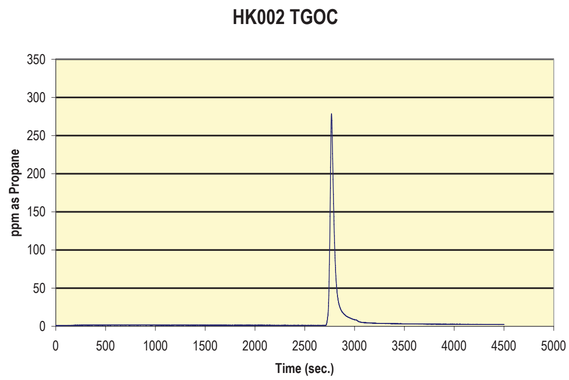
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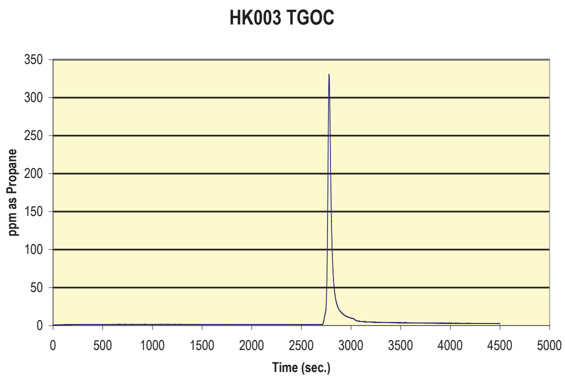
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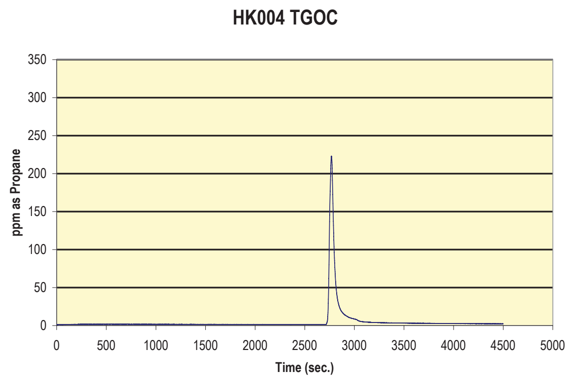
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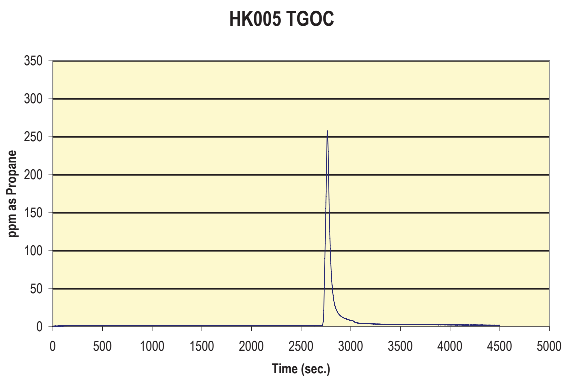
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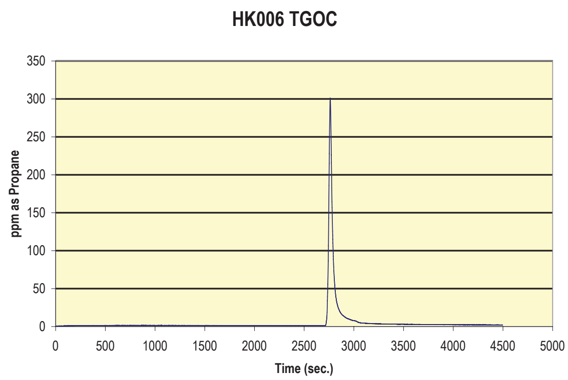
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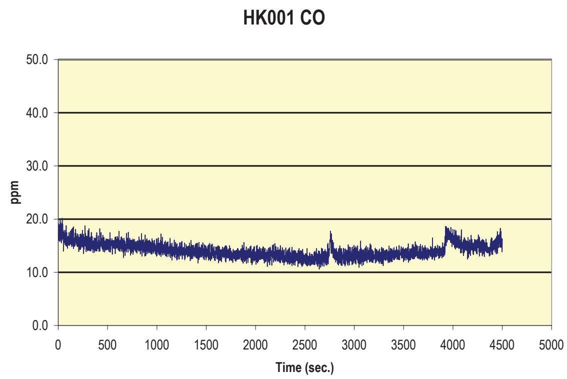
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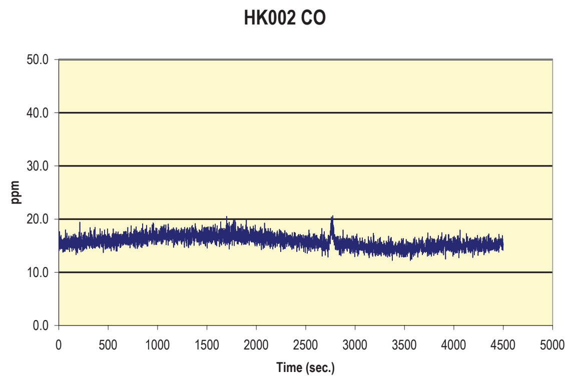
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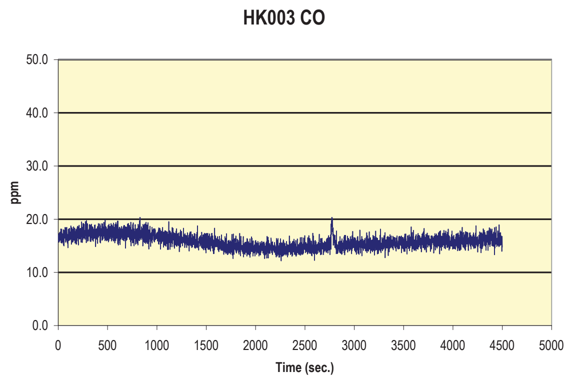
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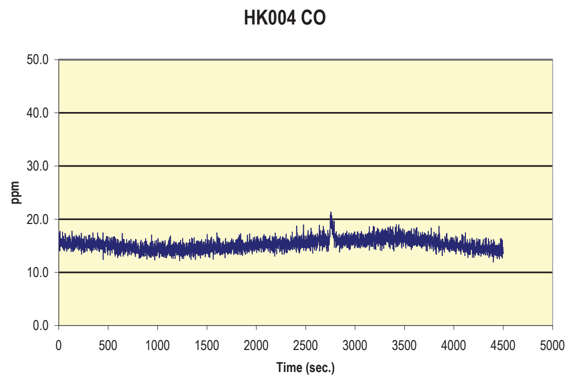
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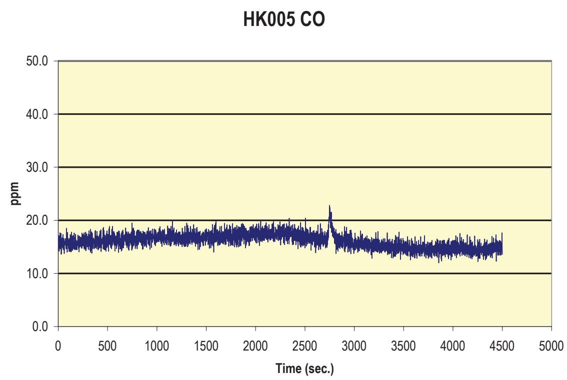
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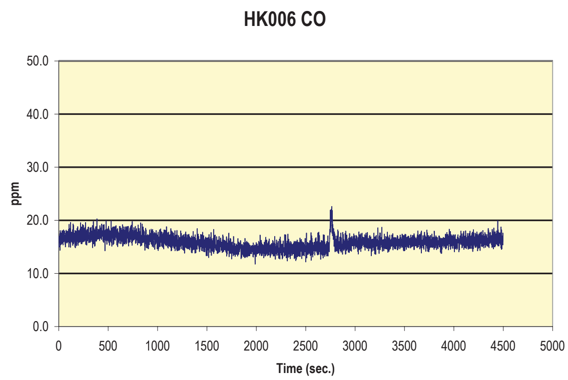
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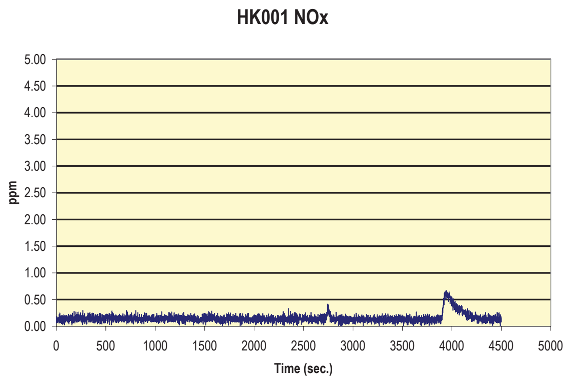
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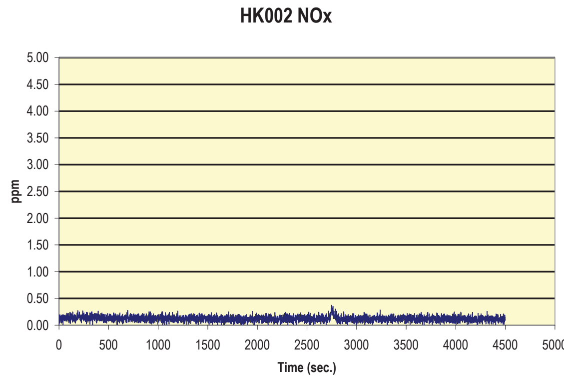
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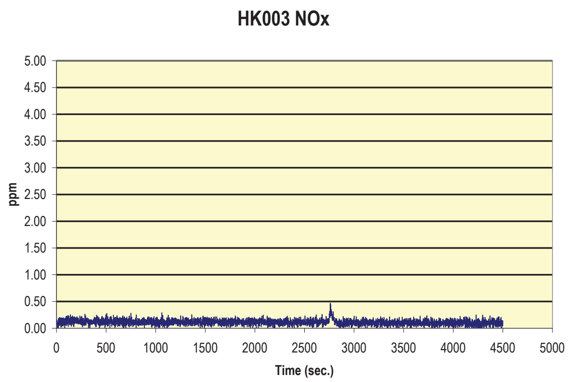
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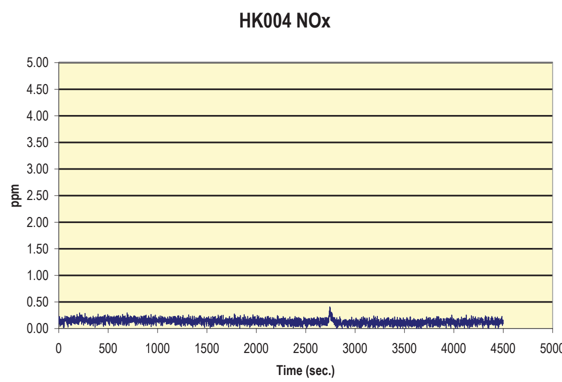
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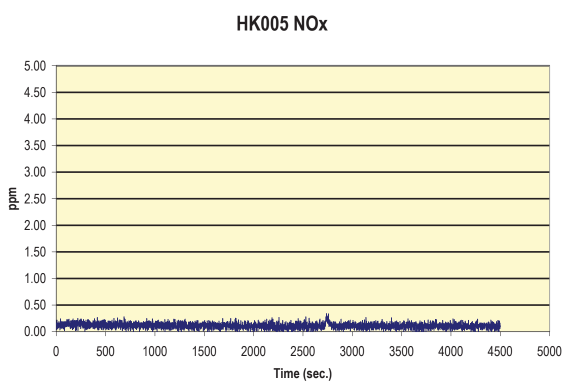
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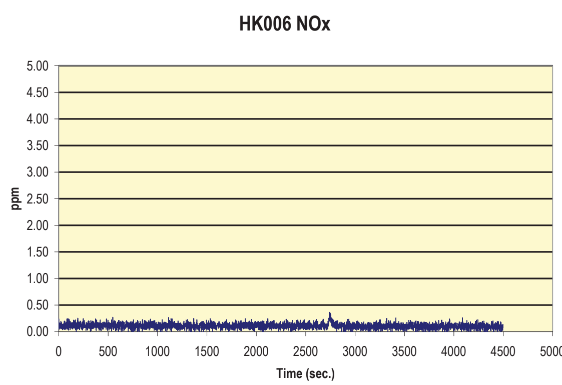
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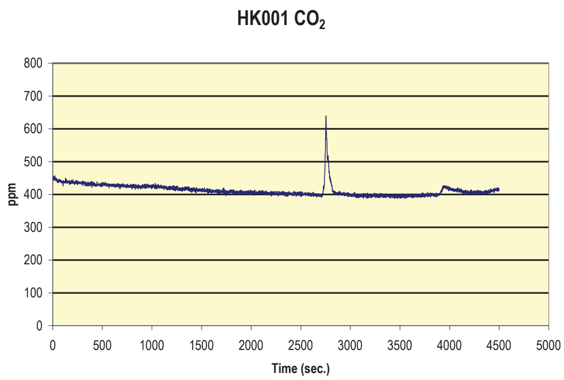
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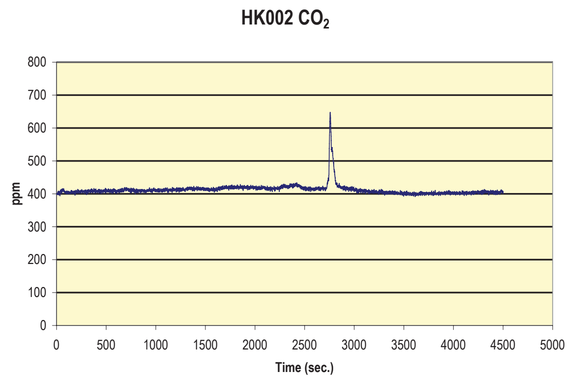
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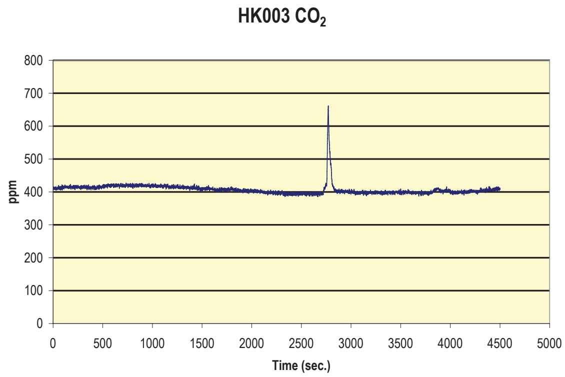
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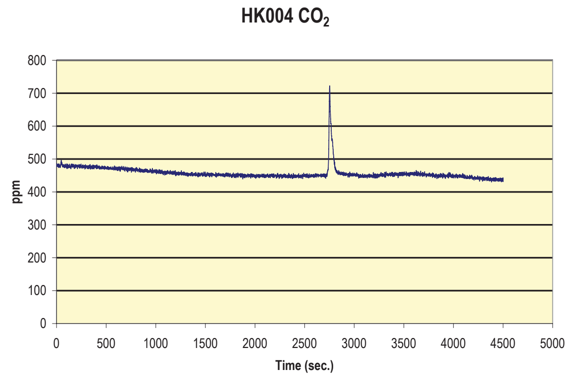
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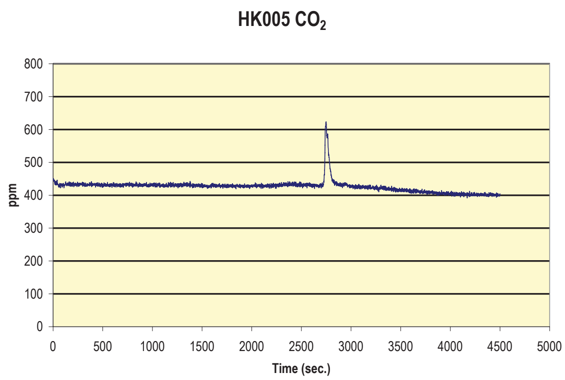
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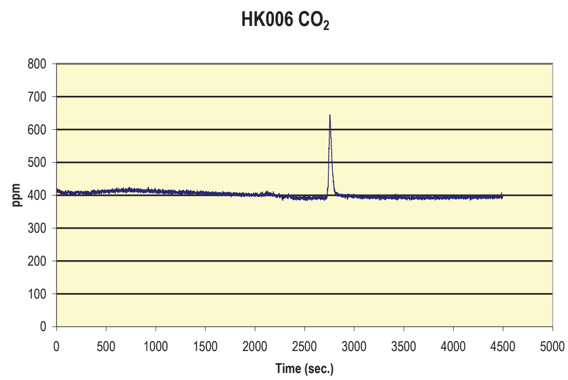
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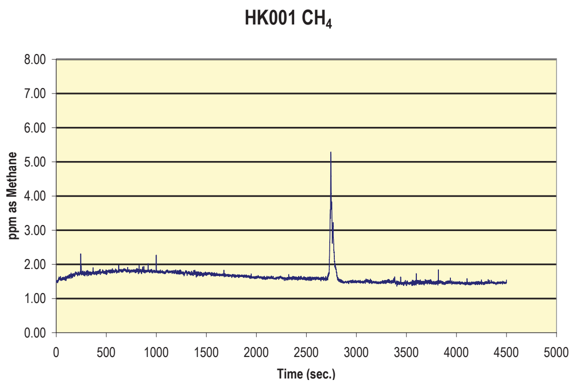
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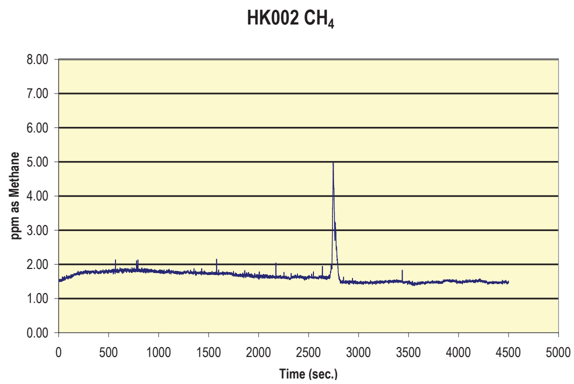
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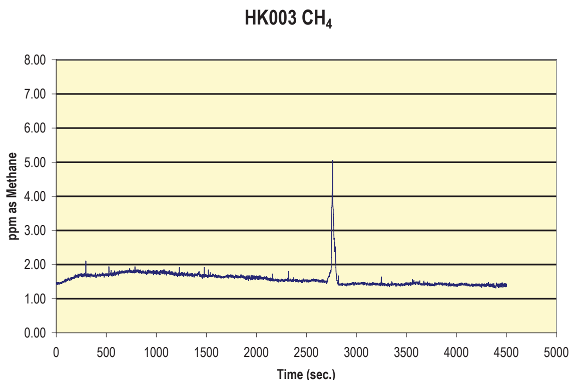
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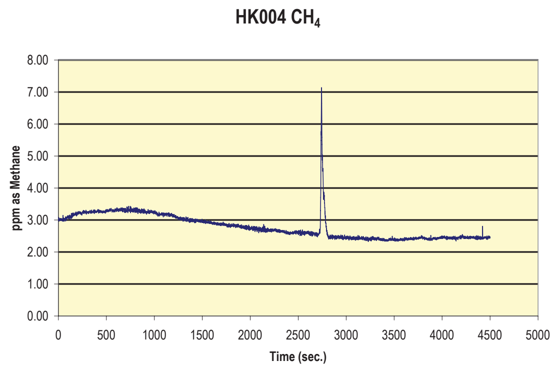
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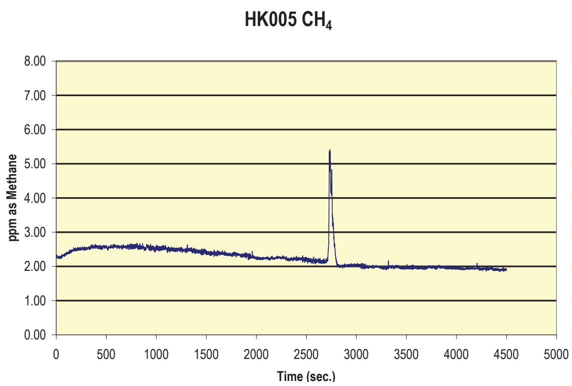
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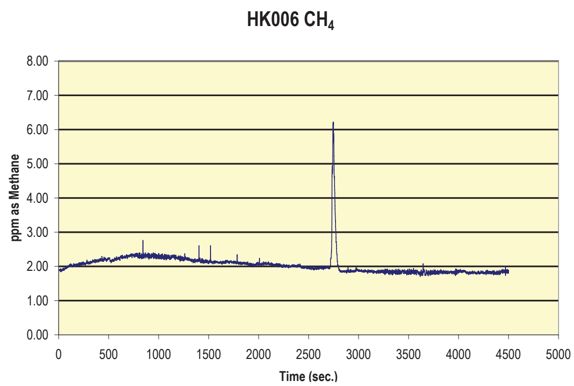
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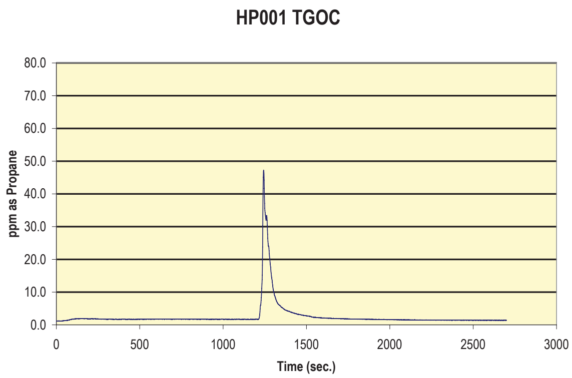
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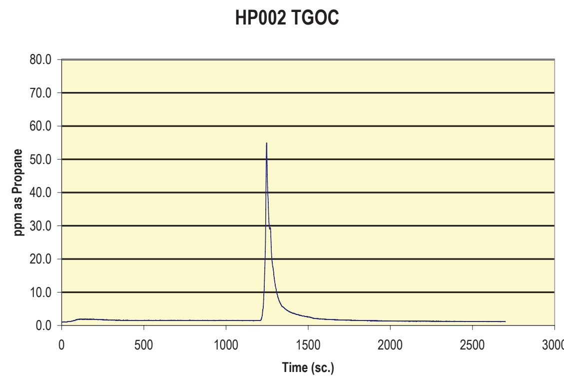
ppm as Propane
Time (sec.)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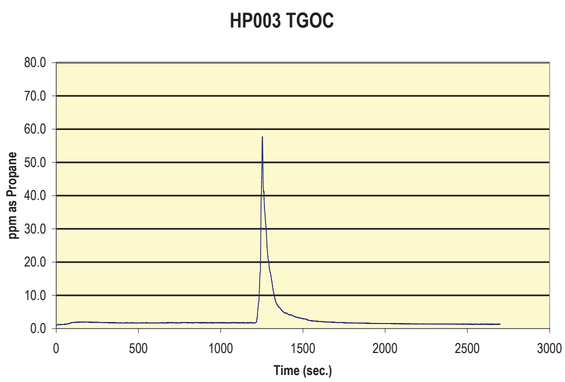
Time (sc.)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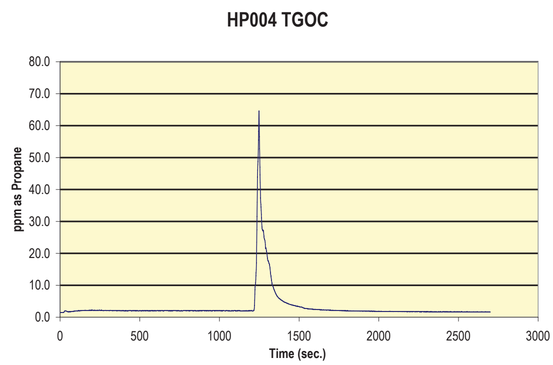
Time (sec.)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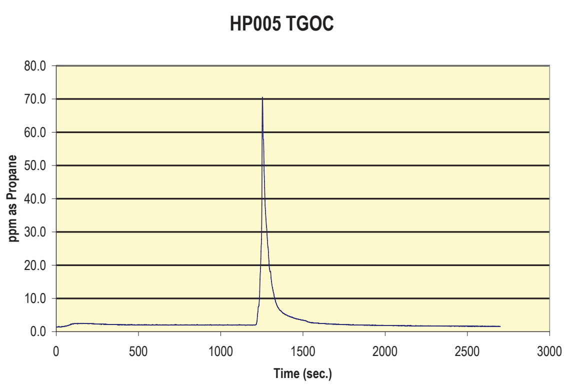
ppm as Propane
Time (sec.)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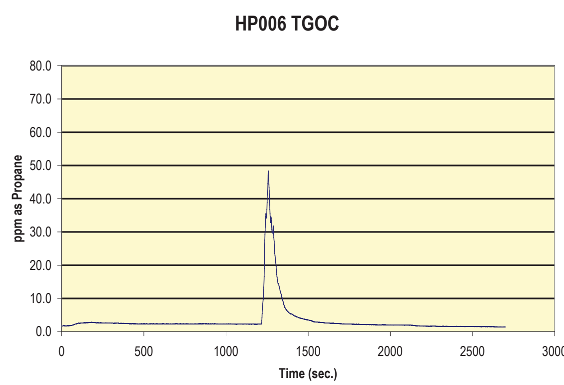
Time (sec.)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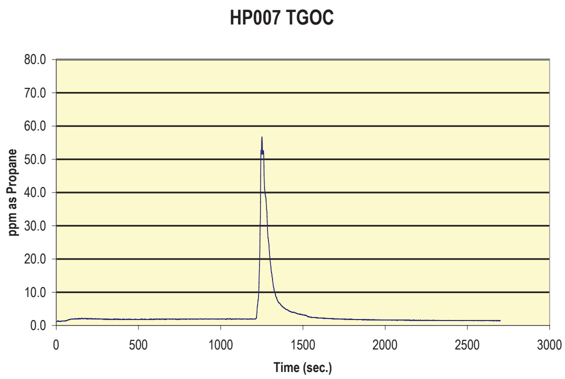
Time (sec.)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ppm as Propane
Time (sec.)
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0
500
1000
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2500
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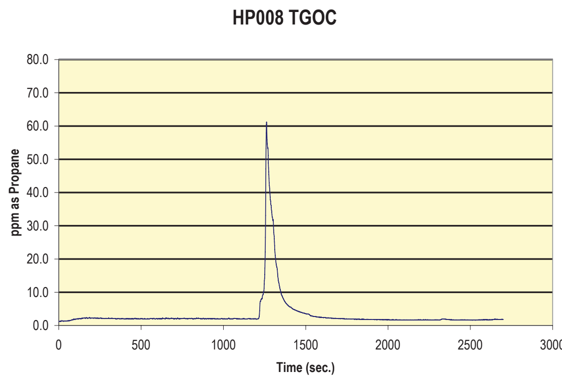
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ppm as Propane
Time (sec.)
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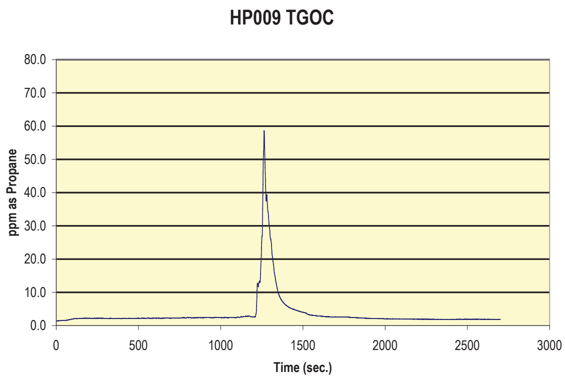
HP009 TGOC
ppm as Propane
Time (sec.)
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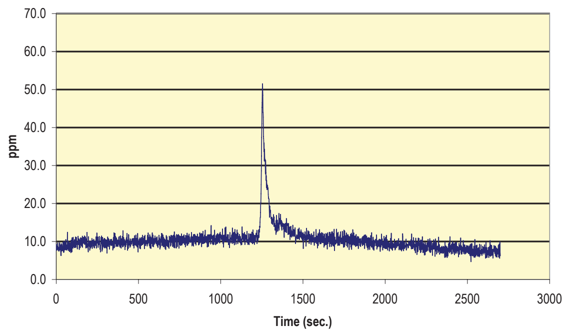
2500
3000

HP001 CO



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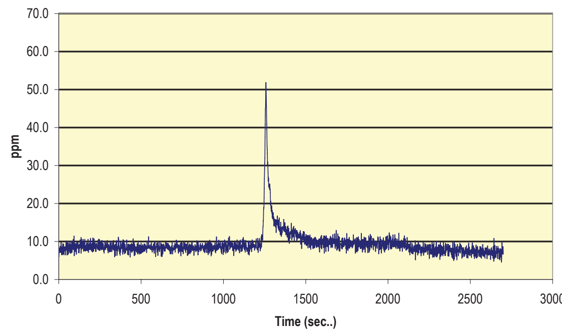

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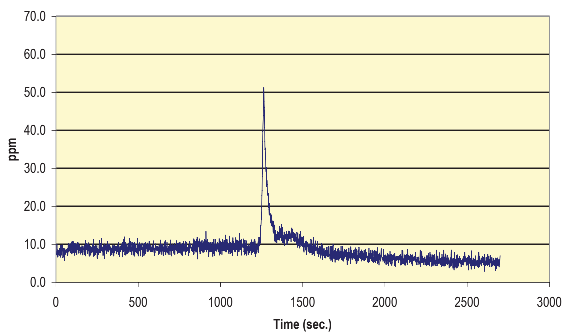

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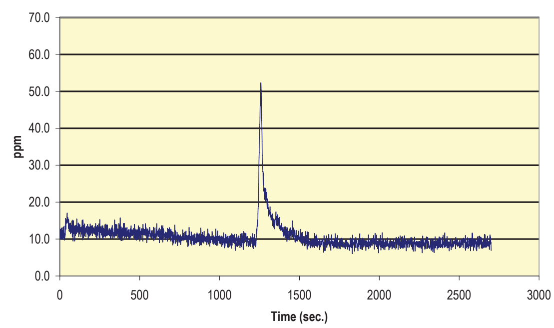

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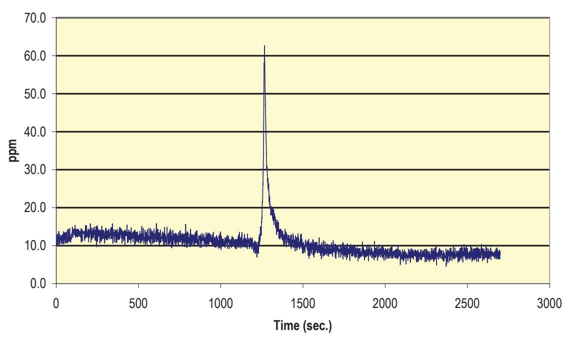

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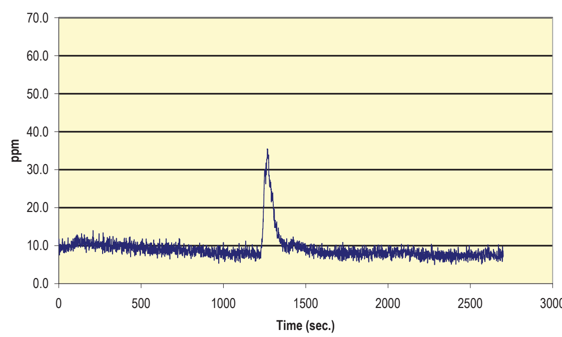

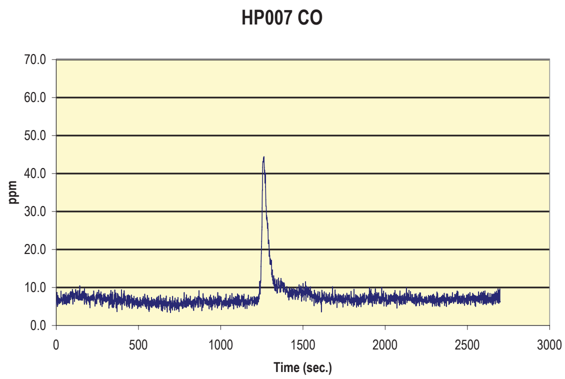
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2500
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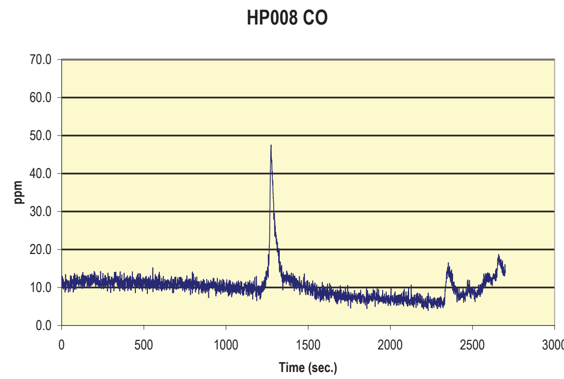
Time (sec.)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2500
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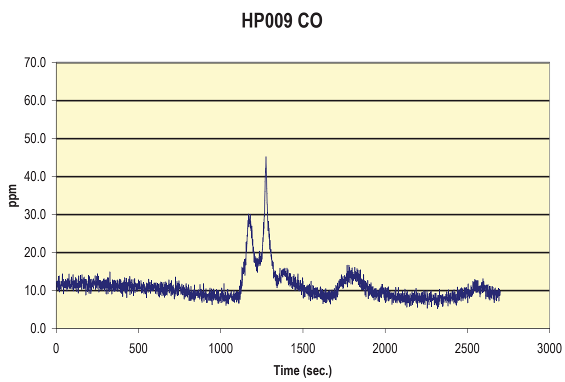
Time (sec.)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2500
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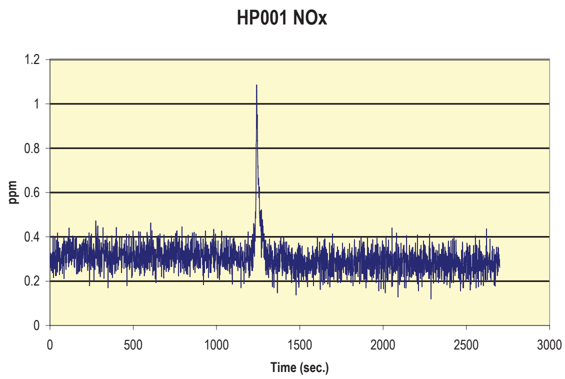
Time (sec.)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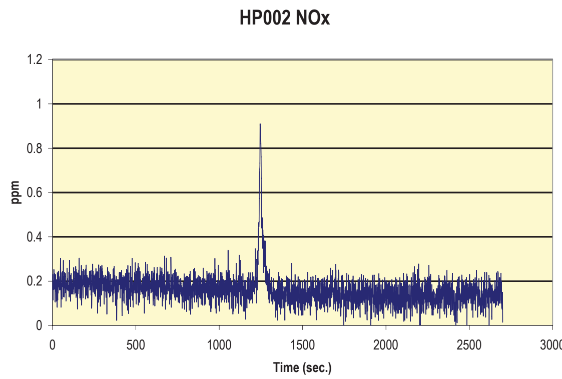
Time (sec.)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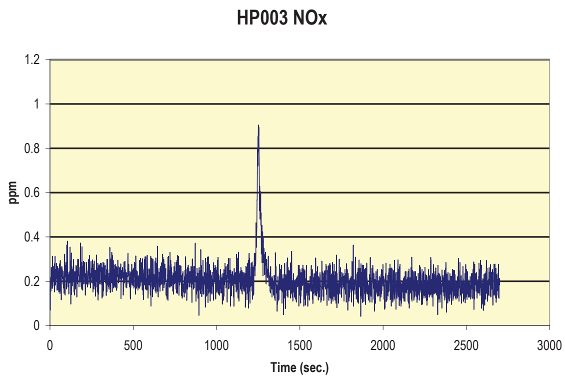
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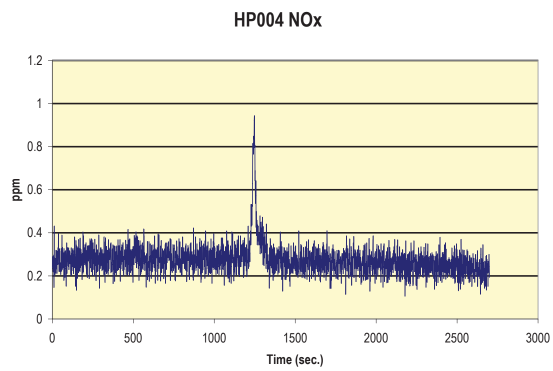
Time (sec.)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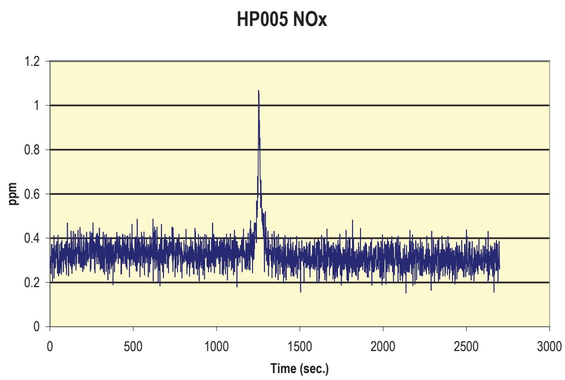
Time (sec.)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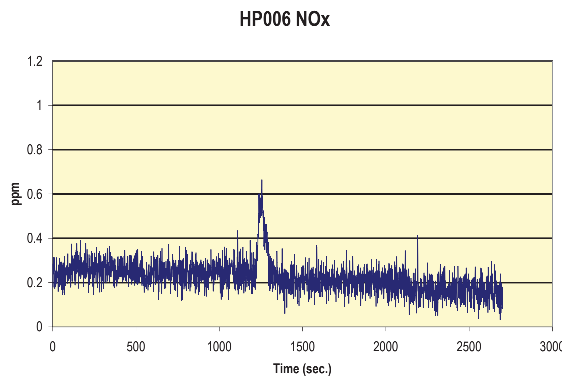
ppm
Time (sec.)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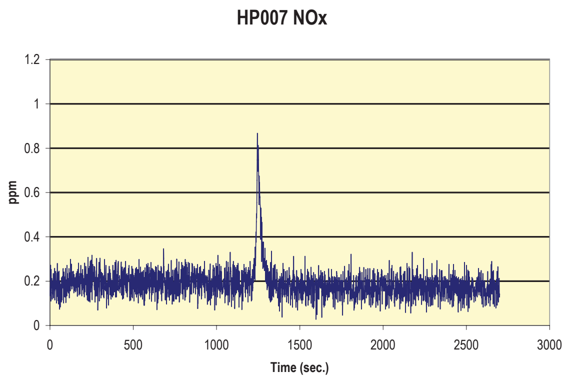
ppm
Time (sec.)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0.6
0.4
0.2
0
0
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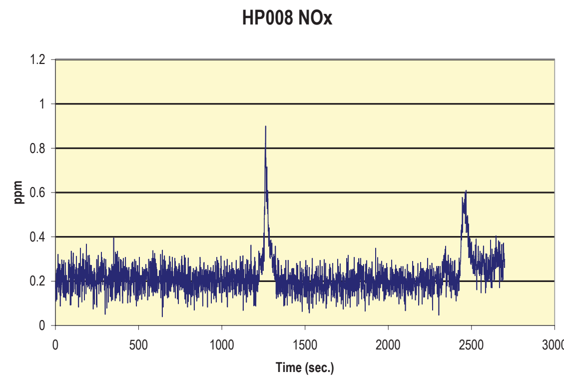
2500
3000
Time (sec.)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ppm
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0.8
0.6
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0.2
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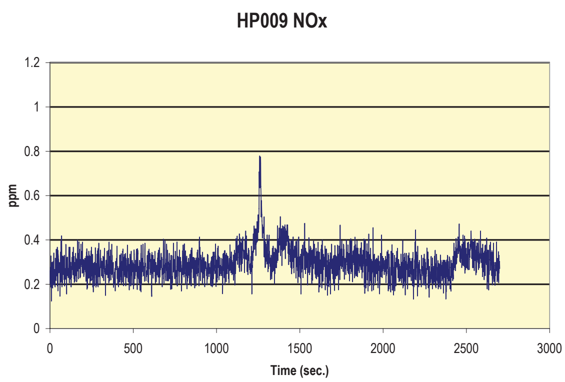
Time (sec.)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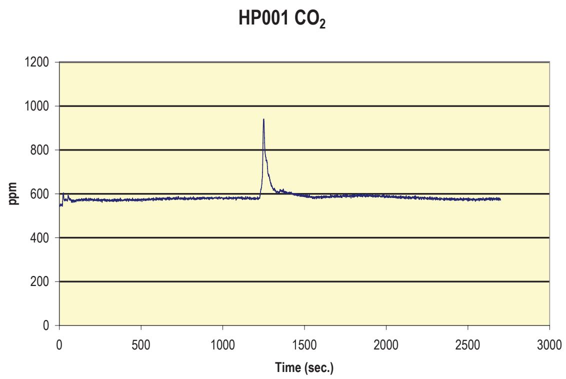
Time (sec.)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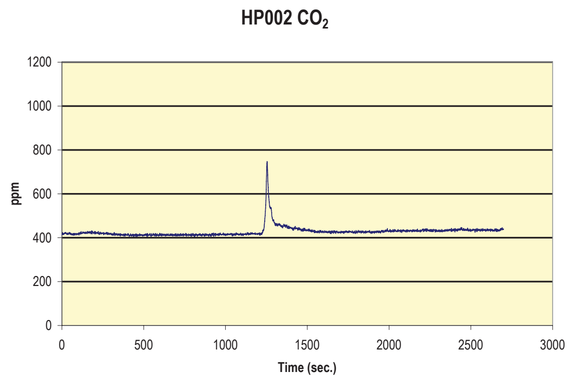
Time (sec.)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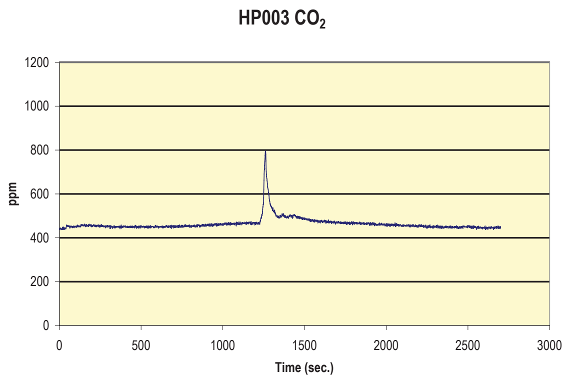
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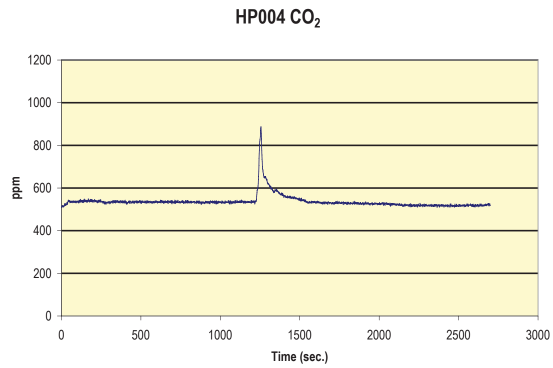
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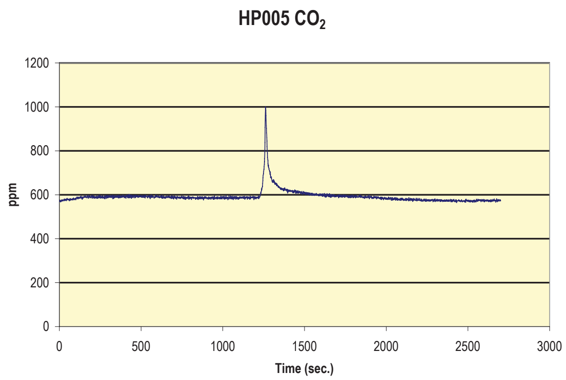
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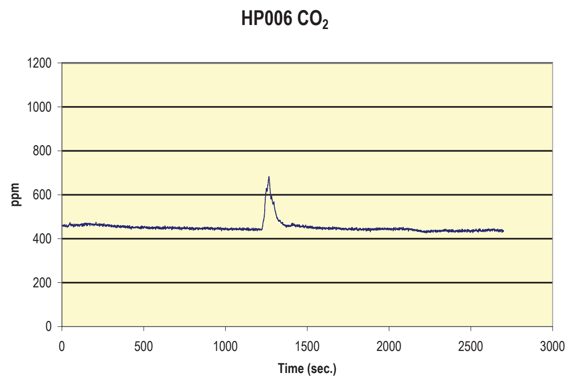
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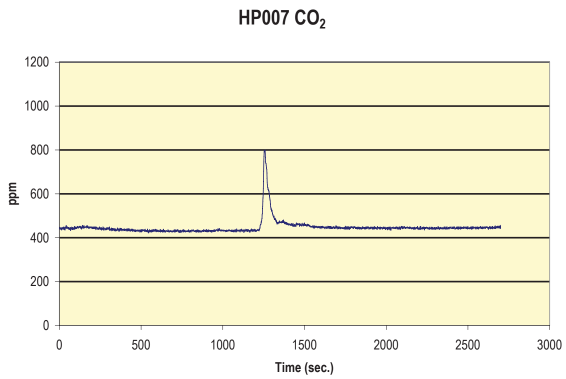
Time (sec.)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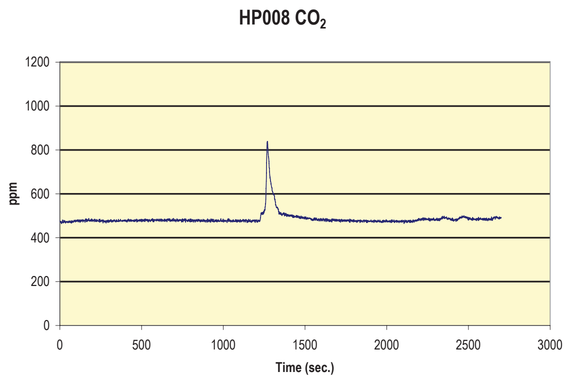
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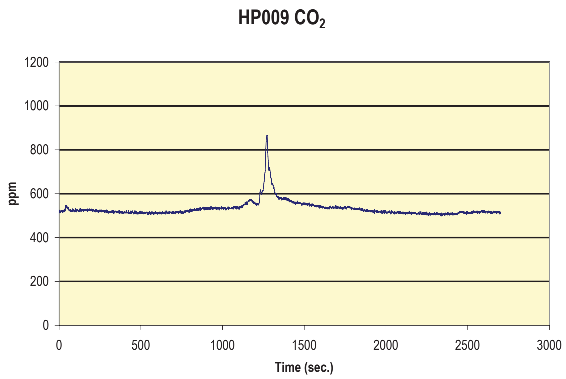
ppm
Time (sec.)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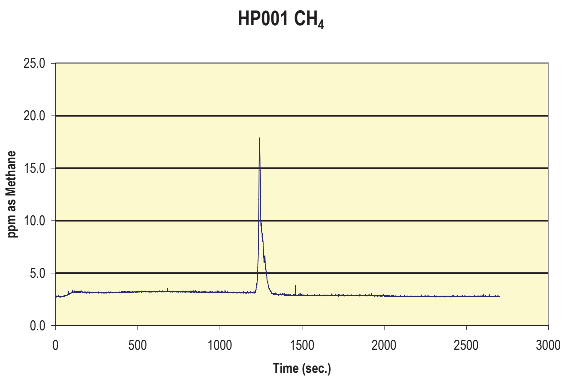
ppm
Time (sec.)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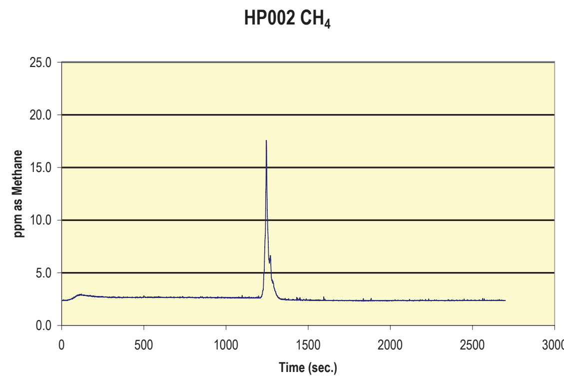
Time (sec.)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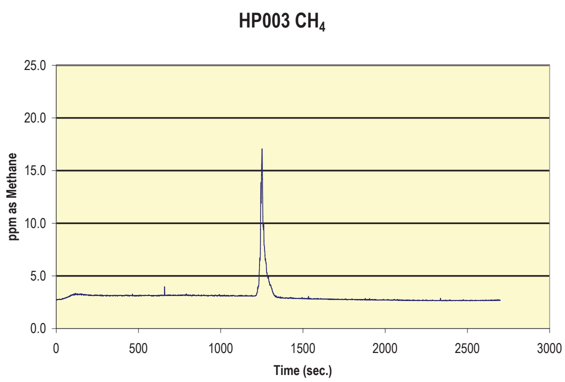
Time (sec.)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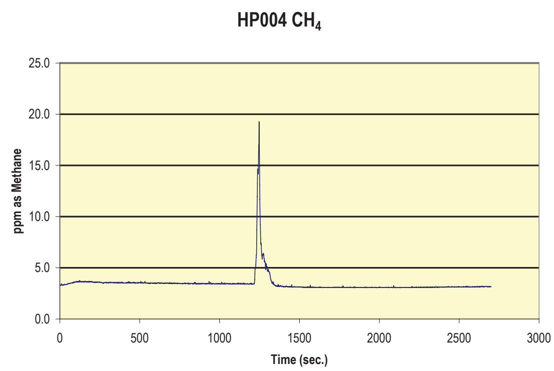
Time (sec.)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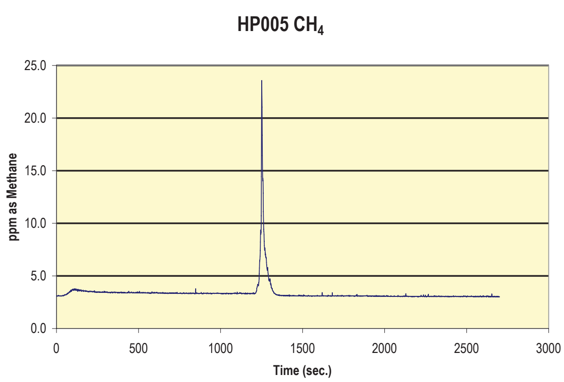
Time (sec.)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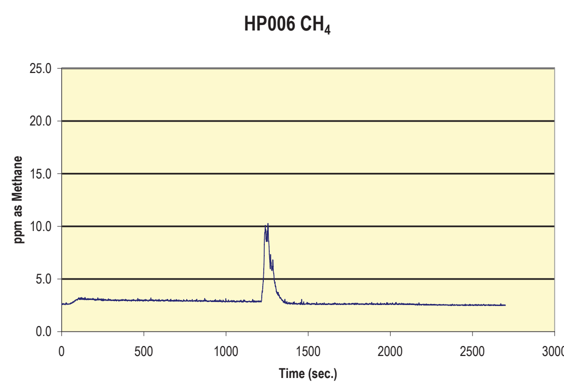
Time (sec.)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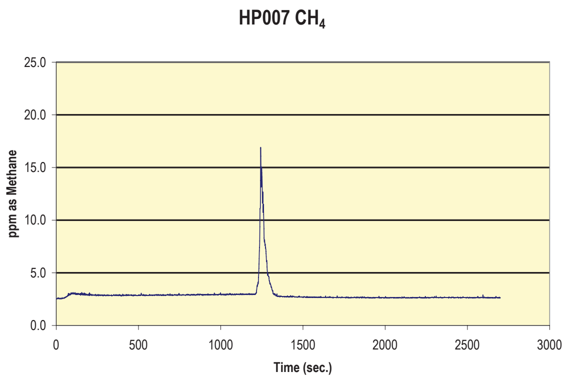
Time (sec.)


HP007 CH_4
ppm as Methane
Time (sec.)
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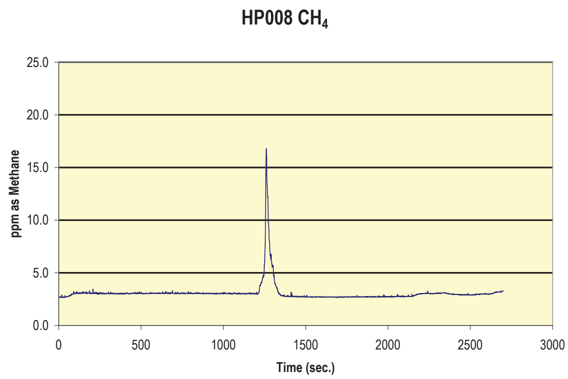
HP008 CH_4
ppm as Methane
Time (sec.)
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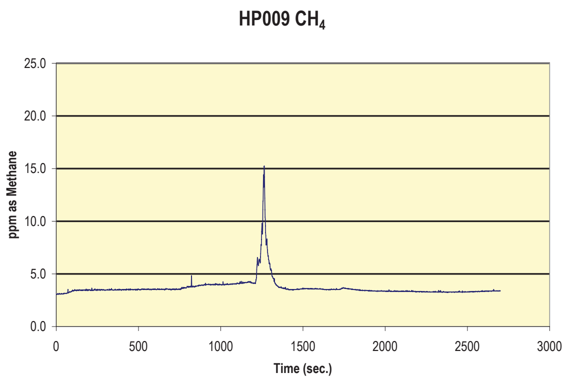
HP009 CH_4
ppm as Methane
Time (sec.)
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15.0
10.0
5.0
0.0
0
500
1000
1500
2000
2500
3000

APPENDIX E ACRONYMS AND ABBREVIATIONS

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ACRONYMS & ABBREVIATIONS

AFS	American Foundry Society
ARDEC	(US) Army Armament Research, Development and Engineering Center
BO	Based on ( ).
BOS	Based on Sand.
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CERP	Casting Emission Reduction Program
CFR	Code of Federal Regulations
CH_4	Methane
CISA	Casting Industry Suppliers Association
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRADA	Cooperative Research and Development Agreement
DOD	Department of Defense
DOE	Department of Energy
EEF	Established Emission Factors
EPA	Environmental Protection Agency
ERC	Environmental Research Consortium
FID	Flame Ionization Detector
GS	Greensand
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC	Hydrocarbon
I	Invalidated Data
Lb/Lb	Pound per Pound of Binder used
Lb/Tn	Pound per Ton of Metal poured
LOI	Loss on Ignition
MB	Methylene Blue
NA	Not Applicable; Not Available
ND	Non-Detect; Not detected below the practical quantitation limit
NMHC	Non-Method Hydro Carbon
NOx	Oxides of Nitrogen
NT	Not Tested - Lab testing was not done

PCS	Pouring, Cooling, Shakeout
POM	Polycyclic Organic Matter
PQL	Practical Quantitation Limits
QA/QC	Quality Assurance/Quality Control
SO_2	Sulfur Dioxide
TA	Target Analyte
TGOC	Total Gaseous Organic Concentration
THC	Total Hydrocarbon Concentration
US EPA	United States Environmental Protection Agency
USCAR	United States Council for Automotive Research
VOST	Volatile Organic Sampling Train
WBS	Work Breakdown Structure