Casting Emission Reduction Program

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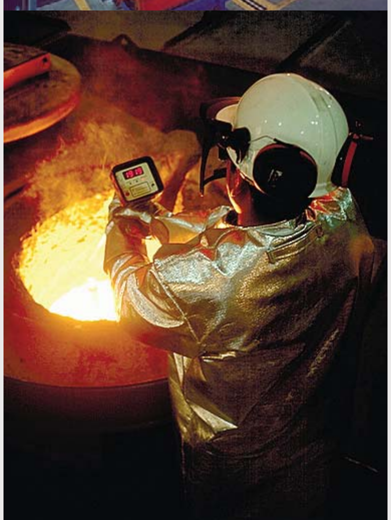

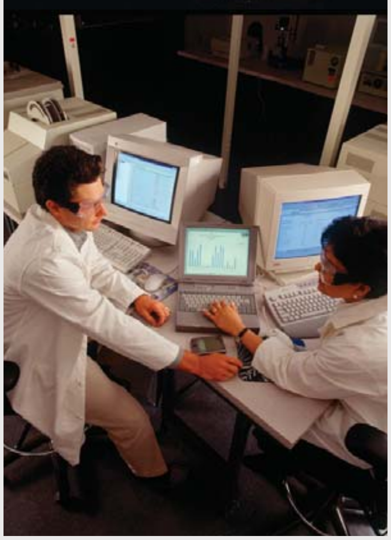

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US Army Contract W15QKN-05-D-0030
FY2006 Tasks
WBS # 1.1.6

Pouring, Cooling, Shakeout Emissions from Shell Step Cores Poured with Iron

1413-116 HM

December 2007
(Revised for public distribution - April 2008)

CISA Casting Industry Suppliers Association

AFS American Foundry Society

Armament Research, Development & Engineering Center, Picatinny, NJ

USCAR United States Council for Automotive Research

DaimlerChrysler Ford GM General Motors

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Pouring, Cooling, Shakeout Emissions from Shell Step Cores Poured with Iron

1413-116 HM

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	*//Origianl 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 HM, a quantitative evaluation of the pouring, cooling and shakeout airborne emissions from phenol-formaldehyde shell resin cores poured with iron. 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. The core binder used for Test HM was a non-hexamethylenetetramine containing shell binder coated onto crystalline silica sand (Technisand™ 630BN Gold, Fairmount Minerals). The concentration was 3% total binder based on sand (BOS). Emission results were compared to the most recent phenolic urethane cold box system tested for iron (Isocure® LF305/52-904GR, Ashland), which has the designation 1413-121 Test HL, runs 1-8. The core binder concentration for Test HL was 1.4% total binder based on sand (BOS) in a 55/45 ratio of Part 1 to Part 2. The binder was activated with triethylamine (TEA).

Molds were poured with iron at 2630 ± 10°F. The pouring time of 13-21 seconds was followed by cooling for an elapsed pouring and cooling time of 45 minutes. This was followed by 5 minutes of shakeout, and a post shakeout cooling period of an additional 25 minutes. Emission samples were continuously collected for the total 75 minute period.

The emissions results were calculated in both pounds of analyte per pound of binder (lb/lb) and pounds of analyte per ton of metal poured (lb/tn). Comparative results between the two tests are reported. All emissions have been background subtracted to provide accurate reporting of results for the tested process only.

Emission Indicators for lb/tn metal for Test HM show statistically significant decreases on average of approximately 65% for Test HM when compared to Test HL as lb/tn metal, as shown in Table 1a, and approximately 80% lower as lb/tn metal as shown in Table 1b. 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, Test HM to Test HL – lb/tn metal

Analyte Name	Reference Test HL	Test HM	Percent Change from Reference
THC as Propane	1.23E+00	6.07E-01	**-51**
Non-Methane Hydrocarbons	1.08E+00	3.95E-01	**-63**
Sum of Target Analytes	6.24E-01	2.67E-01	**-57**
Sum of Target HAPs	5.42E-01	2.35E-01	**-57**
Sum of Target POMs	1.88E-01	2.74E-03	**-99**

Table 1b Average Emission Indicators Summary Table, Test HM to Test HL – lb/lb binder

Analyte Name	Reference Test HL	Test HM	Percent Change from Reference
THC as Propane	1.99E-01	5.42E-02	**-73**
Non-Methane Hydrocarbons	1.75E-01	3.53E-02	**-80**
Sum of Target Analytes	1.01E-01	2.33E-02	**-77**
Sum of Target HAPs	8.74E-02	2.04E-02	**-77**
Sum of Target POMs	3.05E-02	2.41E-04	**-99**

Nine targeted HAP emissions were lower when comparing the shell resin system tested in Test HM to the phenolic urethane cold box system tested under Test HL. The largest decrease of nearly 100% was found for the methylnaphthalenes. Naphthalene showed a similar decrease. Biphenyl, phenol, styrene, and acetaldehyde had decreases ranging from 90 to 60% as lb/tn metal and 94 to 77% as lb/lb binder. Seven target analytes showed increases in emissions from Test HL to Test HM ranging from 25% for ethylbenzene to over 380% for hexane.

A comparative qualitative assessment was made for the surface quality of castings from Test HM to Test HL. A photographic record was made of the 12 castings from cavity 3 of Test HM. Castings made from cores coated with Ashland Velvaplast® and uncoated cores from Test HM were compared to the castings made from cores coated with Foseco Rheotec® XL+ from Test HL. The castings made from uncoated cores from Test HM had more burn-in and a rougher surface than the castings from Test HL. The castings from Test HM made from coated cores had less veining than the castings from Test HL.

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.

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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 developed 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 a shell core binder poured with iron. Cores were in non-seacoal containing greensand molds. Binder concentration was 3.0% BOS.

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 HM was designed to evaluate airborne emissions from pouring, cooling and shakeout of a shell core binder. All cores were uncoated and made with Fairmount Minerals Technisand™ 630BN Gold phenol-formaldehyde shell resin at 3.0 % BOS.

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 Shell cores in greensand without seacoal, Iron, PCS	Uncoated and coated phenolic core in greensand without seacoal, Iron, PCS
Test Plan Number	1413-116 HM	1413-121-HL
Metal Poured	Iron	Iron
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	3% (BOS) Fairmount Minerals Techniset ® 630 BN Gold sand	1.4 % (BOS) Ashland Isocure® 305/904, TEA activated, Wedron 530 sand
Core Coating	None for conditioning or emissions runs, Ashland Velvaplast for one coated core run	Foseco Rheotec® XL+, and Foseco Rheotec® 204P-40
Number of Molds Poured	3 conditioning runs, 9 emissions measurement runs, and 1 run for casting comparison	3 runs with uncoated cores for sand conditioning, 3 sampling runs with cores coated with Foseco Rheotec® XL+, 3 sampling runs with cores coated with Foseco Rheotec® 204P-40, 4 sampling runs with uncoated cores
Test Dates	May 7, 2007 through May 10, 2007	September 26, 2006 through October 4, 2006
Emissions Measured	80 target analytes and TGOC as Propane, CO, CO_2, NOx, SO_2	80 target analytes and TGOC as Propane, CO, CO_2, NOx, SO_2
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

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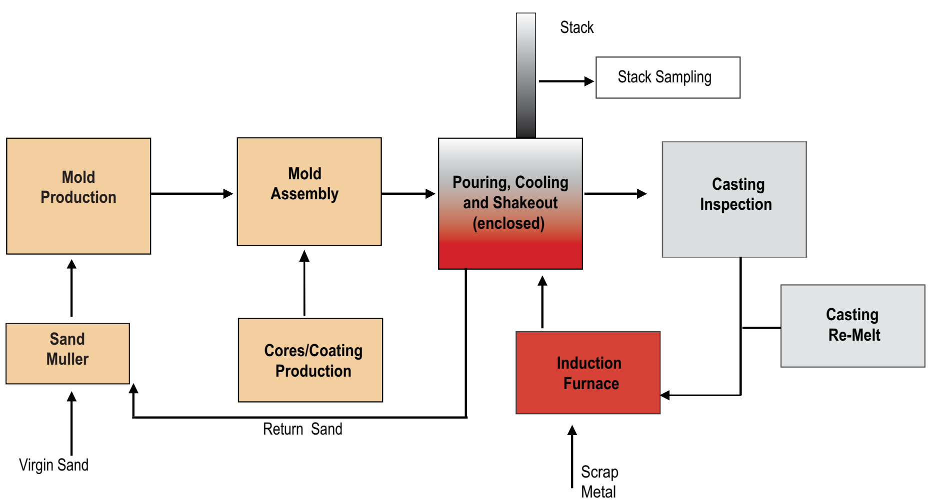
2.0 TEST METHODS, ASSUMPTIONS AND PROCEDURES

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, Pouring, and Shakeout 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 hydrocarbons included several methods. Method 18 is one of the US Environmental Protection Agency's (EPA) promulgated 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 emissions during 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 seventy-nine (79) target compounds using specific collection and analysis 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 in a manner prescribed in 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 was 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 directly subtracting the detected methane from the total hydrocarbon value.

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.

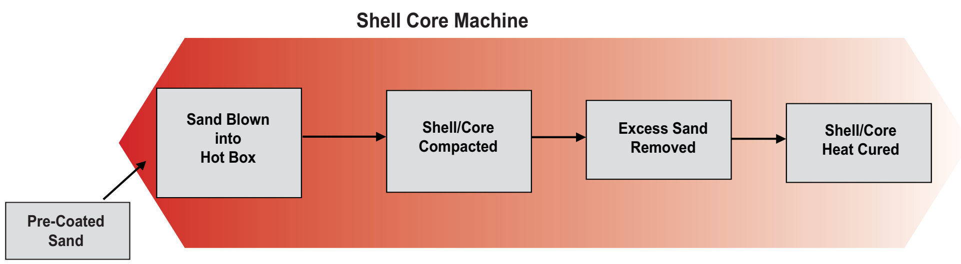
2.2.1. Test Plan Review and Approval

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. Shell cores were produced using a Beardsley and Piper Cormatic Shell core machine, model SF6CA, that was heated using 32 natural gas burners, under 1413-115 Test HO. The shell core making and storage process is shown schematically in Figure 2-2. The greensand molds 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, as was the final casting weight.

Figure 2-2 Shell Core Making/Storage Process



2.2.3. Individual Sampling Events

Test HM was a test designed to determine emissions from a shell core binder poured with iron. Prior to pouring and emission sampling for each run, 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 85° to 90° F. The flow rate of the emission capture air was nominally 600 scfm. Iron at approximately 2630 °F was then poured through an opening in the top of the emission enclosure into the mold, after which the opening was closed (Figure 2-3).

Figure 2-3 Pouring Metal into Mold inside Total Enclosure Hood

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 2-4a). 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 2-4b) located in Technikon's laboratory. This console, or emissions bench, consists of a flame ionization detector based total hydrocarbon analyzer for TGOC analysis, two infrared analyzers (for CO and CO_2) and a chemiluminescence analyzer for NOx.

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

Figure 2-4 Stack Sampling Equipment

a) Sampling Train ***b) E-bench***

Table 2-1 Process Equipment and Methods

Process Parameters	Equipment (Method)
Mold Weight	Cardinal 748E Platform Scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
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.

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 sampling 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.

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 Analytes including HAPs and POMs	US EPA Methods TO17, TO11; NIOSH Methods 2002, 6010, S-347; OSHA Method PV-2003
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.

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.

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3.0 Test Results

Average results for the relative pouring, cooling and shakeout airborne emissions for Test HM are presented in Tables 3-1a and 3-1b, as lb/tn metal and lb/lb binder, respectively. The core binder used for Test HM was a non-hexamethylenetetramine containing shell binder coated onto crystalline silica sand (Technisand™ 630BN Gold, Fairmount Minerals), at a concentration of 3% total binder BOS. Emission results are compared to the most recent phenolic urethane cold box system tested for iron (Isocure® LF305/52-904GR, Ashland), which has the designation 1413-121 Test HL, runs 1-8. The core binder concentration for reference Test HL was 1.4% total binder based on sand (BOS) in a 55/45 ratio of Part 1 to Part 2. The binder was activated with triethylamine (TEA).

Table 3-1a Test HM Comparison Summary of Selected Target Analytes, Average Results – lb/tn metal

Analyte Name	Reference Test HL	Test HM	Percent Change from Reference
Emission Indicators			
THC as Propane	1.23E+00	6.07E-01	**-51**
Non-Methane Hydrocarbons	1.08E+00	3.95E-01	**-63**
Sum of Target Analytes	6.24E-01	2.67E-01	**-57**
Sum of Target HAPs	5.42E-01	2.35E-01	**-57**
Sum of Target POMs	1.88E-01	2.74E-03	**-99**
Selected Target HAPs and POMs			
Benzene	1.20E-01	9.78E-02	**-18**
Phenol	1.14E-01	3.56E-02	**-69**
Naphthalene	7.18E-02	1.70E-03	**-98**
Methylnaphthalene, 2-	5.79E-02	3.32E-04	**-99**
Cresol, o-	3.25E-02	2.59E-02	**-20**
Aniline	3.06E-02	≤PQL	NA
Methylnaphthalene, 1-	2.60E-02	2.98E-04	**-99**
Toluene	1.98E-02	3.75E-02	**89**
Dimethylnaphthalene, 1,3-	9.85E-03	≤PQL	NA
Acetaldehyde	9.51E-03	4.02E-03	**-58**
Xylene, mp-	6.84E-03	1.53E-02	**124**
o-Toluidine	6.60E-03	NT	NA
Cresol, mp-	5.89E-03	6.99E-03	19
Dimethylnaphthalene, 2,7-	5.74E-03	≤PQL	NA
Dimethylnaphthalene, 1,6-	4.61E-03	≤PQL	NA
Dimethylnaphthalene, 2,3-	3.93E-03	≤PQL	NA
Dimethylnaphthalene, 2,6-	3.47E-03	≤PQL	NA
Biphenyl	2.35E-03	2.93E-04	**-88**
Dimethylnaphthalene, 1,2-	2.28E-03	≤PQL	NA
Xylene, o-	1.55E-03	1.93E-03	**25**
Dimethylnaphthalene, 1,5-	1.29E-03	≤PQL	NA
Styrene	1.21E-03	4.64E-04	**-62**
Trimethylnaphthalene, 2,3,5-	1.18E-03	≤PQL	NA
Triethylamine	9.08E-04	NT	NA
Ethylbenzene	9.04E-04	1.13E-03	**25**
Formaldehyde	8.15E-04	2.12E-03	**160**
Hexane	6.46E-04	3.14E-03	**386**
Propionaldehyde (Propanal)	3.90E-04	6.00E-04	**54**
Acenaphthalene	≤PQL	4.05E-04	NA
Additional Selected Target Analytes			
Trimethylbenzene, 1,2,4-	2.80E-02	1.67E-03	**-94**
Ethyltoluene, 3-	1.32E-02	5.08E-04	**-96**
Ethyltoluene, 2-	5.85E-03	2.87E-04	**-95**
Dodecane	5.37E-03	6.11E-04	**-89**
Dimethylphenol, 2,4-	4.89E-03	3.36E-03	-31
Indene	4.36E-03	6.06E-04	**-86**
Propylbenzene, n-	4.08E-03	≤PQL	NA
Dimethylphenol, 2,6-	4.04E-03	3.88E-03	-4
Undecane	3.71E-03	4.25E-04	**-89**
Tetradecane	2.58E-03	4.34E-04	**-83**
2-Butanone (MEK)	2.33E-03	3.20E-04	**-86**
Trimethylbenzene, 1,2,3-	1.97E-03	3.38E-04	-83
Butyraldehyde/Methacrolein	4.77E-04	4.74E-04	-1
Trimethylbenzene, 1,3,5-	3.75E-04	≤PQL	NA
Crotonaldehyde	2.75E-04	≤PQL	NA
Benzaldehyde	≤PQL	2.19E-04	NA
Decane	≤PQL	6.62E-04	NA
Nonane	≤PQL	8.70E-04	NA
Heptane	≤PQL	1.10E-03	NA
Octane	≤PQL	1.27E-03	NA
Ammonia	NT	1.44E-02	NA
Tridecane	NT	5.26E-04	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	3.50E+00	4.47E+00	**28**
Carbon Monoxide	2.01E+00	3.19E+00	**59**
Methane	1.46E-01	2.12E-01	**45**
Sulfur Dioxide	1.12E-02	9.23E-03	**-17**
Nitrogen Oxides	≤PQL	≤PQL	NA

NT= Not Tested

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 α =0.05

Table 3-1b Test HM Comparison Summary of Selected Target Analytes, Average Results – lb/lb binder

Analyte Name	Reference Test HL	Test HM	Percent Change from Reference
Emission Indicators			
THC as Propane	1.99E-01	5.42E-02	**-73**
Non-Methane Hydrocarbons	1.75E-01	3.53E-02	**-80**
Sum of Target Analytes	1.01E-01	2.33E-02	**-77**
Sum of Target HAPs	8.74E-02	2.04E-02	**-77**
Sum of Target POMs	3.05E-02	2.41E-04	**-99**
Selected Target HAPs and POMs			
Benzene	1.94E-02	8.48E-03	**-56**
Phenol	1.85E-02	3.09E-03	**-83**
Naphthalene	1.17E-02	1.47E-04	**-99**
Methylnaphthalene, 2-	9.39E-03	2.88E-05	**-100**
Cresol, o-	5.28E-03	2.23E-03	**-58**
Aniline	4.49E-03	≤PQL	NA
Methylnaphthalene, 1-	4.21E-03	1.74E-05	**-100**
Toluene	3.21E-03	3.25E-03	**1**
Dimethylnaphthalene, 1,3-	1.60E-03	≤PQL	NA
Acetaldehyde	1.54E-03	3.49E-04	**-77**
Xylene, mp-	1.11E-03	2.29E-05	**-98**
o-Toluidine	9.71E-04	NT	NA
Cresol, mp-	9.58E-04	6.03E-04	**-37**
Dimethylnaphthalene, 2,7-	9.32E-04	≤PQL	NA
Dimethylnaphthalene, 1,6-	7.48E-04	≤PQL	NA
Dimethylnaphthalene, 2,3-	6.38E-04	≤PQL	NA
Dimethylnaphthalene, 2,6-	5.65E-04	≤PQL	NA
Biphenyl	3.82E-04	2.11E-05	**-94**
Dimethylnaphthalene, 1,2-	3.69E-04	≤PQL	NA
Xylene, o-	2.51E-04	1.33E-03	**429**
Dimethylnaphthalene, 1,5-	2.10E-04	≤PQL	NA
Styrene	1.96E-04	4.03E-05	**-79**
Trimethylnaphthalene, 2,3,5-	1.95E-04	≤PQL	NA
Triethylamine	1.50E-04	NT	NA
Ethylbenzene	1.47E-04	9.78E-05	**-33**
Formaldehyde	1.32E-04	1.84E-04	**39**
Hexane	1.04E-04	2.70E-04	**159**
Propionaldehyde (Propanal)	6.33E-05	5.20E-05	**-18**
Acenaphthalene	≤PQL	3.52E-05	NA
Additional Selected Target Analytes			
Trimethylbenzene, 1,2,4-	4.55E-03	2.93E-05	**-99**
Ethyltoluene, 3-	2.14E-03	4.50E-05	**-98**
Ethyltoluene, 2-	9.50E-04	2.49E-05	**-97**
Dodecane	8.70E-04	5.29E-05	**-94**
Dimethylphenol, 2,4-	7.99E-04	2.88E-04	**-64**
Indene	7.08E-04	5.44E-05	**-92**
Propylbenzene, n-	6.63E-04	≤PQL	NA
Dimethylphenol, 2,6-	6.61E-04	3.33E-04	**-50**
Undecane	6.05E-04	≤PQL	NA
Tetradecane	4.18E-04	3.76E-05	**-91**
2-Butanone (MEK)	3.78E-04	2.78E-05	**-93**
Trimethylbenzene, 1,2,3-	3.22E-04	4.55E-05	**-86**
Butyraldehyde/Methacrolein	7.74E-05	4.11E-05	**-47**
Trimethylbenzene, 1,3,5-	6.06E-05	1.45E-04	139
Crotonaldehyde	4.45E-05	≤PQL	NA
Benzaldehyde	≤PQL	6.42E-06	NA
Decane	≤PQL	5.74E-05	NA
Heptane	≤PQL	9.51E-05	NA
Nonane	≤PQL	7.55E-05	NA
Octane	≤PQL	1.10E-04	NA
Ammonia	NT	7.13E-04	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	5.68E-01	4.00E-01	**-30**
Carbon Monoxide	3.27E-01	2.85E-01	**-13**
Methane	2.37E-02	1.89E-02	**-20**
Sulfur Dioxide	1.81E-03	8.04E-04	**-56**
Nitrogen Oxides	≤PQL	≤PQL	NA

NT= Not Tested

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 α =0.05

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 plus methane averages approximately 78% of TGOC as Propane results adjusted by addition of less responsive target compounds such as aldehydes and ketones.

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-methane hydrocarbon (NMHC) as determined by CTM-042. The second section of the table includes average emission results for individual HAP and POM compounds selected as target analytes, while the third section contains results for additional speciated compounds that are not HAPs or POMs but may be on the EPA SARA 313 list of toxic chemicals, such as ammonia. 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 fourth section of the tables.

Speciated results presented in the tables of this report, including those gases measured continuously on-line in real time at Technikon during both Test HM and Test HL, 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 HL to Test HM. 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 HM 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 was made to verify the effectiveness of controlling these influences. This was 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 indicated 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 targeted for collection and analyses from airborne emissions for this test were chosen based on the chemistry of the binder under investigation as well as analytes historically targeted. The fundamental analyte lists were similar for Test HM and Test HL, differing based on the chemistries of the different binder systems. Triethylamine (TEA), along with dimethylaniline and o-toluidine, were also targeted for Test HL. TEA was specifically targeted for analysis since it was the gas used for curing the binder used for Test HL, but was not targeted for analysis for Test HM since no TEA source was present. Hydrogen cyanide and ammonia were additionally targeted for Test HM.

Confirmatory GC/MS analysis showed nearly 200 peaks in the chromatogram, although the majority of the hydrocarbon concentration (as determined by peak area) was for benzene, toluene, phenol, o-cresol, and p-xylene. These compounds accounted for 71% of the peak area, and 79% of the measured emission concentration as determined by speciated target analysis summarized in Tables 3-1a and 3-1b. The next 26 compounds found in the GC/MS chromatogram accounted for approximately 19% of the remaining peak area. The 26 total GC/MS compounds accounting for 90% of the peak area are summarized in Table 3-2. Some of the compounds found in the GC/MS results and included in the table were in addition to those pre-selected for collection and analysis, and included two siloxane compounds (most likely from the release agent used), and four C_4 benzene compounds.

Table 3-2 Compounds which account for 90% of emissions of Test HM as determined by peak area from GC/MS Analysis (listed in decreasing order).

Benzene
Toluene
Phenol
Cresol,-o
Xylene, -p
Cyclotrisiloxane, hexamethyl-
Cresol, -p
Benzene, 1,3,5-trimethyl-
Cyclotetrasiloxane, octamethyl-
Phenol, 2,6-dimethyl-
Phenol, 2,4-dimethyl-
Xylene, o-
Hexane
Heptane
Benzene, 1,3,5-trimethyl-
Ethylbenzene
Benzofuran
C_4 benzene - isomer 1
Ether, hexyl pentyl
C_4 benzene - isomer 2
Hexane, 2,3,4-trimethyl-
C_4 benzene - isomer 3
Hexane, 2,4-dimethyl-
3-ethyltoluene
Isopropylbenzene
C_4 benzene - isomer 4

Figures 3-1a to 3-4b graphically present the data from Tables 3-1a and 3-1b for Test HM and Test HL for the five emissions indicators, selected individual HAP, target analyte, and criteria pollutant and greenhouse gas emissions as both lb/tn of metal and lb/lb of binder.

Figure 3-1a Comparison of Emissions Indicators of Test HM to Reference Test HL, Average Results- lb/tn Metal

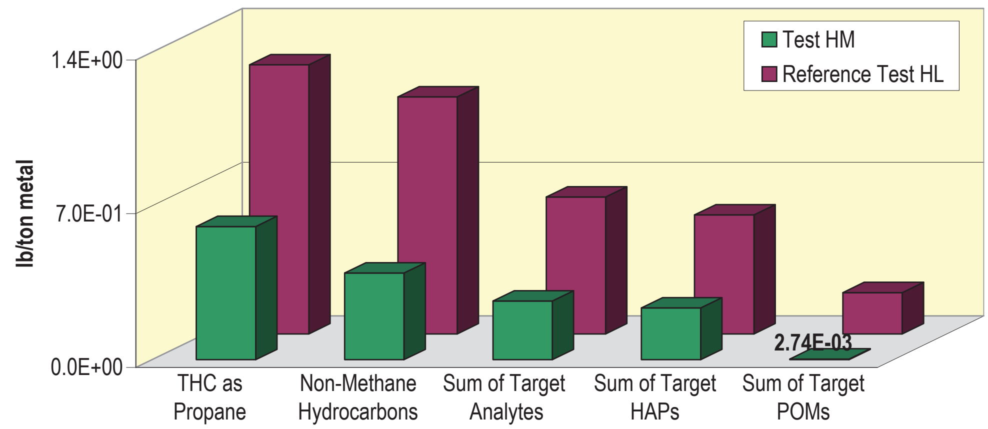


Figure 3-2a Comparison of Selected HAP and POM Emissions of Test HM to Reference Test HL, Average Results – lb/tn Metal

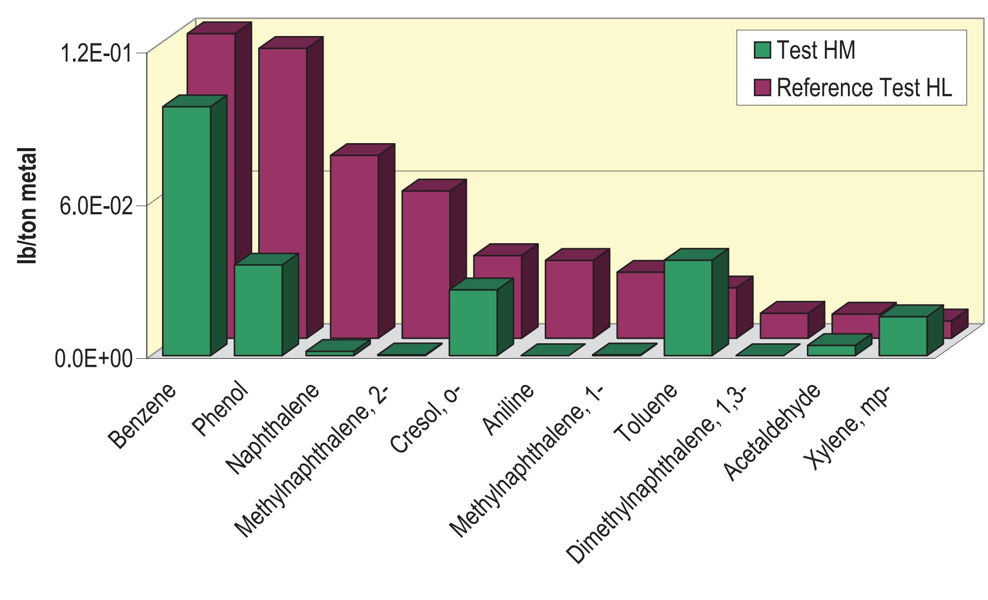


Figure 3-3a Comparison of Selected Target Analyte Emissions of Test HM to Reference Test HL, Average Results – lb/tn Metal

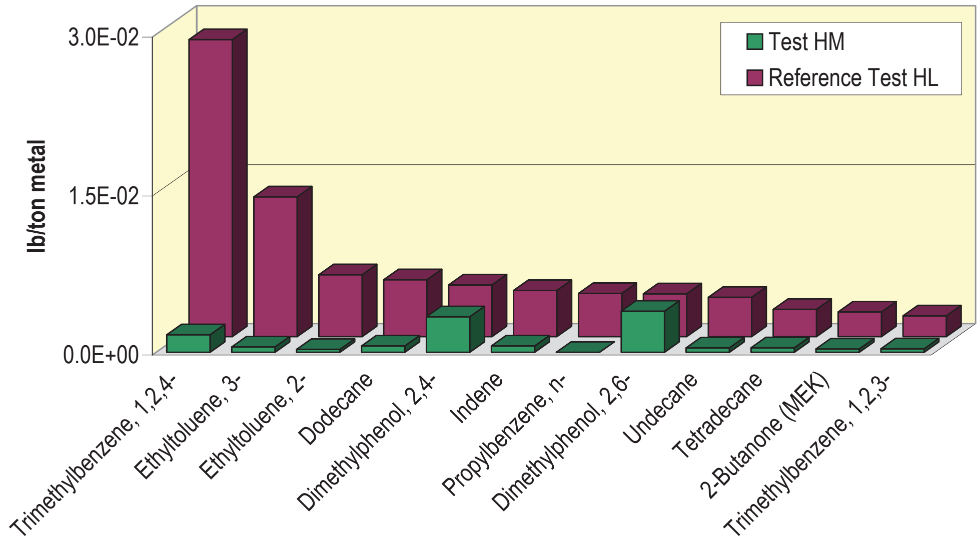


Figure 3-4a Comparison of Criteria Pollutants and Greenhouse Gases of Test HM to Reference Test HL, Average Results – lb/tn Metal

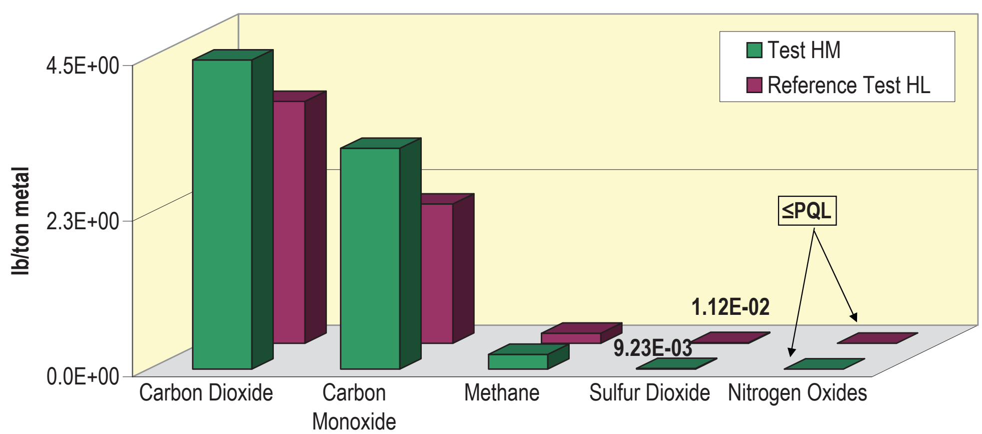


Figure 3-1b Comparison of Emissions Indicators of Test HM to Reference Test HL, Average Results- lb/lb binder

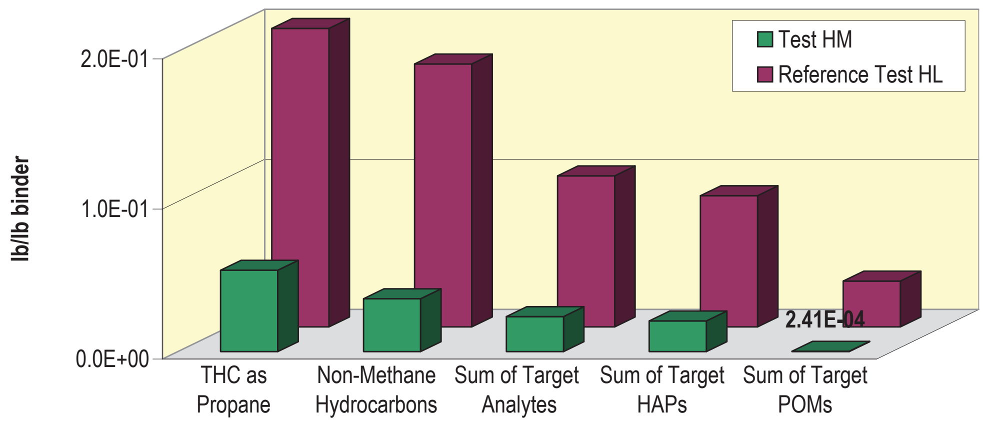


Figure 3-2b Comparison of Selected HAP and POM Emissions of Test HM to Reference Test HL, Average Results – lb/lb binder

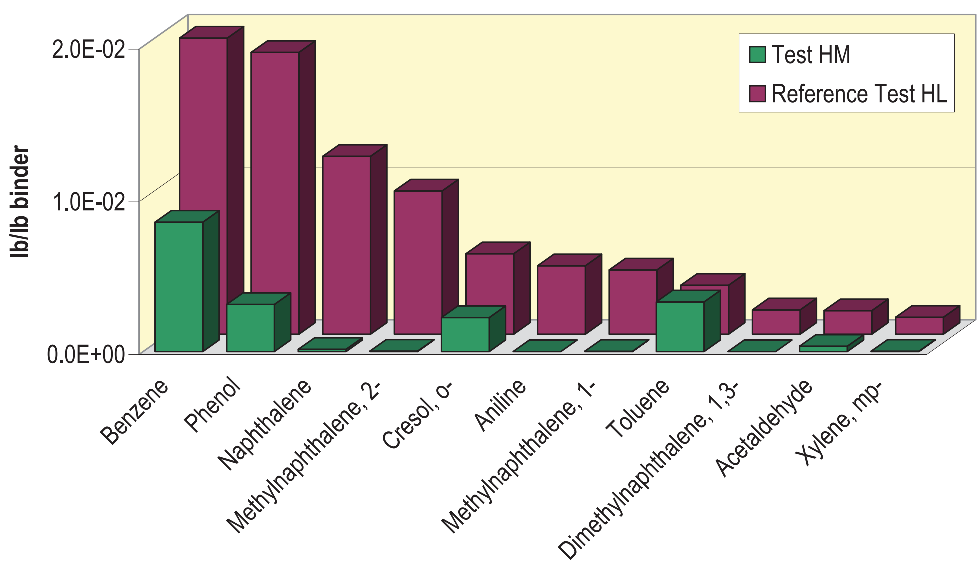


Figure 3-3b Comparison of Selected Target Analyte Emissions of Test HM to Reference Test HL, Average Results – lb/lb binder

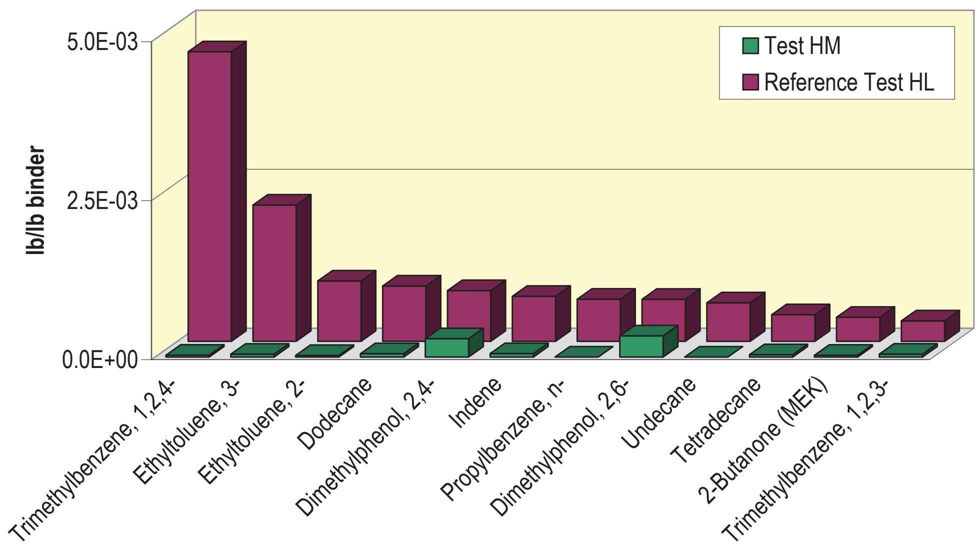
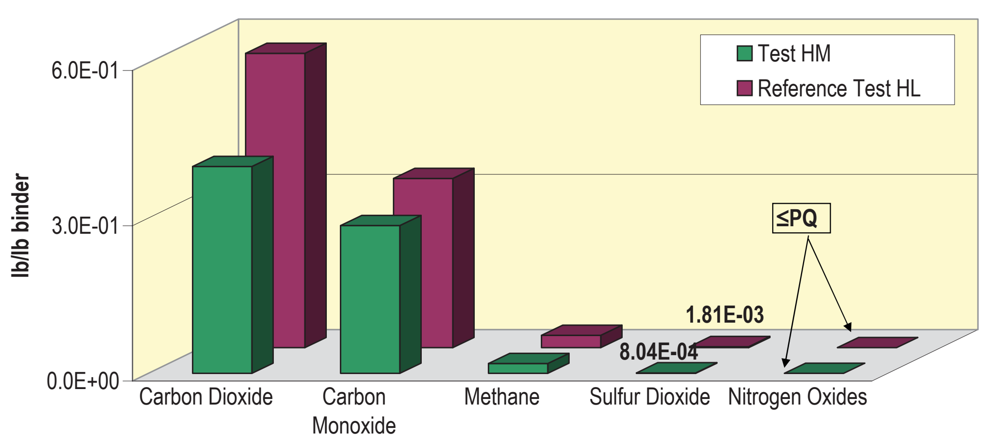


Figure 3-4b Comparison of Criteria Pollutants and Greenhouse Gases of Test HM to Reference Test HL, Average Results – lb/lb binder



Emission Indicators for lb/tn metal for Test HM show statistically significant decreases on average of approximately 65% for Test HM when compared to Test HL as lb/tn metal, as shown in Table 3-1a, and approximately 80% lower as lb/lb binder as shown in Table 3-1b. The biggest single change was in the Sum of Target POMs, which showed a relative decrease of approximately 99%.

Nine targeted HAP emissions were lower when comparing the shell resin system tested in Test HM to the phenolic urethane cold box system testing under Test HL. The largest decrease of nearly 100% was found for the methylnaphthalenes. Naphthalene showed a similar decrease. Biphenyl, phenol, styrene, and acetaldehyde had decreases ranging from 90 to 60% as lb/tn metal and 94 to 77% as lb/lb binder. Seven target analytes showed increases in emissions from Test HL to Test HM ranging from 25% for ethylbenzene to over 380% for hexane.

The additional targeted analytes given in the third section of Table 3-1a and Table 3-1b, show decreases averaging 90% as lb/tn metal and 83% as lb/lb binder. None of the additional targeted analytes showed a statistically relevant increase in emissions.

Of the 79 individual Target Analytes sampled by adsorption tube from Test HM (excluding criteria pollutants and greenhouse gases), only 38 contributed to emissions above the PQL. Of the 33 HAPs targeted for analysis, 18 contributed to emissions above the PQL. Benzene, toluene, phenol, o-cresol, and p-xylene, acetaldehyde and hexane accounted for approximately 85% of the measured emissions. The remaining compounds contributed less than 1% each to total emissions.

The top non-HAP contributors for Test HM were ammonia at 5%, followed by 2,4- and 2,6-dimethylphenols at slightly over 1% each. All remaining compounds contributed less than 1% to total emissions.

The average process parameters measured and recorded for Test HM are reported in Table 3-3.

Table 3-3 Summary of Test Plan Average Process Parameters

	Test HL	Test HM
Test Dates	10/3/06-10/4/06	5/7/07-5/10/07
Cast weight, lbs.	124.94	113.88
Pouring time, sec.	14	15
Pouring temp ,°F	2634	2631
Pour hood process air temp at start of pour, °F	88	87
Mixer auto dispensed sand weight, Lbs	50.4	NA
Core binder weight part 1, g	175.7	NA
Core binder weight part 2, g	144.2	NA
Core binder weight, g	319.9	NA
% core binder (BOS)	1.40	3
% core binder, actual	1.38	3
Total core weight in mold, lbs.	27.88	21.88
Total binder weight in mold, lbs.	0.38	0.64
Core LOI, %	1.11	2.85
2 hour core dogbone tensile, psi	224.5	NT
Core age when poured, hrs.	39	317
Muller batch weight, lbs.	906	903
GS mold sand weight, lbs.	624	626
Mold temperature, °F	85	86
Average green compression , psi	21.94	22.16
GS compactability, %	44	42
GS moisture content, %	2.07	1.86
GS MB clay content, %	7.14	6.99
MB clay reagent, ml	37.4	34.9
1800°F LOI - mold sand, %	0.8498	0.9896
900°F volatiles , %	0.43	0.50
Permeability index	245	240
Sand temperature, °F	85	88

Test HL=Greensand PCS with Phenolic Urethane Ashland 305/904 Cores

Test HM=Greensand PCS with 630BN Gold Shell cores

Castings were selected from Test HM and Test HL for quality comparison purposes. The twelve castings made from cores coated with Foseco Rheotec® XL+ were chosen from Test HL. Twelve castings, one each from cavity 3 of each mold made with uncoated cores, were chosen from Test HM. Four more castings from each mold made from cores coated with Ashland Velvaplast® from Test HM were also used for comparison.

Three benchmark visual casting quality rankings consisting of the best, the median, and the worst casting were assigned to three of the castings from the baseline Test HL and Test HM. The "best" designation means that the internal surface of a casting is the best appearing of the lot of 12, and was 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. In the case of only 4 castings being ranked, the "best" casting would also be given the rank of 1, the "median" casting the rank of 2, and the "worst" casting the rank of 4.

The twelve castings from Test HM were compared to the benchmark castings from Test HL. The results are shown in Tables 3-4. The castings from Test HL had less burn-in and a smoother surface than the castings from uncoated cores used in Test HM. The four castings of coated cores made for Test HM were compared to the same three benchmark castings and ranked. These are shown in Table 3-5. The castings made from coated cores in Test HM had less veining than the castings made from coated cores in Test HL.

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,

Table 3-4 Rank Order of Casting Appearance – Uncoated Core

	Coated PU Cores		Uncoated Shell Cores		
Overall Rank Order of Appearance	Sample Number	Cavity Number	Sample Number	Cavity Number	Test Rank Comparative
Rank 1	HL022	2			HL Best
Rank 2	HL020	4			HL Median
Rank 3	HL021	1			HL Worst
Rank 4			HM005	3	HM Best
Rank 5			HMCR3	3	
Rank 6			HMCR2	3	
Rank 7			HM009	3	
Rank 8			HM008	3	
Rank 9			HMCR1	3	
Rank 10			HM003	3	HM Median
Rank 11			HM002	3	
Rank 12			HM007	3	
Rank 13			HM001	3	
Rank 14			HM004	3	
Rank 15			HM006	3	HM Worst

Table 3-5 Rank Order of Casting Appearance – Coated Core

	Coated PU Cores		Coated Shell Cores		
Overal Rank Order of Appearance	Sample Number	Cavity Number	Sample Number	Cavity Number	Test Rank Comparative
Rank 1			HM013	2	HM Best
Rank 2			HM013	3	HM Median
Rank 3	HL022	2			HL Best
Rank 4			HM013	4	
Rank 5	HL020	4			HL Median
Rank 6			HM013	1	HM Worst
Rank 7	HL021	1			HL Worst

instructions, and the sampling plans for Test HK and Test HM. 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/tn 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. These charts have not been background corrected. Appendix E contains acronyms and abbreviations.

Appendix A Test and Sample Plans and Process Instructions

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TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1413 **TASK NUMBER** 121 **SERIES** HL
- **SITE:** Research Foundry
- **TEST TYPE:** PCS, of uncoated Ashland Isocure 305/904 phenolic urethane cores and coated Ashland Isocure 305/904 phenolic urethane cores in greensand, Iron
- **METAL TYPE:** Iron
- **MOLD TYPE:** 4-on stepcore
- **NUMBER OF MOLDS:** 3 conditioning, 8 uncoated core emissions runs, 6 coated core emissions runs (3 of each kind of Rheotec®)
- **CORE TYPE:** Ashland Isocure 305/904 Phenolic Urethane
- **CORE COATING:** Rheotec® XL+, Rheotec® 204P
- **SAMPLE EVENTS:** 14
- **TEST DATE(S):** **START:** 9/25/06
  FINISH: 10/06/06

TEST OBJECTIVES:

Measure selected PCS HAP & VOC emissions, CO, CO_2, NOx, and TGOC from pouring cooling and shakeout of coated and uncoated 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. One coating is a insulating coating, while the other is a standard coating.

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 iron at 2630±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. The coated cores will be dried in the OSI oven, while the uncoated cores will not be.

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 1300 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with 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.

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
9/26/2006											
CONDITIONING - 1											
THC, CH4, CO, CO_2 & NOx	HL CR-1	X									TOTAL

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
9/26/2006											
CONDITIONING - 2											
THC, CH4, CO, CO_2 & NOx	HL CR-2	X									TOTAL

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
9/26/2006											
CONDITIONING - 3											
THC, CH4, CO, CO_2 & NOx	HL CR-3	X									TOTAL

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/3/2006											
THC, CH4, CO, CO_2 & NOx	HL001	X									TOTAL
TO-17	HL00101		1						60	1	Carbopak charcoal
TO-17	HL00102					1			60	1	Carbopak charcoal
TO-17 MS	HL00103		1						60	2	Carbopak charcoal
TO-17 MS	HL00104			1					60	3	Carbopak charcoal
TO-17	HL00105				1				0		Carbopak charcoal
NIOSH 2002	HL00106		1						500	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00107			1					500	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00108				1				0		150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00109		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00110			1					1000	7	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00111				1				0		100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00112		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00113				1				0		100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL00114		1						800	9	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00115				1				0		150/75 mg Silica Gel (SKC 226-10)
TO11	HL00116		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HL00117			1					1000	11	DNPH Silica Gel (SKC 226-119)
TO11	HL00118				1				0		DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
10/3/2006											
THC, CH4, CO, CO_2 & NOx	HL002	X									TOTAL
TO-17	HL00201		1						60	1	Carbopak charcoal
TO-17	HL00202			1					60	2	Carbopak charcoal
NIOSH 2002	HL00203		1						100	3	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00204			1					100	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00205		1						500	5	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00206		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00207		1						1000	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00208			1					1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL00209		1						800	9	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00210			1					800	10	150/75 mg Silica Gel (SKC 226-10)
TO11	HL00211		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/3/2006											
THC, CH4, CO, CO_2 & NOx	HL003	X									TOTAL
TO-17	HL00301		1						60	1	Carbopak charcoal
NIOSH 2010	HL00302		1						100	2	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00303			1					100	3	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL00304		1						200	4	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00305			1					200	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Blocked
NIOSH 2002	HL00306		1						500	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00307		1						800	8	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00308		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00309		1						1000	10	100/50 mg Charcoal (SKC 226-01)
TO11	HL00310		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
10/3/2006											
THC, CH4, CO, CO_2 & NOx	HL004	X									TOTAL
TO-17	HL00401		1						60	1	Carbopak charcoal
TO-17	HL00402		1						200	2	Carbopak charcoal
TO-17	HL00403					1			200	2	Carbopak charcoal
TO-17	HL00404			1					200	3	Carbopak charcoal
TO-17	HL00405					1			200	3	Carbopak charcoal
OSHA ID200	HL00406		1						200	4	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00407			1					200	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Blocked
NIOSH 2002	HL00408		1						500	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00409		1						800	8	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00410		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00411		1						1000	10	100/50 mg Charcoal (SKC 226-01)
TO11	HL00412		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/4/2006											
THC, CH4, CO, CO_2 & NOx	HL005	X									TOTAL
TO-17	HL00501		1						60	1	Carbopak charcoal
TO-17	HL00502		1						20	2	Carbopak charcoal
TO-17	HL00503			1					20	3	Carbopak charcoal
TO11	HL00504		1						200	4	DNPH Silica Gel (SKC 226-119)
TO11	HL00505			1					200	5	DNPH Silica Gel (SKC 226-119)
	Excess								1000	6	Blocked
NIOSH 2002	HL00506		1						500	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00507		1						800	8	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00508		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00509		1						1000	10	100/50 mg Charcoal (SKC 226-01)
TO11	HL00510		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/4/2006											
THC, CH4, CO, CO_2 & NOx	HL006	X									TOTAL
TO-17	HL00601		1						60	1	Carbopak charcoal
NIOSH 2002	HL00602		1						500	2	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00603		1						800	3	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00604		1						1000	4	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00605		1						1000	5	100/50 mg Charcoal (SKC 226-01)
TO11	HL00606		1						1000	6	DNPH Silica Gel (SKC 226-119)
NIOSH 2010	HL00607		1						1200	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00608					1			1200	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00609			1					1200	8	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00610					1			1200	8	150/75 mg Silica Gel (SKC 226-10)
TO11	HL00611		1						1500	9	DNPH Silica Gel (SKC 226-119)
TO11	HL00612					1			1500	9	DNPH Silica Gel (SKC 226-119)
TO11	HL00613			1					1500	10	DNPH Silica Gel (SKC 226-119)
TO11	HL00614					1			1500	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/4/2006											
THC, CH4, CO, CO_2 & NOx	HL007	X									TOTAL
TO-17	HL00701		1						60	1	Carbopak charcoal
NIOSH 2002	HL00702		1						500	2	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00703		1						800	3	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00704		1						1000	4	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00705		1						1000	5	100/50 mg Charcoal (SKC 226-01)
TO11	HL00706		1						1000	6	DNPH Silica Gel (SKC 226-119)
NIOSH 1500	HL00707		1						1500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00708					1			1500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00709			1					1500	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL00710					1			1500	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	HL00711		1						1500	9	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00712					1			1500	9	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00713			1					1500	10	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL00714					1			1500	10	150/75 mg Silica Gel (SKC 226-10)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
10/4/2006											
THC, CH4, CO, CO_2 & NOx	HL008	X									TOTAL
TO-17	HL00801		1						60	1	Carbopak charcoal
NIOSH 2002	HL00802		1						500	2	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00803		1						800	3	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00804		1						1000	4	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00805		1						1000	5	100/50 mg Charcoal (SKC 226-01)
TO11	HL00806		1						1000	6	DNPH Silica Gel (SKC 226-119)
OSHA ID200	HL00807		1						1500	7	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00808					1			1500	7	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00809			1					1500	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL00810					1			1500	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1500	9	Blocked
	Excess								1500	10	Blocked
	Excess								1500	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

Series HL

PCS Baseline: Coated Phenolic Urethane Ashland ISOCURE® LF305/52-904GR Cold Box Cores and Uncoated Phenolic Urethane Ashland ISOCURE® LF305/52-904GR Cold Box Cores in Greensand no Seacoal

Process Instructions

A Experiment:

1 Baseline emissions measurement from greensand molds, with TEA cured Ashland ISOCURE® LF305/52-904GR cores, made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5% MB Clay, & no seacoal. The cores shall be both coated and uncoated. 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. Uncoated cores will be used to condition the sand in three conditioning runs (HLCR1-HLCR3), then there will be 6 coated core emission runs (HL020-HL022, HL030-HL032), and 8 uncoated core emission runs (HL001-HL008.) Emission results from HL001-HL008 will be used as a baseline comparison. Castings from HL020-HL022 will also be used as a baseline comparison.

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 and 1.4% (BOS) Ashland ISOCURE® LF305/52-904GR binder in a 55/45 ratio, TEA cured.

b) Coated step core made with virgin Wedron 530 silica sand and 1.4% (BOS) Ashland ISOCURE® LF305/52-904GR binder in a 55/45 ratio, TEA cured.

3 Core coating:

a) Rheotec® coated cores for emissions measurement runs HL020-022 and HL030-032 only, none for runs HL001 through HL009 and HLCR1-HLCR3.

4 Metal:

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

5 Pattern release:

a) Black Diamond, hand wiped.

b) 20 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 Cold box one-piece Step Cores:

1 Cores were manufactured at Technikon LLC.

a) After manufacture the cores were sealed in polyethylene bags, numbered and dated to relate to manufacturing process parameters recorded at that, time.

b) The sand lab will sample one (1) core from each mold produced just prior to the emission test to represent the four (4) cores placed in that mold. Those cores sampled 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.

2 Core coating for runs HL020 to HL022 and HL030 to HL032.

a) Store the client supplied core coating at 70-80°F for 24 hours prior to use.

b) Vigorously stir the client supplied core coating.

c) Test the Baumé

d) Dilute the samples to the correct Baumé.

i) Rheotec® XL will be applied at 36-40 Baumé.

ii) Rheotec® 204P will be applied at 34-36 Baumé.

e) Measure and record the coating temperature.

f) Dip the core in the tip-down position to within ½ inch of the blow end.

i) The tip of an un-dipped core can be used as a substitute for the LOI test sample for the engineering runs.

g) Allow the coating to stop running and begin dripping, then shake the core a couple of times and set it aside tip up.

h) Dry the coated core at 230°F for 2 hours. The belt will have to be stopped for one hour. Measure and record un-dipped and dried dipped weight.

Note:

Do not put un-dipped cores for production runs HL001 through HL009 in the drying oven as un-captured emissions will result.

i) Re-bag the cores.

E Sand preparation

1 Start up batch: make 1, HLCR1.

- **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 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
- **h)** Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability, as would be measured at the mold, is in the range 40-45%.
- **i)** Discharge the sand into the mold station elevator.
- **j)** Grab sufficient sample after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
- **k)** Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge into the mold. The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, Permeability 1800°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.
- **l)** 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: HLCR2

- **a)** Add to the sand recovered from poured mold HLCR1 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.

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

3 Re-mulling: HLCR3, HL001-HL009

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

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

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

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

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

F Molding: Step core pattern.

1 Pattern preparation:

a) Inspect and tighten all loose pattern and gating pieces.

b) Repair any damaged pattern or gating parts.

2 Making the green sand mold.

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

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

Caution:

Do not pour gross amounts of parting oil on the pattern to be blown 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.

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

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

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

WARNING

Only properly trained personnel may operate this machine.

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

WARNING

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

a) Open the air supply to the mold machine.

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

b) On the operator's panel turn the POWER switch to ON.
c) Turn the RAM-JOLT-SQUEEZE switch to ON.
d) Turn the DRAW UP switch to AUTO.
e) Set the PRE-JOLT timer to 4-5 seconds.
f) Set the squeeze timer to 8 seconds.
g) Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
h) Manually riddle a half to one inch or so of sand on the pattern using a ¼ inch mesh riddle. Source the sand from the overhead mold sand hopper by actuating the CHATTER GATE valve located under the operators panel.
i) Fill the center potion of the flask.
j) Manually move sand from the center portion to the outboard areas and hand tuck the sand.
k) Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
l) Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.
m) 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.
n) Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.
o) 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.

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

WARNING

Do not re-approach the machine until the squeeze head has stopped at the side of the machine.

- **q)** Screed the bottom of the drag mold flat to the bottom of the flask if required.
- **r)** Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
- **s)** 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.
- **t)** Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.

6 Set four (4) step cores that have been weighed and logged into the drag. Verify that the cores are fully set and flush with the parting line and insert foam filter into its receiver.
7 Close the cope over the drag being careful not to crush anything.
8 Clamp the flask halves together.
9 Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the uncoated cores, and the sand weight by difference.
10 Measure and record the sand temperature.
11 Deliver the mold to the previously cleaned shakeout to be poured.
12 Cover the mold with the emission hood.

G Pig molds
1 Each day make a 900 pound capacity pig mold for the following day's use.

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

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

3 When the emission sampling is completed remove the flask, with casting, and recover the sand from the hopper and surrounding floor.
- **a)** Weigh and record the metal poured and the total sand weight recovered and rejoined

with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.

b) Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

I Melting:

1 Initial iron charge:

a) Charge the furnace according to the heat recipe.
b) Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
c) Place a pig on top of the other materials.
d) Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
e) Add the balance of the metallics under full power until all is melted and the temperature has reached 2600 to 2700°F.
f) Slag the furnace and add the balance of the alloys.
g) Raise the temperature of the melt to 2700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
h) Hold the furnace at 2500-2550°F until near ready to tap.
i) When ready to tap raise the temperature to 2700°F and slag the furnace.
j) Record all metallic and alloy additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with an associated time.

2 Back charging.

a) Back charge the furnace according to the heat recipe.
b) Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.
c) Follow the above steps beginning with I.1.e

3 Emptying the furnace.

a) Pig the extra metal only after the last emission measurement is complete to avoid contaminating the air sample.
b) Cover the empty furnace with ceramic blanket to cool.

J Pouring:

1 Preheat the ladle.

a) Tap 400 pounds more or less of 2700°F iron into the cold ladle.
b) Carefully pour the metal back into the furnace.
c) Cover the ladle.
d) Reheat the metal to 2780 +/- 20°F.
e) Tap 450 pounds of iron into the ladle while pouring inoculating alloys onto the metal stream near its base.

f) Cover the ladle to conserve heat.
g) Move the ladle to the pour position and wait until the metal temperature reaches 2630 +/- 10°F.
h) Commence pouring keeping the sprue full.
i) Upon completion, return the extra metal to the furnace and cover the ladle.
j) Record the pour temperature and pour time on the heat log.

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 coated core runs HL020-022, with coated cores, only.
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 order.
b) Beginning with the casting from mold HL020, compare it to casting from mold HL021.
c) Place the better appearing casting in the first position and the lesser appearing casting in the second position.
d) Repeat this procedure with HL020 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HL021 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.

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

Thomas J Fennell Jr.
Process Engineer

Technikon Test Plan

page 1 of 2

Fill-in and check all that apply

♦ **CONTRACT NUMBER:** 1413 **TASK NUMBER** 116 **DOUBLE ALPHA** HM

♦ **SITE:** ☒ On Site at Research Foundry ☐ Off Site at _____

♦ **DATE RANGE:** From May. 7, 07 to May. 10, 07

♦ **TEST TYPE:** ☒ Emissions Testing ☐ Mechanical Properties ☐ Casting Quality
☐ Baseline ☒ Comparison to HL ☐ Other _____

♦ **PROCESSES:** ☐ Core ☐ Mold
☒ Pouring ☒ Cooling ☒ Shakeout ☐ Mixing ☐ Making ☐ Storage
☐ Other _____

♦ **METAL:** ☒ Iron ☐ Aluminum ☐ Steel ☐ Other _____ Pour Temp: 2630±10°F
Alloy Class 30 Gray Iron

♦ **PATTERN:** ☒ Step ☐ Star ☐ Irregular Gear ☐ Other _____

♦ **MOLD:** Number Molds 12 Number Cavities 4
Flask Dimensions 24"x24"x10" over 10" Storage Temp: 70-90°F

♦ **CORE TYPE:** ☐ Cold box ☐ Warm box ☐ Hot box ☐ No-bake ☒ Shell ☐ Oil
☐ Phenolic Urethane ☐ Furan ☐ Inorganic (inc. Sodium Silicate) ☐ Epoxy-Acrylic
☐ Alkaline Phenolic Ester
☐ Coated ☐ Core Wash ☐ Naphthalene Depleted
☐ CO_2 Cured ☐ SO_2 Cured ☐ Acid Cured ☐ TEA Cured ☐ Methyl Formate Cured
☐ Hot Air Cured
☐ Other _____
Product Name(s) Fairmount Minerals 630BN Gold

♦ **CORE COATING:** ☒ None ☐ All Runs ☐ Conditioning Runs Only ☐ Test Runs Only ☐ Baumé _____
Application Method _____ Drying Method _____
Product Name(s) _____

♦ **CORE SAND:** Additives Crystalline Silca coated with 3.0 % BOS Phenol-Formaldehyde resin
Product Name(s) Fairmount Minerals 630BN Gold

♦ **BINDER:** Type Phenol-Formaldehyde Concentration 3.0% (BOS) Ratio ($\frac{P1}{P2}$) _____
Product Name(s) Novalac

♦ **MOLD SAND:** ☒ Greensand ☐ Seacoal ☐ No-Bake ☐ Other _____
Additives Wexford 450 Lakesand with 7.0±0.5% Western and Southern Bentonite in a 5:2 ratio

Technikon Test Plan

page 2 of 2

Fill-in and check all that apply

♦ **CONTRACT NUMBER:** 1413 **TASK NUMBER** 116 **DOUBLE ALPHA** HM

♦ **RELEASE AGENT:** Type _____ Concentration Sprayed and hand wiped

Product Name(s) Hickman and Williams Black Diamond

♦ **RUNS:** Number for Conditioning 3 Duration 75 min Description _____

Number for Test Sampling 9 Duration 75 min Description _____

♦ **WASTE MATERIAL TO BE SAMPLED:**

☒ All ☐ None ☐ Core Butts ☐ Loose Sand ☐ Dogbones

For: Contaminates listed in EPA CFR section 40 part 261.24

♦ **TEST OBJECTIVES:** *To measure emissions from pouring, cooling, and shakeout of uncoated shell cores made from Fairmount minerals Technisand 630BN Gold*

♦ **RESULTS TO BE REPORTED:** *CO, CO_2, NOx, NH_3, SO_2, Select Target Analytes (including HAPs and POMs), to be reported in pounds of emissions per pound of binder, and pounds of emissions per ton of metal poured.*

♦ **ADDITIONAL COMMENTS:** *The cores were made during CERP Test 1413-115-HO. The 3 conditioning runs will be made with unfilled shell cores. If 1 of the 12 unfilled cores fills with metal, then the remaining shell cores will be filled with Wedron 530 sand in order to prevent metal filling the cores during test sampling runs.*

This test plan reviewed by:

Senior Process Engineer
Production Engineer
Measurement Technology Manager
V.P. Operations
Steering Committee Emissions Team Chair

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/7/2007											**HM CONDITIONING - RUN 1**
HM CR-1											
THC, CO, CO2, Nox and CH4	HM CR-1	X									

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/7/2007											**HM CONDITIONING - RUN 2**
HM CR-2											
THC, CO, CO2, Nox and CH4	HM CR-2	X									

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/7/2007											**HM CONDITIONING - RUN 3**
HM CR-3											
THC, CO, CO2, Nox and CH4	HM CR-3	X									

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/8/2007											
RUN 1											
THC, CO, CO2, Nox and CH4	HM001	X									TOTAL
TO-17	HM00101		1						60	1	Carbopak charcoal
TO-17	HM00102				1				0		Carbopak charcoal
	Excess								60	2	BLOCKED
	Excess								60	3	BLOCKED
NIOSH 6010	HM00103		1						200	4	Soda Lime (SKC 226-28)
NIOSH 6010	HM00104				1				0		Soda Lime (SKC 226-28)
NIOSH 2002	HM00113		1						200	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HM00114				1				0		150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00105		1						200	6	15/30 Tenax (SKC 226-35-03)
Acetophenone	HM00106				1				0		15/30 Tenax (SKC 226-35-03)
	Excess								200	7	BLOCKED
NIOSH S347	HM00107		1						1000	8	Acid Silica Gel (SKC 226-10-06)
NIOSH S347	HM00108				1				0		Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00109		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
OSHA-ID200	HM00110				1				0		100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00111		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HM00112				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/8/2007											
RUN 2											
THC, CO, CO2, Nox and CH4	HM002	X									TOTAL
TO-17	HM00201		1						60	1	Carbopak charcoal
TO-17	HM00202			1					60	2	Carbopak charcoal
	Excess								60	3	BLOCKED
NIOSH 6010	HM00203		1						200	4	Soda Lime (SKC 226-28)
NIOSH 6010	HM00204			1					200	5	Soda Lime (SKC 226-28)
Acetophenone	HM00205		1						200	6	15/30 Tenax (SKC 226-35-03)
NIOSH 2002	HM00211		1						200	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH S347	HM00206		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00207		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
OSHA-ID200	HM00208			1					1000	10	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00209		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/8/2007											
RUN 3											
THC, CO, CO2, Nox and CH4	HM003	X									TOTAL
TO-17	HM00301		1						60	1	Carbopak charcoal
TO-17	HM00302					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00303		1						200	4	Soda Lime (SKC 226-28)
Acetophenone	HM00304		1						200	5	15/30 Tenax (SKC 226-35-03)
Acetophenone	HM00305			1					200	6	15/30 Tenax (SKC 226-35-03)
NIOSH 2002	HM00310		1						200	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH S347	HM00306		1						1000	8	Acid Silica Gel (SKC 226-10-06)
NIOSH S347	HM00307			1					1000	9	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00308		1						1000	10	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00309		1						1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/9/2007											
RUN 4											
THC, CO, CO2, Nox and CH4	HM004	X									TOTAL
TO-17	HM00401		1						60	1	Carbopak charcoal
TO-17 MS	HM00402		1						60	2	Carbopak charcoal
TO-17 MS	HM00403			1					60	3	Carbopak charcoal
NIOSH 6010	HM00404		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00409		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00405		1						200	6	15/30 Tenax (SKC 226-35-03)
NIOSH 2002	HM00411			1					200	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH S347	HM00406		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00407		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00408		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HM00410			1					1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/9/2007											
RUN 5											
THC, CO, CO2, Nox and CH4	HM005	X									TOTAL
TO-17	HM00501		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00502		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00507		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00503		1						200	6	15/30 Tenax (SKC 226-35-03)
	Excess								200	7	BLOCKED
NIOSH S347	HM00504		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00505		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00506		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	BLOCKED
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/9/2007											
RUN 6											
THC, CO, CO2, Nox and CH4	HM006	X									TOTAL
TO-17	HM00601		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00602		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00607		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00603		1						200	6	15/30 Tenax (SKC 226-35-03)
	Excess								200	7	BLOCKED
NIOSH S347	HM00604		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00605		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00606		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/10/2007											
RUN 7											
THC, CO, CO2, Nox and CH4	HM007	X									TOTAL
TO-17	HM00701		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00702		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00707		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00703		1						200	6	15/30 Tenax (SKC 226-35-03)
	Excess		1						200	7	BLOCKED
NIOSH S347	HM00704		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00705		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00706		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/10/2007											
RUN 8											
THC, CO, CO2, Nox and CH4	HM008	X									TOTAL
TO-17	HM00801		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00802		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00807		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00803		1						200	6	15/30 Tenax (SKC 226-35-03)
	Excess								200	7	BLOCKED
NIOSH S347	HM00804		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00805								1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00806		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION HM - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
5/10/2007											
RUN 9											
THC, CO, CO2, Nox and CH4	HM009	X									TOTAL
TO-17	HM00901		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
NIOSH 6010	HM00902		1						200	4	Soda Lime (SKC 226-28)
NIOSH 2002	HM00907		1						200	5	150/75 mg Silica Gel (SKC 226-10)
Acetophenone	HM00903		1						200	6	15/30 Tenax (SKC 226-35-03)
	Excess								200	7	BLOCKED
NIOSH S347	HM00904		1						1000	8	Acid Silica Gel (SKC 226-10-06)
OSHA-ID200	HM00905		1						1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HM00906		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

Series HM

PCS Comparison: Uncoated Fairmount Minerals Technisand 630BNGold Shell cores in Greensand no Seacoal

Process Instructions

A Experiment:

1 Emissions measurement from greensand molds, with cores made from Technisand *630BNGold*, made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5% MB Clay, & no seacoal. The cores shall be both coated and uncoated. 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. Cores will be made during test 1413-115 HO. Emission results from test HM will be compared to results from test HL.

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 Technisand 630BNGold.

3 Core coating:

a) Ashland Velvaplast for one casting quality run only after all emissions runs have been poured.

4 Metal:

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

5 Pattern release:

a) Black Diamond, hand wiped.

b) 20 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 Shell one-piece Step Cores:

1 Cores were manufactured at Technikon LLC .

a) After manufacture the cores were sealed in polyethylene bags, and dated to relate to manufacturing process parameters recorded at that, time.

b) Cores will have to be filed to fit the mold.

c) If 1 of the cores form the conditioning run fills with metal, then the remaining cores will be filled with Wedron 530 sand.

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

E Sand preparation

1 Start up batch: make 1, HMCR1.

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 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.

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

i) Discharge the sand into the mold station elevator.

j) Grab sufficient sample after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis

k) Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge into the mold. The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, Permeability 1800°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.

l) 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: HMCR2

a) Add to the sand recovered from poured mold HMCR1 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.

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

3 Re-mulling: HMCR3, HM001-HM009

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

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

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

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

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

F Molding: Step core pattern.

1 Pattern preparation:

a) Inspect and tighten all loose pattern and gating pieces.

b) Repair any damaged pattern or gating parts.

2 Making the green sand mold.

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

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

Caution:

Do not pour gross amounts of parting oil on the pattern to be blown 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.

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

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

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

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

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

a) Open the air supply to the mold machine.

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

b) On the operator's panel turn the POWER switch to ON.
c) Turn the RAM-JOLT-SQUEEZE switch to ON.
d) Turn the DRAW UP switch to AUTO.
e) Set the PRE-JOLT timer to 4-5 seconds.
f) Set the squeeze timer to 8 seconds.
g) Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
h) Manually riddle a half to one inch or so of sand on the pattern using a ¼ inch mesh riddle. Source the sand from the overhead mold sand hopper by actuating the CHATTER GATE valve located under the operators panel.
i) Fill the center potion of the flask.
j) Manually move sand from the center portion to the outboard areas and hand tuck the sand.
k) Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
l) Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.
m) 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.
n) Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.

o) 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.

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

WARNING
Do not re-approach the machine until the squeeze head has stopped at the side of the machine.

q) Screed the bottom of the drag mold flat to the bottom of the flask if required.
r) Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
s) 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.
t) Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.

6 Set four (4) step cores that have been weighed and logged into the drag. Verify that the cores are fully set and flush with the parting line and insert foam filter into its receiver.
7 Close the cope over the drag being careful not to crush anything.
8 Clamp the flask halves together.
9 Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the uncoated cores, and the sand weight by difference.
10 Measure and record the sand temperature.
11 Deliver the mold to the previously cleaned shakeout to be poured.
12 Cover the mold with the emission hood.

G Pig molds
1 Each day make a 900 pound capacity pig mold for the following day's use.

H Emission hood:

1 Loading.
- **a)** Hoist the mold onto the shakeout deck within the emission hood.
- **b)** Close, seal, and lock the emission hood.
- **c)** Adjust the ambient air heater control so that the measured temperature of the blended air within the hood is 85-90°F at the start of the test run.

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

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

I Melting:

1 Initial iron charge:
- **a)** Charge the furnace according to the heat recipe.
- **b)** Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
- **c)** Place a pig on top of the other materials.
- **d)** Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
- **e)** Add the balance of the metallics under full power until all is melted and the temperature has reached 2600 to 2700°F.
- **f)** Slag the furnace and add the balance of the alloys.
- **g)** Raise the temperature of the melt to 2700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
- **h)** Hold the furnace at 2500-2550°F until near ready to tap.
- **i)** When ready to tap raise the temperature to 2700°F and slag the furnace.
- **j)** Record all metallic and alloy additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with an associated time.

2 Back charging.
- **a)** Back charge the furnace according to the heat recipe.
- **b)** Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.

- **c)** Follow the above steps beginning with I.1.e

3 Emptying the furnace.
- **a)** Pig the extra metal only after the last emission measurement is complete to avoid contaminating the air sample.
- **b)** Cover the empty furnace with ceramic blanket to cool.

J Pouring:

1 Preheat the ladle.
- **a)** Tap 400 pounds more or less of 2700°F iron into the cold ladle.
- **b)** Carefully pour the metal back into the furnace.
- **c)** Cover the ladle.
- **d)** Reheat the metal to 2780 +/- 20°F.
- **e)** Tap 450 pounds of iron into the ladle while pouring inoculating alloys onto the metal stream near its base.
- **f)** Cover the ladle to conserve heat.
- **g)** Move the ladle to the pour position and wait until the metal temperature reaches 2630 +/- 10°F.
- **h)** Commence pouring keeping the sprue full.
- **i)** Upon completion, return the extra metal to the furnace and cover the ladle.
- **j)** Record the pour temperature and pour time on the heat log.

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 castings from cavity 3 only.

3 Review the general appearance of the interior of the castings and select specific casting features to compare.

4 For each cavity 3 :
- **a)** Place each casting initially in sequential mold number order.
- **b)** Beginning with the casting from mold HM001, compare it to casting from mold HM009.
- **c)** Place the better appearing casting in the first position and the lesser appearing casting in the second position.
- **d)** Repeat this procedure with HM001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HM009 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.

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

Thomas J Fennell Jr.
Process Engineer

APPENDIX B DETAILED EMISSION RESULTS AND QUANTITATION LIMITS

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Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 1 through 8 (No Core Coating)

TA	POM	HAP		HL001	HL002	HL003	HL004	HL005	HL006	HL007	HL008	Average	Standard Deviation
			Test Dates	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	—	—
Emission Indicators													
			THC as Propane	1.28E+00	1.25E+00	1.16E+00	1.30E+00	1.16E+00	1.20E+00	1.29E+00	1.16E+00	1.23E+00	6.30E-02
			Non-Methane Hydrocarbons	1.10E+00	1.11E+00	1.03E+00	1.15E+00	1.03E+00	1.07E+00	1.14E+00	1.01E+00	1.08E+00	5.22E-02
			Sum of Target Analytes	5.84E-01	6.01E-01	6.55E-01	6.70E-01	6.00E-01	5.94E-01	6.53E-01	6.05E-01	6.24E-01	3.32E-02
			Sum of Target HAPs	4.92E-01	5.11E-01	5.59E-01	5.79E-01	5.33E-01	5.22E-01	5.80E-01	5.41E-01	5.42E-01	3.14E-02
			Sum of Target POMs	1.68E-01	1.75E-01	2.09E-01	2.04E-01	1.94E-01	1.75E-01	2.06E-01	1.71E-01	1.88E-01	1.73E-02
Selected Target HAPs and POMs													
TA		H	Benzene	1.46E-01	1.19E-01	1.07E-01	1.28E-01	1.06E-01	1.11E-01	1.23E-01	1.17E-01	1.20E-01	1.31E-02
TA		H	Phenol	9.34E-02	1.03E-01	1.14E-01	1.17E-01	1.16E-01	1.17E-01	1.24E-01	1.27E-01	1.14E-01	1.08E-02
TA	P	H	Naphthalene	6.98E-02	6.90E-02	7.75E-02	7.57E-02	7.24E-02	6.88E-02	7.44E-02	6.69E-02	7.18E-02	3.77E-03
TA	P	H	Methylnaphthalene, 2-	4.99E-02	5.24E-02	6.53E-02	6.39E-02	6.09E-02	5.38E-02	6.48E-02	5.19E-02	5.79E-02	6.49E-03
TA		H	Cresol, o-	2.83E-02	3.00E-02	3.56E-02	3.62E-02	3.09E-02	3.22E-02	3.25E-02	3.43E-02	3.25E-02	2.76E-03
TA		H	Aniline	2.09E-02	2.84E-02	3.46E-02	3.29E-02	3.06E-02	3.12E-02	3.67E-02	2.96E-02	3.06E-02	4.75E-03
TA	P	H	Methylnaphthalene, 1-	2.27E-02	2.37E-02	2.94E-02	2.82E-02	2.73E-02	2.40E-02	2.90E-02	2.34E-02	2.60E-02	2.77E-03
TA		H	Toluene	I	1.98E-02	1.92E-02	2.09E-02	1.85E-02	1.93E-02	2.00E-02	2.09E-02	1.98E-02	8.85E-04
TA	P	H	Dimethylnaphthalene, 1,3-	8.08E-03	8.52E-03	1.15E-02	1.08E-02	1.05E-02	8.97E-03	1.14E-02	9.07E-03	9.85E-03	1.35E-03
TA		H	Acetaldehyde	9.09E-03	9.62E-03	9.48E-03	9.15E-03	9.87E-03	9.40E-03	1.02E-02	9.31E-03	9.51E-03	3.71E-04
TA		H	Xylene, mp-	7.95E-03	6.87E-03	6.91E-03	7.01E-03	6.24E-03	6.08E-03	6.61E-03	7.05E-03	6.84E-03	5.73E-04
TA		H	o-Toluidine	≤PQL	6.06E-03	7.63E-03	6.84E-03	6.50E-03	6.45E-03	7.70E-03	6.65E-03	6.60E-03	8.81E-04
TA		H	Cresol, mp-	4.38E-03	4.99E-03	6.88E-03	6.68E-03	5.23E-03	5.69E-03	4.78E-03	8.53E-03	5.89E-03	1.38E-03
TA	P	H	Dimethylnaphthalene, 2,7-	4.23E-03	5.71E-03	9.88E-03	9.39E-03	≤PQL	4.65E-03	9.86E-03	≤PQL	5.74E-03	3.67E-03
TA	P	H	Dimethylnaphthalene, 1,6-	3.57E-03	4.29E-03	5.37E-03	5.13E-03	4.94E-03	4.04E-03	5.62E-03	3.90E-03	4.61E-03	7.54E-04
TA	P	H	Dimethylnaphthalene, 2,3-	3.31E-03	3.43E-03	4.50E-03	4.27E-03	4.18E-03	3.53E-03	4.60E-03	3.64E-03	3.93E-03	5.12E-04
TA	P	H	Dimethylnaphthalene, 2,6-	2.61E-03	3.26E-03	≤PQL	≤PQL	8.47E-03	2.90E-03	≤PQL	7.22E-03	3.47E-03	2.85E-03
TA		H	Biphenyl	1.91E-03	2.03E-03	2.67E-03	2.57E-03	2.50E-03	2.15E-03	2.75E-03	2.25E-03	2.35E-03	3.13E-04
TA	P	H	Dimethylnaphthalene, 1,2-	2.12E-03	2.09E-03	2.37E-03	2.52E-03	2.40E-03	2.06E-03	2.68E-03	1.98E-03	2.28E-03	2.50E-04
TA		H	Xylene, o-	1.80E-03	1.52E-03	1.57E-03	1.65E-03	1.38E-03	1.46E-03	1.44E-03	1.55E-03	1.55E-03	1.31E-04
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	1.29E-03	1.41E-03	1.35E-03	1.30E-03	1.16E-03	1.50E-03	1.23E-03	1.29E-03	1.31E-04
TA		H	Styrene	1.41E-03	1.15E-03	1.15E-03	1.27E-03	1.11E-03	1.06E-03	1.18E-03	1.32E-03	1.21E-03	1.19E-04
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	1.12E-03	1.51E-03	≤PQL	≤PQL	1.34E-03	≤PQL	1.18E-03	1.56E-04
TA		H	Triethylamine	≤PQL	1.37E-03	8.76E-04	1.18E-03	≤PQL	≤PQL	≤PQL	≤PQL	9.08E-04	2.36E-04
TA		H	Ethylbenzene	1.04E-03	8.51E-04	8.95E-04	8.98E-04	8.12E-04	7.51E-04	8.29E-04	1.15E-03	9.04E-04	1.32E-04
TA		H	Formaldehyde	7.42E-04	7.42E-04	7.59E-04	7.78E-04	8.53E-04	7.70E-04	8.95E-04	9.84E-04	8.15E-04	8.74E-05
TA		H	Hexane	5.14E-04	4.63E-04	3.07E-04	1.05E-03	4.79E-04	1.43E-03	5.50E-04	3.71E-04	6.46E-04	3.89E-04
TA		H	Propionaldehyde (Propanal)	3.81E-04	4.31E-04	3.75E-04	3.53E-04	4.14E-04	3.48E-04	3.80E-04	4.36E-04	3.90E-04	3.36E-05
TA	P	H	Acenaphthalene	≤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	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 1 through 8 (No Core Coating)

TA	POM	HAP		HL001	HL002	HL003	HL004	HL005	HL006	HL007	HL008	Average	Standard Deviation
			Test Dates	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	—	—
Additional Selected Target Analytes													
TA			Trimethylbenzene, 1,2,4-	3.32E-02	3.28E-02	3.06E-02	3.24E-02	2.38E-02	2.37E-02	2.61E-02	2.17E-02	2.80E-02	4.73E-03
TA			Ethyltoluene, 3-	1.67E-02	1.63E-02	1.48E-02	1.58E-02	1.06E-02	1.04E-02	1.18E-02	9.16E-03	1.32E-02	3.02E-03
TA			Ethyltoluene, 2-	6.90E-03	6.89E-03	6.33E-03	7.00E-03	5.00E-03	4.74E-03	5.47E-03	4.46E-03	5.85E-03	1.05E-03
TA			Dodecane	7.37E-03	6.29E-03	4.82E-03	4.43E-03	4.27E-03	7.23E-03	4.73E-03	3.84E-03	5.37E-03	1.39E-03
TA			Dimethylphenol, 2,4-	5.07E-03	4.84E-03	6.92E-03	6.28E-03	3.82E-03	5.19E-03	≤PQL	5.87E-03	4.89E-03	1.80E-03
TA			Indene	4.52E-03	4.53E-03	4.57E-03	4.97E-03	4.01E-03	3.97E-03	4.21E-03	4.09E-03	4.36E-03	3.47E-04
TA			Propylbenzene, n-	4.53E-03	4.91E-03	4.60E-03	5.11E-03	3.45E-03	3.56E-03	3.89E-03	2.61E-03	4.08E-03	8.52E-04
TA			Dimethylphenol, 2,6-	3.92E-03	3.36E-03	5.38E-03	4.87E-03	3.29E-03	3.82E-03	≤PQL	6.60E-03	4.04E-03	1.64E-03
TA			Undecane	3.95E-03	4.09E-03	3.76E-03	4.07E-03	3.24E-03	3.16E-03	—	—	3.71E-03	4.14E-04
TA			Tetradecane	2.29E-03	2.33E-03	3.18E-03	2.67E-03	2.58E-03	2.29E-03	2.85E-03	2.42E-03	2.58E-03	3.15E-04
TA			2-Butanone (MEK)	1.90E-03	2.29E-03	2.49E-03	2.22E-03	2.32E-03	2.50E-03	2.53E-03	2.42E-03	2.33E-03	2.08E-04
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	7.63E-03	≤PQL	≤PQL	≤PQL	6.80E-03	≤PQL	1.97E-03	3.25E-03
TA			Butyraldehyde/Methacrolein	4.70E-04	5.25E-04	5.20E-04	4.58E-04	4.38E-04	4.66E-04	4.73E-04	4.68E-04	4.77E-04	3.00E-05
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	1.47E-03	≤PQL	3.75E-04	4.41E-04
TA			Crotonaldehyde	2.26E-04	2.69E-04	2.62E-04	2.59E-04	3.01E-04	3.00E-04	3.13E-04	2.68E-04	2.75E-04	2.84E-05
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases													
			Carbon Dioxide	4.67E+00	3.37E+00	3.11E+00	3.07E+00	4.03E+00	2.62E+00	3.10E+00	4.01E+00	3.50E+00	6.75E-01
			Carbon Monoxide	2.09E+00	1.85E+00	2.01E+00	2.02E+00	1.89E+00	2.03E+00	2.06E+00	2.15E+00	2.01E+00	9.86E-02
			Methane	1.77E-01	1.43E-01	1.27E-01	1.55E-01	1.32E-01	1.40E-01	1.52E-01	1.44E-01	1.46E-01	1.55E-02
			Sulfur Dioxide	1.17E-02	1.05E-02	1.13E-02	1.16E-02	1.16E-02	9.83E-03	1.16E-02	1.11E-02	1.12E-02	6.61E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 1 through 8 (No Core Coating)

TA	POM	HAP		HL001	HL002	HL003	HL004	HL005	HL006	HL007	HL008	Average	Standard Deviation
			Test Dates	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	—	—
Emission Indicators													
			THC as Propane	2.11E-01	2.01E-01	1.98E-01	2.11E-01	1.89E-01	1.91E-01	2.01E-01	1.88E-01	1.99E-01	9.14E-03
			Non-Methane Hydrocarbons	1.82E-01	1.78E-01	1.76E-01	1.86E-01	1.67E-01	1.69E-01	1.78E-01	1.65E-01	1.75E-01	7.45E-03
			Sum of Target Analytes	9.59E-02	9.64E-02	1.11E-01	1.09E-01	9.80E-02	9.41E-02	9.74E-02	9.86E-02	1.01E-01	6.33E-03
			Sum of Target HAPs	8.09E-02	8.20E-02	9.51E-02	9.38E-02	8.70E-02	8.28E-02	8.60E-02	8.81E-02	8.74E-02	5.27E-03
			Sum of Target POMs	2.77E-02	2.80E-02	3.56E-02	3.31E-02	3.17E-02	2.77E-02	3.22E-02	2.80E-02	3.05E-02	3.06E-03
Selected Target HAPs and POMs													
TA		H	Benzene	2.40E-02	1.91E-02	1.81E-02	2.08E-02	1.73E-02	1.77E-02	1.91E-02	1.91E-02	1.94E-02	2.15E-03
TA		H	Phenol	1.54E-02	1.66E-02	1.94E-02	1.90E-02	1.90E-02	1.85E-02	1.93E-02	2.06E-02	1.85E-02	1.70E-03
TA	P	H	Naphthalene	1.15E-02	1.11E-02	1.32E-02	1.23E-02	1.18E-02	1.09E-02	1.16E-02	1.09E-02	1.17E-02	7.78E-04
TA	P	H	Methylnaphthalene, 2-	8.19E-03	8.41E-03	1.11E-02	1.04E-02	9.93E-03	8.53E-03	1.01E-02	8.46E-03	9.39E-03	1.12E-03
TA		H	Cresol, o-	4.65E-03	4.80E-03	6.05E-03	5.88E-03	5.05E-03	5.10E-03	5.08E-03	5.59E-03	5.28E-03	5.06E-04
TA		H	Aniline	3.44E-03	4.55E-03	5.89E-03	5.33E-03	4.99E-03	4.94E-03	1.91E-03	4.83E-03	4.49E-03	1.25E-03
TA	P	H	Methylnaphthalene, 1-	3.73E-03	3.80E-03	5.00E-03	4.57E-03	4.45E-03	3.81E-03	4.53E-03	3.81E-03	4.21E-03	4.83E-04
TA		H	Toluene	—	3.17E-03	3.27E-03	3.40E-03	3.02E-03	3.05E-03	3.13E-03	3.40E-03	3.21E-03	1.53E-04
TA	P	H	Dimethylnaphthalene, 1,3-	1.33E-03	1.37E-03	1.96E-03	1.75E-03	1.71E-03	1.42E-03	1.78E-03	1.48E-03	1.60E-03	2.30E-04
TA		H	Acetaldehyde	1.49E-03	1.54E-03	1.61E-03	1.48E-03	1.61E-03	1.49E-03	1.59E-03	1.52E-03	1.54E-03	5.49E-05
TA		H	Xylene, mp-	1.31E-03	1.10E-03	1.18E-03	1.14E-03	1.02E-03	9.64E-04	1.03E-03	1.15E-03	1.11E-03	1.07E-04
TA		H	o-Toluidine	≤PQL	9.71E-04	1.30E-03	1.11E-03	1.06E-03	1.02E-03	4.01E-04	1.08E-03	9.71E-04	2.66E-04
TA		H	Cresol, mp-	7.20E-04	8.00E-04	1.17E-03	1.08E-03	8.53E-04	9.01E-04	7.46E-04	1.39E-03	9.58E-04	2.36E-04
TA	P	H	Dimethylnaphthalene, 2,7-	6.95E-04	9.15E-04	1.68E-03	1.52E-03	≤PQL	7.36E-04	1.54E-03	≤PQL	9.32E-04	5.97E-04
TA	P	H	Dimethylnaphthalene, 1,6-	5.87E-04	6.88E-04	9.13E-04	8.32E-04	8.05E-04	6.41E-04	8.79E-04	6.36E-04	7.48E-04	1.24E-04
TA	P	H	Dimethylnaphthalene, 2,3-	5.44E-04	5.49E-04	7.64E-04	6.93E-04	6.81E-04	5.60E-04	7.19E-04	5.93E-04	6.38E-04	8.65E-05
TA	P	H	Dimethylnaphthalene, 2,6-	4.29E-04	5.23E-04	≤PQL	≤PQL	1.38E-03	4.60E-04	≤PQL	1.18E-03	5.65E-04	4.64E-04
TA		H	Biphenyl	3.13E-04	3.25E-04	4.54E-04	4.17E-04	4.08E-04	3.41E-04	4.29E-04	3.66E-04	3.82E-04	5.25E-05
TA	P	H	Dimethylnaphthalene, 1,2-	3.49E-04	3.34E-04	4.03E-04	4.08E-04	3.92E-04	3.27E-04	4.19E-04	3.23E-04	3.69E-04	3.99E-05
TA		H	Xylene, o-	2.96E-04	2.44E-04	2.66E-04	2.67E-04	2.26E-04	2.32E-04	2.25E-04	2.53E-04	2.51E-04	2.46E-05
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	2.07E-04	2.40E-04	2.18E-04	2.11E-04	1.83E-04	2.34E-04	2.01E-04	2.10E-04	2.10E-05
TA		H	Styrene	2.32E-04	1.84E-04	1.96E-04	2.06E-04	1.81E-04	1.68E-04	1.84E-04	2.16E-04	1.96E-04	2.10E-05
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	1.90E-04	2.45E-04	≤PQL	≤PQL	2.09E-04	≤PQL	1.95E-04	2.21E-05
TA		H	Triethylamine	≤PQL	2.20E-04	1.49E-04	1.91E-04	≤PQL	≤PQL	≤PQL	≤PQL	1.50E-04	3.59E-05
TA		H	Ethylbenzene	1.72E-04	1.36E-04	1.52E-04	1.46E-04	1.32E-04	1.19E-04	1.30E-04	1.88E-04	1.47E-04	2.30E-05
TA		H	Formaldehyde	1.22E-04	1.19E-04	1.29E-04	1.26E-04	1.39E-04	1.22E-04	1.40E-04	1.60E-04	1.32E-04	1.38E-05
TA		H	Hexane	8.44E-05	7.42E-05	5.22E-05	1.71E-04	7.82E-05	2.27E-04	8.59E-05	6.05E-05	1.04E-04	6.14E-05
TA		H	Propionaldehyde (Propanal)	6.27E-05	6.91E-05	6.38E-05	5.73E-05	6.76E-05	5.52E-05	5.94E-05	7.11E-05	6.33E-05	5.74E-06
TA	P	H	Acenaphthalene	≤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	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 1 through 8 (No Core Coating)

TA	POM	HAP		HL001	HL002	HL003	HL004	HL005	HL006	HL007	HL008	Average	Standard Deviation
			Test Dates	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**3-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	**4-Oct-06**	—	—
Additional Selected Target Analytes													
TA			Trimethylbenzene, 1,2,4-	5.45E-03	5.26E-03	5.21E-03	5.26E-03	3.88E-03	3.75E-03	4.08E-03	3.53E-03	4.55E-03	8.10E-04
TA			Ethyltoluene, 3-	2.74E-03	2.61E-03	2.51E-03	2.57E-03	1.73E-03	1.65E-03	1.84E-03	1.49E-03	2.14E-03	5.09E-04
TA			Ethyltoluene, 2-	1.13E-03	1.10E-03	1.08E-03	1.13E-03	8.16E-04	7.51E-04	8.55E-04	7.27E-04	9.50E-04	1.79E-04
TA			Dodecane	1.21E-03	1.01E-03	8.20E-04	7.18E-04	6.96E-04	1.15E-03	7.39E-04	6.26E-04	8.70E-04	2.22E-04
TA			Dimethylphenol, 2,4-	8.32E-04	7.76E-04	1.18E-03	1.02E-03	6.23E-04	8.22E-04	≤PQL	9.57E-04	7.99E-04	3.00E-04
TA			Indene	7.42E-04	7.26E-04	7.78E-04	8.06E-04	6.54E-04	6.29E-04	6.59E-04	6.67E-04	7.08E-04	6.47E-05
TA			Propylbenzene, n-	7.44E-04	7.88E-04	7.82E-04	8.29E-04	5.63E-04	5.64E-04	6.08E-04	4.26E-04	6.63E-04	1.43E-04
TA			Dimethylphenol, 2,6-	6.45E-04	5.38E-04	9.15E-04	7.90E-04	5.38E-04	6.05E-04	≤PQL	1.08E-03	6.61E-04	2.71E-04
TA			Undecane	6.49E-04	6.56E-04	6.39E-04	6.60E-04	5.28E-04	5.01E-04	—	—	6.05E-04	7.12E-05
TA			Tetradecane	3.77E-04	3.73E-04	5.40E-04	4.33E-04	4.21E-04	3.63E-04	4.46E-04	3.94E-04	4.18E-04	5.76E-05
TA			2-Butanone (MEK)	3.11E-04	3.68E-04	4.23E-04	3.59E-04	3.79E-04	3.96E-04	3.95E-04	3.94E-04	3.78E-04	3.33E-05
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	1.30E-03	≤PQL	≤PQL	≤PQL	1.06E-03	≤PQL	3.22E-04	5.33E-04
TA			Butyraldehyde/Methacrolein	7.73E-05	8.41E-05	8.84E-05	7.43E-05	7.14E-05	7.38E-05	7.39E-05	7.62E-05	7.74E-05	5.83E-06
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	2.29E-04	≤PQL	6.06E-05	6.81E-05
TA			Crotonaldehyde	3.71E-05	4.31E-05	4.46E-05	4.21E-05	4.92E-05	4.75E-05	4.88E-05	4.37E-05	4.45E-05	4.03E-06
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases													
			Carbon Dioxide	7.68E-01	5.40E-01	5.30E-01	4.99E-01	6.57E-01	4.15E-01	4.85E-01	6.53E-01	5.68E-01	1.15E-01
			Carbon Monoxide	3.44E-01	2.97E-01	3.42E-01	3.29E-01	3.08E-01	3.22E-01	3.22E-01	3.50E-01	3.27E-01	1.81E-02
			Methane	2.91E-02	2.29E-02	2.17E-02	2.52E-02	2.15E-02	2.22E-02	2.37E-02	2.34E-02	2.37E-02	2.48E-03
			Sulfur Dioxide	1.92E-03	1.69E-03	1.92E-03	1.88E-03	1.89E-03	1.56E-03	1.82E-03	1.81E-03	1.81E-03	1.27E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

Practical Reporting Limit -Test HL- Runs 1 through 8 (No Core Coating)

Analyte	lb/ton Metal	Analyte	lb/ton Metal
Carbon Dioxide	8.39E-02	Ethylbenzene	2.19E-04
Carbon Monoxide	5.34E-02	Ethyltoluene, 2-	2.19E-04
Methane	3.05E-02	Ethyltoluene, 3-	1.10E-03
Nitrogen Oxides	5.72E-02	Formaldehyde	2.20E-04
Sulfur Dioxide	2.63E-03	Heptane	1.10E-03
THC as Propane	8.39E-02	Hexaldehyde	2.20E-04
2-Butanone (MEK)	2.20E-04	Hexane	2.19E-04
Acenaphthalene	1.10E-03	Indan	1.10E-03
Acetaldehyde	2.20E-04	Indene	1.10E-03
Acrolein	2.20E-04	Methylnaphthalene, 1-	2.19E-04
Aniline	4.93E-03	Methylnaphthalene, 2-	2.19E-04
Benzaldehyde	2.20E-04	N,N-Diethylaniline	4.93E-03
Benzene	2.19E-04	Naphthalene	2.19E-04
Biphenyl	1.10E-03	Nonane	1.10E-03
Butyraldehyde/Methacrolein	3.66E-04	o,m,p-Tolualdehyde	5.86E-04
Cresol, mp-	1.10E-03	Octane	1.10E-03
Cresol, o-	1.10E-03	o-Toluidine	4.93E-03
Crotonaldehyde	2.20E-04	Pentanal (Valeraldehyde)	2.20E-04
Cumene	1.24E-03	Phenol	1.10E-03
Cyclohexane	1.10E-03	Phenyl Isopropyl Alcohol	1.24E-03
Decane	1.10E-03	Propionaldehyde (Propanal)	2.20E-04
Diethylbenzene, 1,3-	1.10E-03	Propylbenzene, n-	1.10E-03
Dimethylaniline	8.64E-03	Styrene	2.19E-04
Dimethylnaphthalene, 1,2-	1.10E-03	Tetradecane	1.10E-03
Dimethylnaphthalene, 1,3-	2.19E-04	Toluene	2.19E-04
Dimethylnaphthalene, 1,5-	1.10E-03	Triethylamine	7.67E-04
Dimethylnaphthalene, 1,6-	1.10E-03	Trimethylbenzene, 1,2,3-	2.19E-04
Dimethylnaphthalene, 1,8-	1.10E-03	Trimethylbenzene, 1,2,4-	2.19E-04
Dimethylnaphthalene, 2,3-	1.10E-03	Trimethylbenzene, 1,3,5-	2.19E-04
Dimethylnaphthalene, 2,6-	1.10E-03	Trimethylnaphthalene, 2,3,5-	1.10E-03
Dimethylnaphthalene, 2,7-	1.10E-03	Undecane	2.19E-04
Dimethylphenol, 2,4-	1.10E-03	Xylene, mp-	2.19E-04
Dimethylphenol, 2,6-	1.10E-03	Xylene, o-	2.19E-04
Dodecane	1.10E-03		

Analyte	lb/lb Binder	Analyte	lb/lb Binder
Carbon Dioxide	1.36E-02	Ethylbenzene	3.66E-05
Carbon Monoxide	8.66E-03	Ethyltoluene, 2-	3.66E-05
Methane	4.95E-03	Ethyltoluene, 3-	1.83E-04
Nitrogen Oxides	9.28E-03	Formaldehyde	3.66E-05
Sulfur Dioxide	4.39E-04	Heptane	1.83E-04
THC as Propane	1.36E-02	Hexaldehyde	3.66E-05
2-Butanone (MEK)	3.66E-05	Hexane	3.66E-05
Acenaphthalene	1.83E-04	Indan	1.83E-04
Acetaldehyde	3.66E-05	Indene	1.83E-04
Acrolein	3.66E-05	Methylnaphthalene, 1-	3.66E-05
Aniline	8.22E-04	Methylnaphthalene, 2-	3.66E-05
Benzaldehyde	3.66E-05	N,N-Diethylaniline	8.22E-04
Benzene	3.66E-05	Naphthalene	3.66E-05
Biphenyl	1.83E-04	Nonane	1.83E-04
Butyraldehyde/Methacrolein	6.10E-05	o,m,p-Tolualdehyde	9.76E-05
Cresol, mp-	1.83E-04	Octane	1.83E-04
Cresol, o-	1.83E-04	o-Toluidine	8.22E-04
Crotonaldehyde	3.66E-05	Pentanal (Valeraldehyde)	3.66E-05
Cumene	2.07E-04	Phenol	1.83E-04
Cyclohexane	1.83E-04	Phenyl Isopropyl Alcohol	2.07E-04
Decane	1.83E-04	Propionaldehyde (Propanal)	3.66E-05
Diethylbenzene, 1,3-	1.83E-04	Propylbenzene, n-	1.83E-04
Dimethylaniline	1.44E-03	Styrene	3.66E-05
Dimethylnaphthalene, 1,2-	1.83E-04	Tetradecane	1.83E-04
Dimethylnaphthalene, 1,3-	3.66E-05	Toluene	3.66E-05
Dimethylnaphthalene, 1,5-	1.83E-04	Triethylamine	1.28E-04
Dimethylnaphthalene, 1,6-	1.83E-04	Trimethylbenzene, 1,2,3-	3.66E-05
Dimethylnaphthalene, 1,8-	1.83E-04	Trimethylbenzene, 1,2,4-	3.66E-05
Dimethylnaphthalene, 2,3-	1.83E-04	Trimethylbenzene, 1,3,5-	3.66E-05
Dimethylnaphthalene, 2,6-	1.83E-04	Trimethylnaphthalene, 2,3,5-	1.83E-04
Dimethylnaphthalene, 2,7-	1.83E-04	Undecane	3.66E-05
Dimethylphenol, 2,4-	1.83E-04	Xylene, mp-	3.66E-05
Dimethylphenol, 2,6-	1.83E-04	Xylene, o-	3.66E-05
Dodecane	1.83E-04		

Detailed Emission Data - Test HM - lb/tn core

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
Emission Indicators														
			THC as Propane	5.58E-01	5.86E-01	6.39E-01	5.79E-01	6.87E-01	6.19E-01	5.68E-01	6.19E-01	6.05E-01	6.07E-01	4.01E-02
			Non-Methane Hydrocarbons	3.63E-01	3.82E-01	4.15E-01	3.75E-01	4.48E-01	4.03E-01	3.74E-01	4.08E-01	3.86E-01	3.95E-01	2.64E-02
			Sum of Target Analytes	2.23E-01	2.56E-01	2.81E-01	2.56E-01	2.92E-01	2.78E-01	2.36E-01	1.78E-01	2.58E-01	2.67E-01	3.49E-02
			Sum of Target HAPs	1.93E-01	2.25E-01	2.46E-01	2.26E-01	2.54E-01	2.44E-01	2.22E-01	1.67E-01	2.38E-01	2.35E-01	2.79E-02
			Sum of Target POMs	2.61E-03	2.31E-03	2.98E-03	2.55E-03	3.08E-03	2.61E-03	2.80E-03	2.67E-03	2.68E-03	2.74E-03	2.32E-04
Selected Target HAPs and POMs														
TA		H	Benzene	9.69E-02	9.19E-02	1.04E-01	9.56E-02	1.08E-01	9.91E-02	8.76E-02	1.00E-01	9.62E-02	9.78E-02	6.10E-03
TA		H	Toluene	3.52E-02	3.95E-02	3.85E-02	3.67E-02	4.09E-02	3.85E-02	3.49E-02	3.74E-02	3.57E-02	3.75E-02	2.06E-03
TA		H	Phenol	I	3.18E-02	3.70E-02	3.41E-02	3.33E-02	3.93E-02	3.56E-02	I	3.81E-02	3.56E-02	2.69E-03
TA		H	Cresol, o-	2.59E-02	2.32E-02	2.82E-02	2.22E-02	2.86E-02	2.95E-02	2.17E-02	I	2.75E-02	2.59E-02	3.09E-03
TA		H	Xylene, mp-	1.43E-02	1.61E-02	1.55E-02	1.53E-02	1.68E-02	1.55E-02	1.50E-02	1.50E-02	1.42E-02	1.53E-02	7.90E-04
TA		H	Cresol, mp-	5.79E-03	5.93E-03	7.28E-03	6.28E-03	7.91E-03	8.05E-03	6.97E-03	I	7.71E-03	6.99E-03	8.97E-04
TA		H	Acetaldehyde	3.83E-03	3.88E-03	3.97E-03	4.08E-03	4.05E-03	4.09E-03	3.92E-03	4.08E-03	4.29E-03	4.02E-03	1.37E-04
TA		H	Hexane	1.10E-03	2.71E-03	1.68E-03	1.99E-03	5.07E-03	1.43E-03	7.58E-03	1.20E-03	5.51E-03	3.14E-03	2.33E-03
TA		H	Formaldehyde	3.00E-03	2.88E-03	2.58E-03	2.04E-03	1.96E-03	1.91E-03	1.38E-03	1.64E-03	1.66E-03	2.12E-03	5.76E-04
TA		H	Xylene, o-	1.98E-03	1.89E-03	1.87E-03	2.08E-03	2.09E-03	1.91E-03	1.85E-03	1.88E-03	1.85E-03	1.93E-03	9.48E-05
TA	P	H	Naphthalene	1.83E-03	1.42E-03	1.78E-03	1.72E-03	2.01E-03	1.70E-03	1.72E-03	1.48E-03	1.65E-03	1.70E-03	1.77E-04
TA		H	Ethylbenzene	1.22E-03	1.17E-03	1.08E-03	1.04E-03	1.27E-03	1.12E-03	1.07E-03	1.11E-03	1.09E-03	1.13E-03	7.56E-05
TA		H	Propionaldehyde (Propanal)	6.44E-04	6.29E-04	6.76E-04	5.79E-04	6.01E-04	5.91E-04	5.29E-04	5.57E-04	5.92E-04	6.00E-04	4.46E-05
TA		H	Styrene	5.73E-04	4.82E-04	4.37E-04	6.39E-04	4.68E-04	4.20E-04	4.00E-04	3.65E-04	3.90E-04	4.64E-04	9.00E-05
TA	P	H	Acenaphthalene	2.82E-04	3.67E-04	5.50E-04	2.92E-04	4.07E-04	2.86E-04	4.49E-04	6.37E-04	3.77E-04	4.05E-04	1.23E-04
TA	P	H	Methylnaphthalene, 2-	I	2.80E-04	2.92E-04	2.94E-04	3.25E-04	3.85E-04	3.89E-04	3.08E-04	3.82E-04	3.32E-04	4.62E-05
TA	P	H	Methylnaphthalene, 1-	5.02E-04	≤PQL	3.61E-04	≤PQL	3.39E-04	≤PQL	≤PQL	2.48E-04	2.69E-04	2.98E-04	8.94E-05
TA		H	Biphenyl	4.04E-04	≤PQL	3.02E-04	≤PQL	2.70E-04	2.69E-04	2.95E-04	3.41E-04	2.76E-04	2.93E-04	5.21E-05
TA	P	H	Anthracene	≤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, 1,3-	≤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	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acetophenone	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Aniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Hydrogen Cyanide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Isopropylbenzene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

I=Invalidated
≤PQL=Less than or equal to practical quantiation limit
NA=Not applicable

Detailed Emission Data - Test HM - lb/tn core

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
Additional Selected Target Analytes														
TA			Ammonia	≤PQL	≤PQL	1.57E-02	≤PQL	1.49E-02	1.43E-02	I	I	I	1.44E-02	7.14E-04
TA			Dimethylphenol, 2,6-	3.97E-03	4.17E-03	4.61E-03	3.58E-03	6.53E-03	5.16E-03	1.36E-03	≤PQL	5.32E-03	3.88E-03	1.97E-03
TA			Dimethylphenol, 2,4-	1.89E-03	3.50E-03	3.94E-03	3.71E-03	5.19E-03	4.16E-03	2.61E-03	≤PQL	4.97E-03	3.36E-03	1.56E-03
TA			Trimethylbenzene, 1,2,4-	1.94E-03	1.69E-03	1.58E-03	1.65E-03	1.71E-03	1.72E-03	1.64E-03	1.60E-03	1.47E-03	1.67E-03	1.28E-04
TA			Octane	1.11E-03	1.27E-03	1.24E-03	1.18E-03	1.44E-03	1.42E-03	1.23E-03	1.24E-03	1.27E-03	1.27E-03	1.06E-04
TA			Heptane	1.04E-03	1.32E-03	1.04E-03	9.77E-04	1.38E-03	1.09E-03	9.64E-04	9.95E-04	1.05E-03	1.10E-03	1.50E-04
TA			Nonane	7.70E-04	8.91E-04	8.72E-04	8.97E-04	9.98E-04	9.12E-04	8.44E-04	8.03E-04	8.42E-04	8.70E-04	6.65E-05
TA			Decane	6.16E-04	7.14E-04	7.33E-04	5.87E-04	7.57E-04	6.39E-04	6.10E-04	5.78E-04	7.25E-04	6.62E-04	6.97E-05
TA			Dodecane	6.50E-04	5.63E-04	6.34E-04	6.21E-04	7.35E-04	5.91E-04	5.57E-04	5.44E-04	6.05E-04	6.11E-04	5.88E-05
TA			Indene	6.36E-04	6.31E-04	7.19E-04	5.78E-04	6.55E-04	6.10E-04	5.36E-04	4.10E-04	6.75E-04	6.06E-04	9.03E-05
TA			Tridecane	5.40E-04	4.34E-04	5.54E-04	4.83E-04	6.15E-04	5.37E-04	4.96E-04	5.59E-04	5.11E-04	5.26E-04	5.20E-05
TA			Ethyltoluene, 3-	4.90E-04	5.22E-04	5.10E-04	5.04E-04	I	5.21E-04	4.95E-04	5.05E-04	5.14E-04	5.08E-04	1.16E-05
TA			Butyraldehyde/Methacrolein	4.47E-04	4.29E-04	4.91E-04	4.51E-04	4.93E-04	4.67E-04	4.84E-04	4.87E-04	5.15E-04	4.74E-04	2.72E-05
TA			Tetradecane	4.14E-04	3.26E-04	4.62E-04	2.97E-04	5.44E-04	4.35E-04	3.89E-04	5.75E-04	4.67E-04	4.34E-04	9.13E-05
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	1.01E-03	1.13E-03	≤PQL	4.25E-04	3.69E-04
TA			Trimethylbenzene, 1,2,3-	2.95E-04	3.02E-04	3.84E-04	3.38E-04	3.66E-04	3.62E-04	3.34E-04	3.22E-04	3.39E-04	3.38E-04	2.95E-05
TA			2-Butanone (MEK)	3.03E-04	3.17E-04	3.72E-04	2.90E-04	3.11E-04	3.24E-04	3.01E-04	3.21E-04	3.40E-04	3.20E-04	2.45E-05
TA			Ethyltoluene, 2-	2.81E-04	2.85E-04	2.93E-04	2.64E-04	3.23E-04	2.79E-04	2.84E-04	2.63E-04	3.12E-04	2.87E-04	2.00E-05
TA			Benzaldehyde	≤PQL	2.20E-04	2.51E-04	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	2.19E-04	1.23E-05
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			Diethylbenzene, 1,3-	≤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			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤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			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	NA
TA			alpha-Methylstyrene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, sec-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, tert-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cymene, p-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,4-	I	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diisopropylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Isobutylbenzene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,4,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emission Data - Test HM - lb/tn core

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Dioxide	5.89E+00	4.01E+00	4.00E+00	4.77E+00	3.85E+00	3.55E+00	4.19E+00	5.81E+00	4.14E+00	4.47E+00	8.49E-01
			Carbon Monoxide	2.71E+00	3.02E+00	2.95E+00	3.14E+00	3.40E+00	3.18E+00	3.14E+00	3.86E+00	3.32E+00	3.19E+00	3.22E-01
			Methane	1.96E-01	2.04E-01	2.24E-01	2.04E-01	2.40E-01	2.16E-01	1.94E-01	2.11E-01	2.19E-01	2.12E-01	1.44E-02
			Sulfur Dioxide	9.37E-03	1.07E-02	9.44E-03	1.19E-02	7.79E-03	8.47E-03	9.40E-03	8.82E-03	7.25E-03	9.23E-03	1.41E-03
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HM, lb/lb binder

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
Emission Indicators														
			THC as Propane	4.81E-02	5.55E-02	5.65E-02	5.39E-02	5.97E-02	5.49E-02	5.01E-02	5.70E-02	5.20E-02	5.42E-02	3.63E-03
			Non-Methane Hydrocarbons	3.12E-02	3.62E-02	3.67E-02	3.49E-02	3.89E-02	3.57E-02	3.30E-02	3.76E-02	3.32E-02	3.53E-02	2.45E-03
			Sum of Target Analytes	1.75E-02	2.22E-02	2.41E-02	2.18E-02	2.46E-02	2.39E-02	2.01E-02	1.58E-02	2.15E-02	2.26E-02	3.01E-03
			Sum of Target HAPs	1.62E-02	2.06E-02	2.12E-02	2.04E-02	2.14E-02	2.10E-02	1.89E-02	1.49E-02	1.98E-02	2.04E-02	2.33E-03
			Sum of Target POMs	2.18E-04	1.90E-04	2.56E-04	2.09E-04	2.60E-04	2.04E-04	2.19E-04	2.39E-04	2.23E-04	2.29E-04	2.23E-05
Selected Target HAPs and POMs														
TA		H	Benzene	8.10E-03	8.45E-03	8.97E-03	8.65E-03	9.09E-03	8.55E-03	7.49E-03	8.99E-03	8.02E-03	8.48E-03	5.27E-04
TA		H	Toluene	2.94E-03	3.63E-03	3.31E-03	3.32E-03	3.45E-03	3.32E-03	2.98E-03	3.35E-03	2.98E-03	3.25E-03	2.37E-04
TA		H	Phenol	I	2.93E-03	3.18E-03	3.09E-03	2.81E-03	3.39E-03	3.05E-03	I	3.18E-03	3.09E-03	1.88E-04
TA		H	Cresol, o-	2.17E-03	2.13E-03	2.43E-03	2.01E-03	2.41E-03	2.55E-03	1.86E-03	I	2.29E-03	2.23E-03	2.31E-04
TA		H	Xylene, mp-	1.20E-03	1.48E-03	1.33E-03	1.39E-03	1.41E-03	1.34E-03	1.28E-03	1.34E-03	1.19E-03	1.33E-03	9.49E-05
TA		H	Cresol, mp-	4.84E-04	5.46E-04	6.26E-04	5.68E-04	6.67E-04	6.94E-04	5.97E-04	I	6.43E-04	6.03E-04	6.89E-05
TA		H	Acetaldehyde	3.20E-04	3.57E-04	3.41E-04	3.69E-04	3.42E-04	3.52E-04	3.35E-04	3.65E-04	3.57E-04	3.49E-04	1.55E-05
TA		H	Hexane	9.20E-05	2.49E-04	1.44E-04	1.80E-04	4.27E-04	1.23E-04	6.49E-04	1.07E-04	4.59E-04	2.70E-04	1.96E-04
TA		H	Formaldehyde	2.51E-04	2.65E-04	2.22E-04	1.85E-04	1.66E-04	1.65E-04	1.18E-04	1.46E-04	1.38E-04	1.84E-04	5.14E-05
TA		H	Xylene, o-	1.66E-04	1.74E-04	1.61E-04	1.88E-04	1.77E-04	1.64E-04	1.58E-04	1.69E-04	1.54E-04	1.68E-04	1.03E-05
TA	P	H	Naphthalene	1.53E-04	1.30E-04	1.53E-04	1.56E-04	1.70E-04	1.47E-04	1.48E-04	1.32E-04	1.38E-04	1.47E-04	1.25E-05
TA		H	Ethylbenzene	1.02E-04	1.07E-04	9.26E-05	9.43E-05	1.07E-04	9.62E-05	9.15E-05	9.89E-05	9.08E-05	9.78E-05	6.37E-06
TA		H	Propionaldehyde (Propanal)	5.38E-05	5.78E-05	5.81E-05	5.24E-05	5.07E-05	5.09E-05	4.53E-05	4.99E-05	4.94E-05	5.20E-05	4.11E-06
TA		H	Styrene	4.79E-05	4.43E-05	3.76E-05	5.78E-05	3.95E-05	3.62E-05	3.42E-05	3.26E-05	3.25E-05	4.03E-05	8.37E-06
TA	P	H	Acenaphthalene	2.36E-05	3.38E-05	4.73E-05	2.64E-05	3.43E-05	2.47E-05	3.84E-05	5.70E-05	3.15E-05	3.52E-05	1.10E-05
TA	P	H	Methylnaphthalene, 2-	I	2.57E-05	2.51E-05	2.66E-05	2.74E-05	3.32E-05	3.32E-05	2.76E-05	3.19E-05	2.88E-05	3.38E-06
TA		H	Biphenyl	3.38E-05	≤PQL	2.60E-05	≤PQL	2.28E-05	2.32E-05	2.52E-05	3.05E-05	2.30E-05	2.11E-05	1.11E-05
TA	P	H	Methylnaphthalene, 1-	4.19E-05	≤PQL	3.11E-05	≤PQL	2.86E-05	≤PQL	≤PQL	2.22E-05	2.24E-05	1.74E-05	1.52E-05
TA	P	H	Anthracene	≤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, 1,3-	≤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	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acetophenone	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Aniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Hydrogen Cyanide	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Isopropylbenzene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HM, lb/lb binder

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
Additional Selected Target Analytes														
TA			Ammonia	≤PQL	≤PQL	1.35E-03	≤PQL	1.25E-03	1.23E-03	I	I	I	7.13E-04	6.20E-04
TA			Dimethylphenol, 2,6-	3.32E-04	3.83E-04	3.96E-04	3.24E-04	5.51E-04	4.45E-04	1.17E-04	≤PQL	4.44E-04	3.33E-04	1.71E-04
TA			Dimethylphenol, 2,4-	1.58E-04	3.21E-04	3.39E-04	3.35E-04	4.38E-04	3.59E-04	2.23E-04	≤PQL	4.15E-04	2.88E-04	1.38E-04
TA			Trimethylbenzene, 1,2,4-	1.62E-04	1.55E-04	1.36E-04	1.49E-04	1.44E-04	1.49E-04	1.40E-04	1.43E-04	1.23E-04	1.45E-04	1.14E-05
TA			Octane	9.28E-05	1.17E-04	1.06E-04	1.07E-04	1.21E-04	1.23E-04	1.05E-04	1.11E-04	1.06E-04	1.10E-04	9.31E-06
TA			Heptane	8.68E-05	1.22E-04	8.98E-05	8.84E-05	1.16E-04	9.41E-05	8.24E-05	8.90E-05	8.78E-05	9.51E-05	1.39E-05
TA			Nonane	6.43E-05	8.19E-05	7.50E-05	8.12E-05	8.42E-05	7.86E-05	7.22E-05	7.18E-05	7.02E-05	7.55E-05	6.47E-06
TA			Decane	5.15E-05	6.56E-05	6.31E-05	5.31E-05	6.39E-05	5.51E-05	5.22E-05	5.17E-05	6.04E-05	5.74E-05	5.80E-06
TA			Indene	5.32E-05	5.81E-05	6.18E-05	5.23E-05	5.52E-05	5.26E-05	4.59E-05	I	5.63E-05	5.44E-05	4.70E-06
TA			Dodecane	5.44E-05	5.17E-05	5.45E-05	5.62E-05	6.20E-05	5.10E-05	4.77E-05	4.86E-05	5.04E-05	5.29E-05	4.38E-06
TA			Tridecane	4.51E-05	3.99E-05	4.77E-05	4.37E-05	5.19E-05	4.64E-05	4.24E-05	5.00E-05	4.26E-05	4.55E-05	3.86E-06
TA			Ethyltoluene, 3-	4.10E-05	4.80E-05	4.39E-05	4.56E-05	5.10E-05	4.50E-05	4.23E-05	4.52E-05	4.28E-05	4.50E-05	3.05E-06
TA			Butyraldehyde/Methacrolein	3.74E-05	3.95E-05	4.22E-05	4.08E-05	4.16E-05	4.03E-05	4.14E-05	4.35E-05	4.30E-05	4.11E-05	1.88E-06
TA			Tetradecane	3.46E-05	3.00E-05	3.97E-05	2.69E-05	4.59E-05	3.75E-05	3.32E-05	5.14E-05	3.90E-05	3.76E-05	7.64E-06
TA			Trimethylbenzene, 1,2,3-	2.46E-05	2.78E-05	3.30E-05	3.05E-05	3.09E-05	3.12E-05	2.85E-05	2.88E-05	2.82E-05	2.93E-05	2.44E-06
TA			2-Butanone (MEK)	2.53E-05	2.92E-05	3.20E-05	2.63E-05	2.63E-05	2.80E-05	2.57E-05	2.87E-05	2.83E-05	2.78E-05	2.12E-06
TA			Ethyltoluene, 2-	2.35E-05	2.62E-05	2.52E-05	2.39E-05	2.72E-05	2.41E-05	2.43E-05	2.35E-05	2.60E-05	2.49E-05	1.36E-06
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	8.68E-05	1.01E-04	≤PQL	2.29E-05	4.05E-05
TA			Benzaldehyde	≤PQL	2.02E-05	2.16E-05	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	6.42E-06	8.22E-06
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			Diethylbenzene, 1,3-	≤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			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤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			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	NA
TA			alpha-Methylstyrene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, sec-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, tert-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cymene, p-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,4-	I	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diisopropylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

I=Invalidated
≤PQL=Less than or equal to practical quantiation limit
NA=Not applicable

Detailed Emissions Data - Test HM, lb/lb binder

TA	POM	HAP		HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	Average	Standard Deviation
			Test Dates	08-May-07	08-May-07	08-May-07	09-May-07	09-May-07	09-May-07	10-May-07	10-May-07	10-May-07	–	–
TA			Dimethylphenol, 3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Isobutylbenzene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,4,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Dioxide	5.08E-01	3.80E-01	3.54E-01	4.44E-01	3.34E-01	3.15E-01	3.69E-01	5.35E-01	3.56E-01	4.00E-01	7.80E-02
			Carbon Monoxide	2.34E-01	2.86E-01	2.61E-01	2.93E-01	2.95E-01	2.83E-01	2.77E-01	3.56E-01	2.85E-01	2.85E-01	3.24E-02
			Methane	1.68E-02	1.93E-02	1.98E-02	1.90E-02	2.08E-02	1.92E-02	1.71E-02	1.94E-02	1.88E-02	1.89E-02	1.25E-03
			Sulfur Dioxide	7.84E-04	9.80E-04	8.12E-04	1.08E-03	6.57E-04	7.30E-04	8.04E-04	7.89E-04	6.04E-04	8.04E-04	1.47E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

I=Invalidated
≤PQL=Less than or equal to practical quantiation limit
NA=Not applicable

Practical Reporting Limits, Test HM, lb/ton metal

Analyte	lb/tn core	Analyte	lb/tn core
2-Butanone (MEK)	2.14E-04	Ethylbenzene	2.40E-04
Acenaphthalene	2.40E-04	Ethyltoluene, 2-	2.40E-04
Acetaldehyde	2.14E-04	Ethyltoluene, 3-	2.40E-04
Acetone	2.14E-04	Ethyltoluene, 4-	2.40E-04
Acetophenone	1.54E-02	Formaldehyde	2.14E-04
Acrolein	2.14E-04	Heptane	2.40E-04
alpha-Methylstyrene	2.40E-04	Hexaldehyde	2.14E-04
Ammonia	1.39E-02	Hexane	2.40E-04
Aniline	1.11E-02	Hydrogen Cyanide	3.55E-03
Anthracene	2.40E-04	Indan	2.40E-04
Benzaldehyde	2.14E-04	Indene	2.40E-04
Benzene	2.40E-04	Isobutylbenzene	2.40E-04
Biphenyl	2.40E-04	Isopropylbenzene	2.40E-04
Butylbenzene, n-	2.40E-04	Methylnaphthalene, 1-	2.40E-04
Butylbenzene, sec-	2.40E-04	Methylnaphthalene, 2-	2.40E-04
Butylbenzene, tert-	2.40E-04	Naphthalene	2.40E-04
Butyraldehyde/Methacrolein	3.57E-04	Nonane	2.40E-04
Cresol, mp-	2.40E-04	o,m,p-Tolualdehyde	5.71E-04
Cresol, o-	2.40E-04	Octane	2.40E-04
Crotonaldehyde	2.14E-04	Pentanal (Valeraldehyde)	2.14E-04
Cyclohexane	2.40E-04	Phenol	2.40E-04
Cymene, p-	2.40E-04	Propionaldehyde (Propanal)	2.14E-04
Decane	2.40E-04	Propylbenzene, n-	2.40E-04
Diethylbenzene, 1,2-	2.40E-04	Styrene	2.40E-04
Diethylbenzene, 1,3-	2.40E-04	Sulfur Dioxide	2.85E-03
Diethylbenzene, 1,4-	2.40E-04	Tetradecane	2.40E-04
Diisopropylbenzene, 1,3-	2.40E-04	THC as Undecane	2.40E-04
Dimethylaniline	1.95E-02	Toluene	2.40E-04
Dimethylnaphthalene, 1,2-	2.40E-04	Tridecane	2.40E-04
Dimethylnaphthalene, 1,3-	2.40E-04	Trimethylbenzene, 1,2,3-	2.40E-04
Dimethylnaphthalene, 1,5-	2.40E-04	Trimethylbenzene, 1,2,4-	2.40E-04
Dimethylnaphthalene, 1,6-	2.40E-04	Trimethylbenzene, 1,3,5-	2.40E-04
Dimethylnaphthalene, 1,8-	2.40E-04	Trimethylnaphthalene, 2,3,5-	2.40E-04
Dimethylnaphthalene, 2,3-	2.40E-04	Trimethylphenol, 2,3,5-	2.40E-04
Dimethylnaphthalene, 2,6-	2.40E-04	Trimethylphenol, 2,4,6-	2.40E-04
Dimethylnaphthalene, 2,7-	2.40E-04	Undecane	2.40E-04
Dimethylphenol, 2,3-	2.40E-04	Xylene, mp-	2.40E-04
Dimethylphenol, 2,4-	2.40E-04	Xylene, o-	2.40E-04
Dimethylphenol, 2,5-	2.40E-04	THC as Propane	9.05E-02
Dimethylphenol, 2,6-	2.40E-04	Carbon Monoxide	5.76E-02
Dimethylphenol, 3,4-	2.40E-04	Carbon Dioxide	9.05E-02
Dimethylphenol, 3,5-	2.40E-04	Nitrogen Oxides	6.17E-02
Dodecane	2.40E-04	Methane	3.29E-02

Practical Reporting Limits, Test HM, lb/lb binder

Analyte	lb/tn core	Analyte	lb/tn core
2-Butanone (MEK)	2.29E-06	Ethylbenzene	2.56E-06
Acenaphthalene	2.56E-06	Ethyltoluene, 2-	2.56E-06
Acetaldehyde	2.29E-06	Ethyltoluene, 3-	2.56E-06
Acetophenone	1.65E-04	Ethyltoluene, 4-	2.56E-06
Acrolein	2.29E-06	Formaldehyde	2.29E-06
alpha-Methylstyrene	2.56E-06	Heptane	2.56E-06
Ammonia	1.49E-04	Hexaldehyde	2.29E-06
Aniline	1.19E-04	Hexane	2.56E-06
Anthracene	2.56E-06	Hydrogen Cyanide	3.79E-05
Benzaldehyde	2.29E-06	Indan	2.56E-06
Benzene	2.56E-06	Indene	2.56E-06
Biphenyl	2.56E-06	Isobutylbenzene	2.56E-06
Butylbenzene, n-	2.56E-06	Isopropylbenzene	2.56E-06
Butylbenzene, sec-	2.56E-06	Methylnaphthalene, 1-	2.56E-06
Butylbenzene, tert-	2.56E-06	Methylnaphthalene, 2-	2.56E-06
Butyraldehyde/Methacrolein	3.81E-06	Naphthalene	2.56E-06
Cresol, mp-	2.56E-06	Nonane	2.56E-06
Cresol, o-	2.56E-06	o,m,p-Tolualdehyde	6.10E-06
Crotonaldehyde	2.29E-06	Octane	2.56E-06
Cyclohexane	2.56E-06	Pentanal (Valeraldehyde)	2.29E-06
Cymene, p-	2.56E-06	Phenol	2.56E-06
Decane	2.56E-06	Propionaldehyde (Propanal)	2.29E-06
Diethylbenzene, 1,2-	2.56E-06	Propylbenzene, n-	2.56E-06
Diethylbenzene, 1,3-	2.56E-06	Styrene	2.56E-06
Diethylbenzene, 1,4-	2.56E-06	Tetradecane	2.56E-06
Diisopropylbenzene, 1,3-	2.56E-06	Toluene	2.56E-06
Dimethylaniline	2.08E-04	Tridecane	2.56E-06
Dimethylnaphthalene, 1,2-	2.56E-06	Trimethylbenzene, 1,2,3-	2.56E-06
Dimethylnaphthalene, 1,3-	2.56E-06	Trimethylbenzene, 1,2,4-	2.56E-06
Dimethylnaphthalene, 1,5-	2.56E-06	Trimethylbenzene, 1,3,5-	2.56E-06
Dimethylnaphthalene, 1,6-	2.56E-06	Trimethylnaphthalene, 2,3,5-	2.56E-06
Dimethylnaphthalene, 1,8-	2.56E-06	Trimethylphenol, 2,3,5-	2.56E-06
Dimethylnaphthalene, 2,3-	2.56E-06	Trimethylphenol, 2,4,6-	2.56E-06
Dimethylnaphthalene, 2,6-	2.56E-06	Undecane	2.56E-06
Dimethylnaphthalene, 2,7-	2.56E-06	Xylene, mp-	2.56E-06
Dimethylphenol, 2,3-	2.56E-06	Xylene, o-	2.56E-06
Dimethylphenol, 2,4-	2.56E-06	THC as Propane	9.67E-04
Dimethylphenol, 2,5-	2.56E-06	Carbon Monoxide	6.15E-04
Dimethylphenol, 2,6-	2.56E-06	Carbon Dioxide	9.67E-04
Dimethylphenol, 3,4-	2.56E-06	Nitrogen Oxides	6.59E-04
Dimethylphenol, 3,5-	2.56E-06	Methane	3.52E-04
Dodecane	2.56E-06	Sulfur Dioxide	3.04E-05

Appendix C Detailed Process Data and Casting Quality Photos

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Detailed Process Data - Test HL

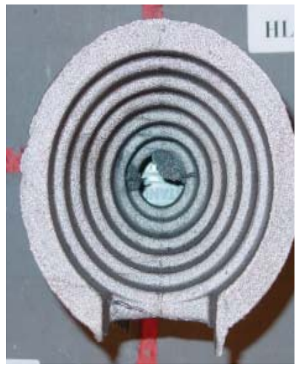
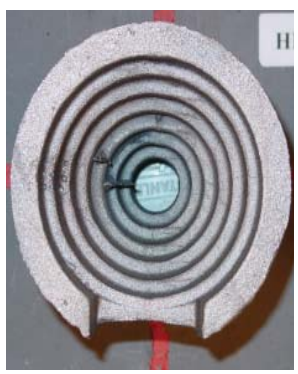
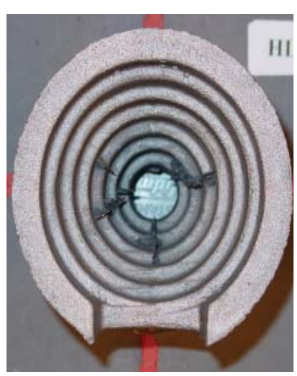
	Uncoated Ashland 305/904 Phenolic Urethane Cores								Averages	Ashland 305/904 Phenolic Urethane			Averages
Test Dates	**10/03/06**	**10/03/06**	**10/03/06**	**10/03/06**	**10/04/06**	**10/04/06**	**10/04/06**	**10/04/06**		**09/27/06**	**09/27/06**	**09/27/06**	
Emissions Sample #	**HL001**	**HL002**	**HL003**	**HL004**	**HL005**	**HL006**	**HL007**	**HL008**		**HL020**	**HL021**	**HL022**	
Production Sample #	**HL010**	**HL011**	**HL012**	**HL013**	**HL014**	**HL015**	**HL016**	**HL017**		**HL004**	**HL005**	**HL006**	
Cast weight, lbs.	126.85	123.75	130.60	126.50	125.30	123.00	120.00	123.55	124.94	121.85	119.25	126.00	122.37
Pouring time, sec.	14	14	12	14	14	14	15	15	14	14	12	11	12
Pouring temp ,°F	2636	2627	2626	2638	2630	2637	2637	2640	2634	2633	2633	2640	2635
Pour hood process air temp at start of pour, °F	88	87	89	86	87	86	89	91	88	87	87	91	89
Mixer auto dispensed sand weight, Lbs	50.37	50.37	50.37	50.37	50.37	50.37	50.37	50.37	50.37	50.32	50.32	50.32	50.32
Core binder weight part 1, g	175.6	174.9	173.7	177.3	176.5	177.6	175.2	175.1	175.7	175.5	175.3	176.7	175.8
Core binder weight partt 2, g	144.6	143.9	145.0	144.6	142.9	144.0	143.1	145.3	144.2	143.3	143.1	145.1	143.8
Core binder weight, g	320.2	318.8	318.7	321.9	319.4	321.6	318.3	320.4	319.9	318.8	318.4	321.8	319.7
% core binder (BOS)	1.40	1.40	1.39	1.41	1.40	1.4	1.4	1.4	1.4	1.40	1.39	1.41	1.40
% core binder, actual	1.38	1.38	1.38	1.39	1.38	1.39	1.37	1.38	1.38	1.38	1.38	1.39	1.38
Total core weight in mold, lbs.	27.92	28.03	27.88	28.04	27.86	27.95	27.94	27.42	27.88	0.00	0.00	0.00	0.00
Total binder weight in mold, lbs.	0.386	0.386	0.384	0.390	0.384	0.388	0.384	0.379	0.385	0.000	0.000	0.000	0.000
Core LOI, %	1.0721	1.0644	1.0931	1.1793	1.1390	1.1329	1.1069	1.1069	1.1118	1.0724	1.0895	1.1058	1.0893
2 hour core dogbone tensile, psi	224.50	224.50	224.50	224.50	224.50	224.50	224.50	224.50	224.5	224.50	224.50	224.50	224.5
Core age when poured, hrs.	24	26	28	30	47	49	51	54	39	0	0	0	0.00
Muller batch weight, lbs.	902	902	908	910	905	905	909	907	906	900	906	901	902
GS mold sand weight, lbs.	614	631	606	623	635	617	642	622	624	634	638	636	636
Mold temperature, °F	77	83	87	89	82	86	89	85	85	84	88	89	87
Average green compression , psi	21.89	22.80	21.85	20.59	23.28	23.10	21.18	20.85	21.94	20.37	21.44	21.03	20.94
GS compactability, %	40	41	45	45	47	47	45	40	44	42	47	40	43
GS moisture content, %	1.94	2.08	2.04	2.20	2.22	2.02	2.08	1.96	2.07	1.98	2.02	1.86	1.95
GS MB clay content, %	7.05	7.24	7.05	7.05	7.15	7.05	7.24	7.24	7.14	7.63	7.24	6.86	7.24
MB clay reagent, ml	37.0	38.0	37.0	37.0	37.5	37.0	38.0	38.0	37.4	40.0	38.0	36.0	38.0
1800°F LOI - mold sand, %	0.8590	0.8576	0.9034	0.8637	0.8655	0.7963	0.7923	0.8608	0.8498	0.0000	0.0000	0.0000	0.0000
900°F volatiles , %	0.42	0.38	0.48	0.58	0.30	0.38	0.42	0.44	0.43	0.38	0.40	0.40	0.39
Permeability index	238	245	265	248	245	245	230	240	245	235	233	240	236
Sand temperature, °F	78	85	87	85	83	86	87	85	85	87	91	88	89

Detailed Process Data - Test HM

	Greensand PCS with Fairmount Minerals 630BN Gold Sand Shell Cores												
Test Dates	**05/07/07**	**05/07/07**	**05/07/07**	**05/08/07**	**05/08/07**	**05/08/07**	**05/09/07**	**05/09/07**	**05/09/07**	**05/10/07**	**05/10/07**	**05/10/07**	**Averages**
Emissions Sample #	**HMCR1**	**HMCR2**	**HMCR3**	**HM001**	**HM002**	**HM003**	**HM004**	**HM005**	**HM006**	**HM007**	**HM008**	**HM009**	
Production Sample #	**HM001**	**HM002**	**HM003**	**HM004**	**HM005**	**HM006**	**HM007**	**HM008**	**HM009**	**HM010**	**HM011**	**HM012**	
Cast weight, lbs.	112.30	116.70	114.40	108.70	119.00	112.50	115.60	114.00	117.45	112.75	115.40	109.55	113.88
Pouring time, sec.	13	18	14	21	14	18	17	15	13	11	11	15	15
Pouring temp ,°F	2636	2610	2620	2631	2624	2626	2633	2630	2636	2635	2632	2632	2631
Pour hood process air temp at start of pour, °F	88	88	88	88	88	87	86	88	87	88	87	87	87.4
Mixer auto dispensed sand weight, Lbs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Core binder weight (Part 1), g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Core binder weight (Part 2), g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Core binder weight, g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
% core binder (BOS)	3	3	3	3	3	3	3	3	3	3	3	3	3.0
% core binder, actual	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Total core weight in mold, Lbs.	21.34	21.57	21.68	21.67	21.55	21.81	21.29	22.53	22.71	21.96	21.51	21.88	21.9
Total stated binder weight in mold, Lbs.	0.62	0.63	0.63	0.63	0.63	0.64	0.62	0.66	0.66	0.64	0.63	0.64	0.64
Core LOI, %	2.8978	2.8760	2.8779	2.8743	2.8594	2.8928	2.8417	2.8295	2.8252	ND	ND	2.8351	2.9
2 hour core dogbone tensile, psi	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Core age when poured, hrs.	283.02	285.92	287.98	291.72	289.98	290.53	311.97	326.94	322.74	347.70	335.42	336.54	317.1
Muller batch weight, lbs.	1200	906	897	909	890	900	900	910	900	910	900	910	903
GS mold sand weight, lbs.	602.7	643.4	633.3	640.2	630.9	621.7	634.2	613.5	613.8	637.5	618.0	ND	626
Mold temperature, °F	72	83	79	78	77	90	84	92	93	81	89.2	90	86
Average green compression , psi	ND	ND	ND	21.84	20.89	21.33	22.15	22.50	22.29	23.26	22.73	22.48	22.16
GS compactability, %	50	43	37	37	38	45	42	42	43	44	45	43	42
GS moisture content, %	ND	ND	ND	1.88	1.60	1.82	1.88	1.82	1.96	2.10	1.80	1.88	1.86
GS MB clay content, %	7.0	7.0	6.8	6.8	6.6	7.3	7.0	7.0	7.3	6.8	7.4	6.6	7.0
MB clay reagent, ml	35.0	35.0	34.0	34.0	33.0	36.5	35.0	35.0	36.5	34.0	37.0	33.0	34.9
1800°F LOI - mold sand, %	0.9227	0.9012	0.9087	0.9248	0.9343	0.8996	0.9823	1.0070	1.0442	1.0250	1.0482	1.0406	0.9896
900°F volatiles , %	0.44	0.42	0.40	0.46	0.50	0.48	0.48	0.52	0.50	0.46	0.50	0.56	0.50
Permeability index	ND	ND	ND	239	241	242	239	240	237	237	241	240	240
Sand temperature, °F	ND	ND	ND	82	87	94	83	91	93	81	92	88	88

Notes:
NT: Not Tested
ND: Not Detected
NA: Not Applicable

Casting Quality Photos for Test HL

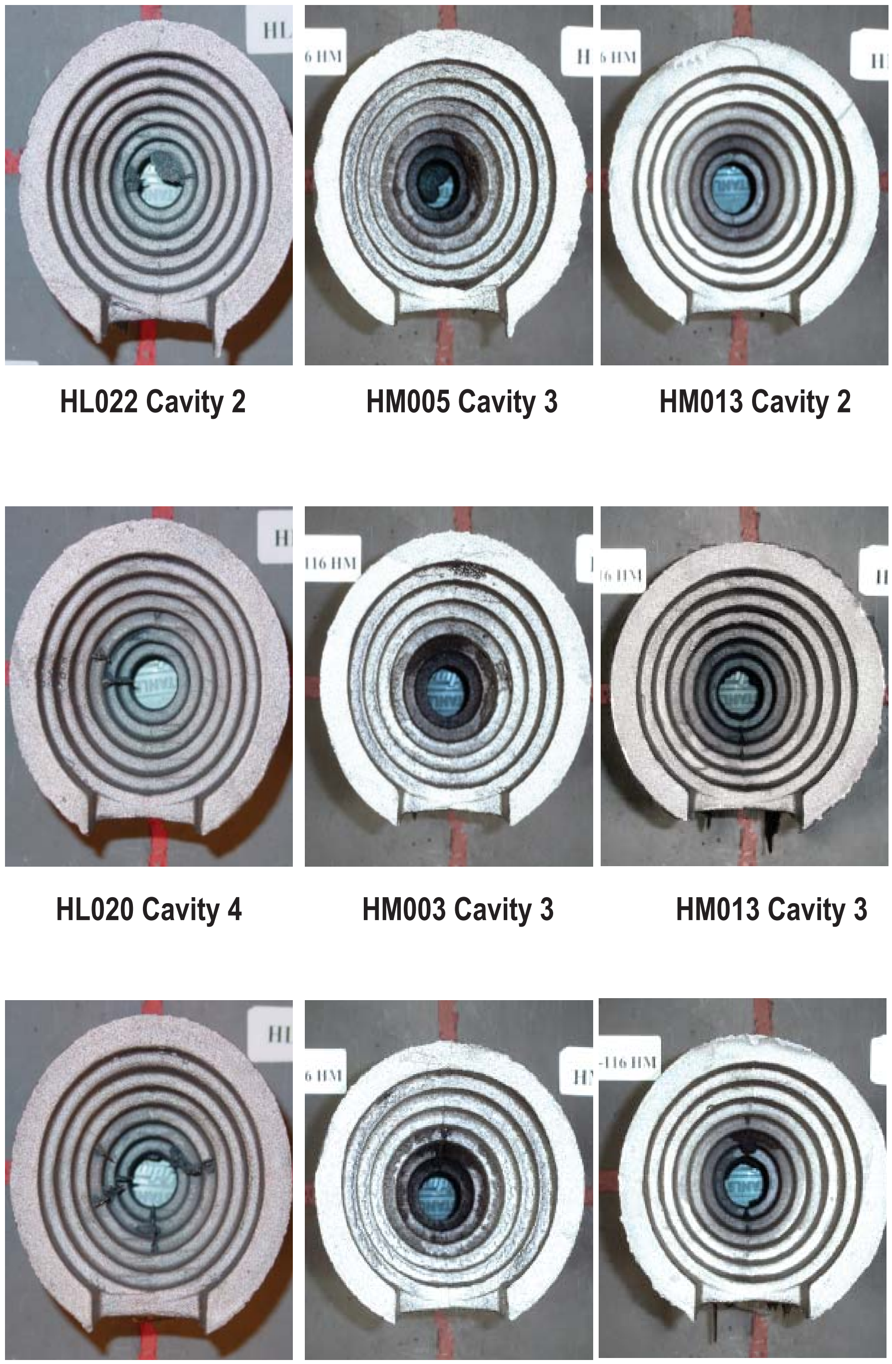
	Rheotec®-XL+	Rheotec®-204P
Best	 HL022 Cavity 2	 HL030 Cavity 2
Median	 HL020 Cavity 4	 HL031 Cavity 1
Worst	 HL021 Cavity 1	 HL031 Cavity 2

Casting Quality Photos

Test HL — Coated PU Cores

Test HM — Uncoated Shell Cores, Coated Shell Cores

Best / Median / Worst



Best: HL022 Cavity 2 | HM005 Cavity 3 | HM013 Cavity 2

Median: HL020 Cavity 4 | HM003 Cavity 3 | HM013 Cavity 3

Worst: HL021 Cavity 1 | HM006 Cavity 3 | HM013 Cavity 1

APPENDIX D CONTINUOUS EMISSION CHARTS

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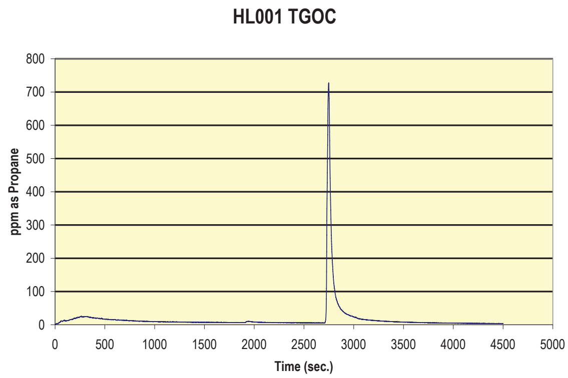
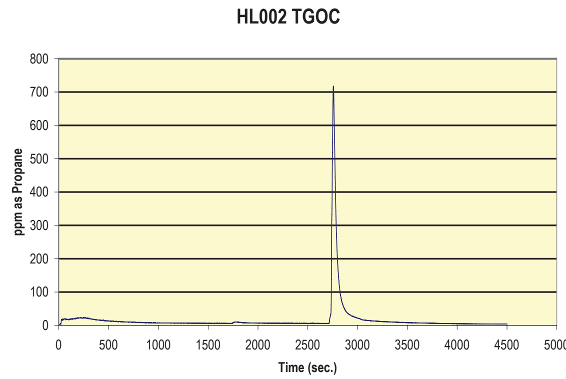

HL001 TGOC
ppm as Propane
0 100 200 300 400 500 600 700 800
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL002 TGOC
ppm as Propane
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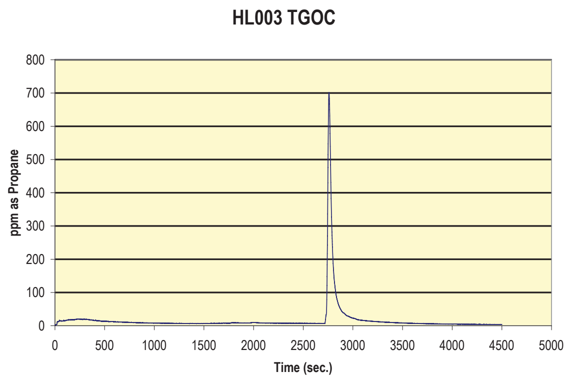
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL003 TGOC
ppm as Propane
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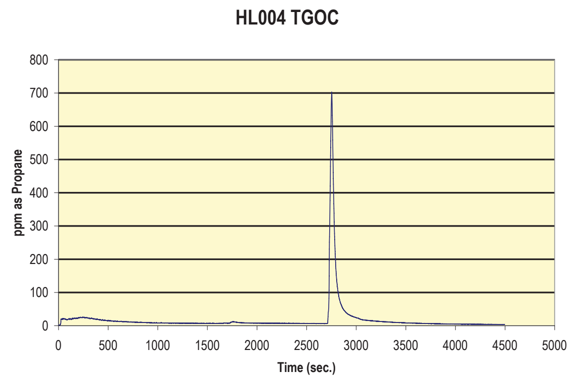
Time (sec.)


HL004 TGOC
ppm as Propane
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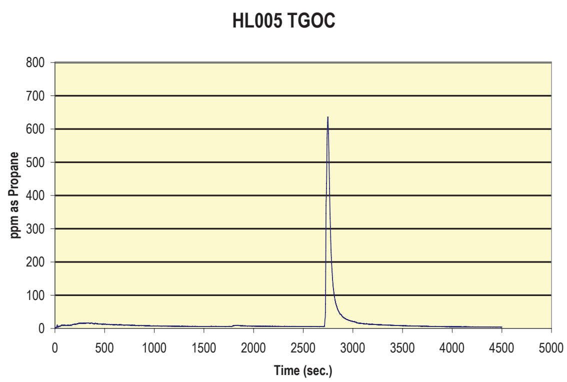
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL005 TGOC
ppm as Propane
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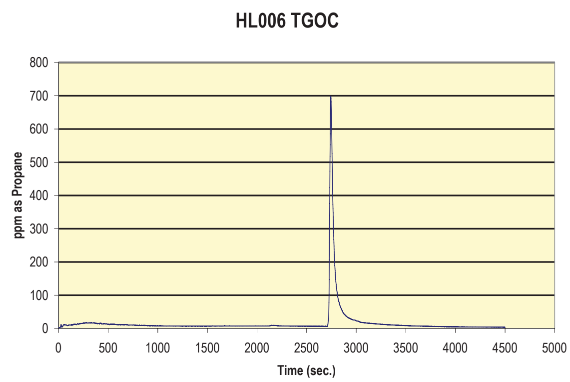
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL006 TGOC
ppm as Propane
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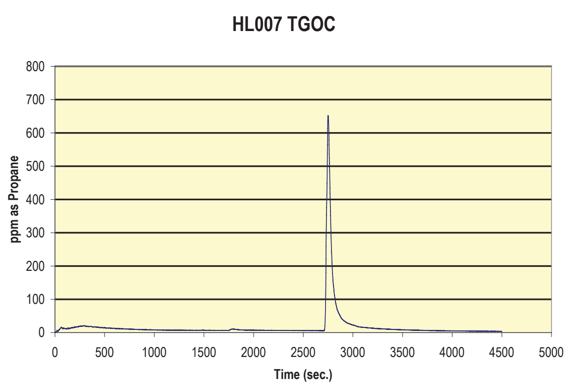
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL007 TGOC
ppm as Propane
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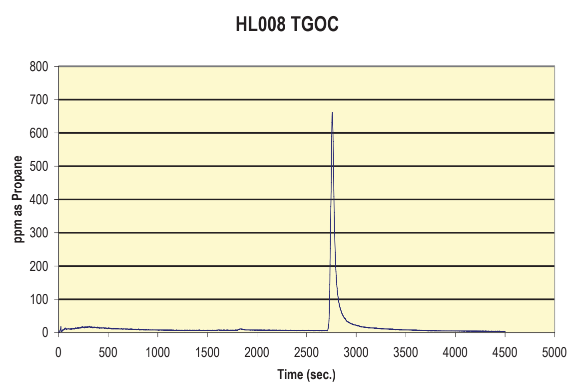
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Time (sec.)


HL008 TGOC
ppm as Propane
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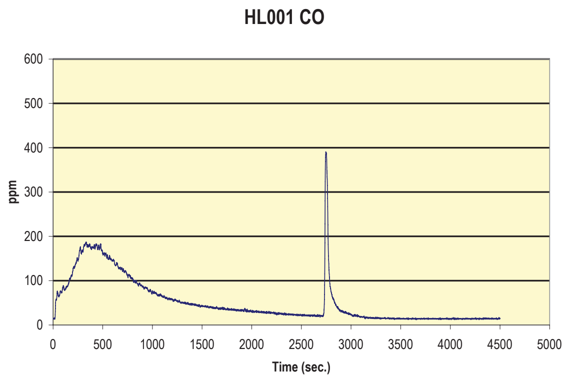
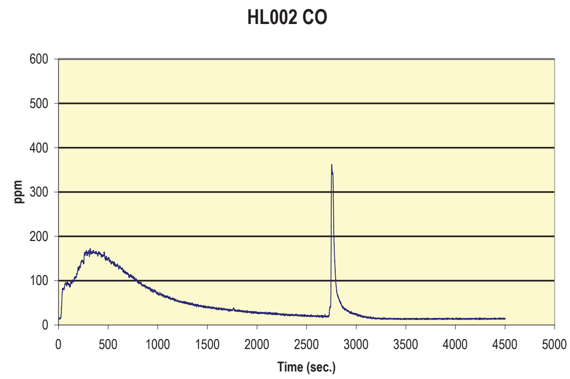
Time (sec.)


HL001 CO
ppm
Time (sec.)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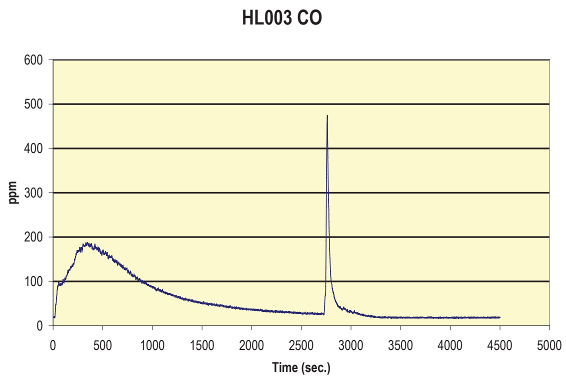
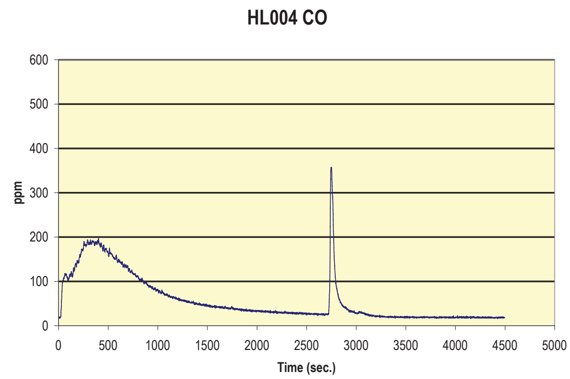
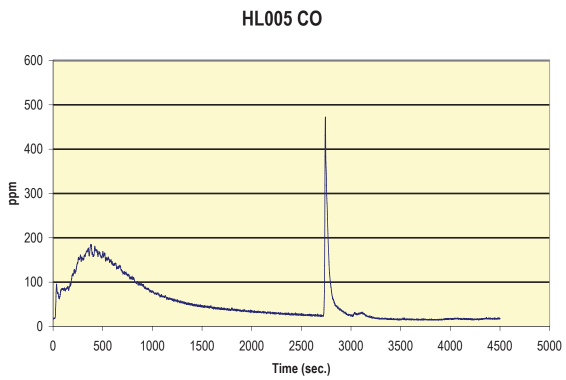
Time (sec.)


HL003 CO
ppm
Time (sec.)


HL004 CO
ppm
Time (sec.)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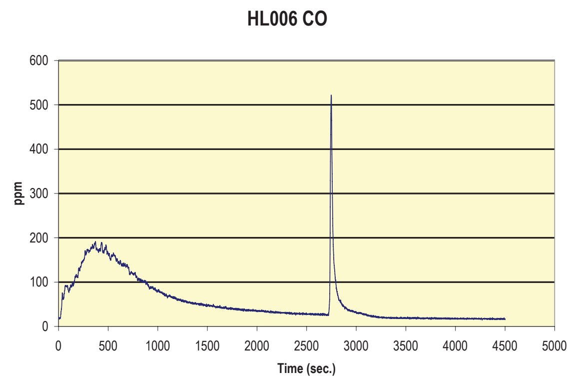
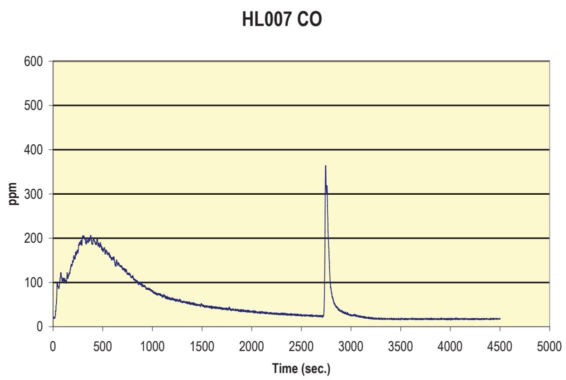
ppm
Time (sec.)


HL006 CO
ppm
Time (sec.)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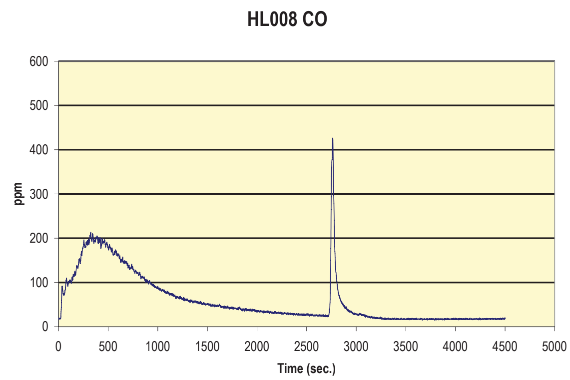
ppm
Time (sec.)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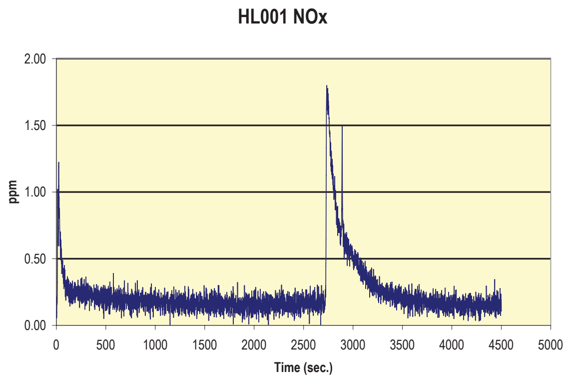
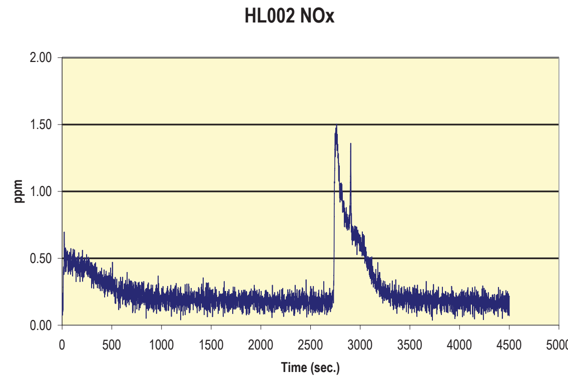
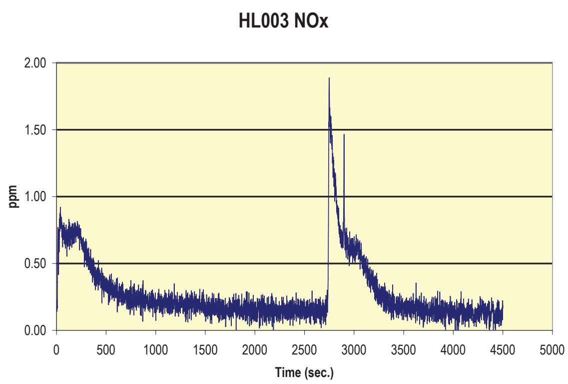
ppm
Time (sec.)


HL001 NOx
ppm
Time (sec.)


HL002 NOx
ppm
Time (sec.)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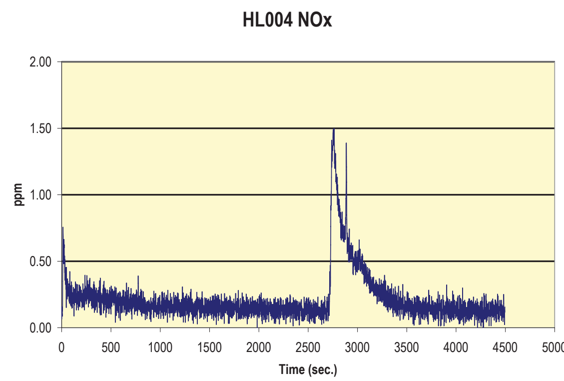
ppm
Time (sec.)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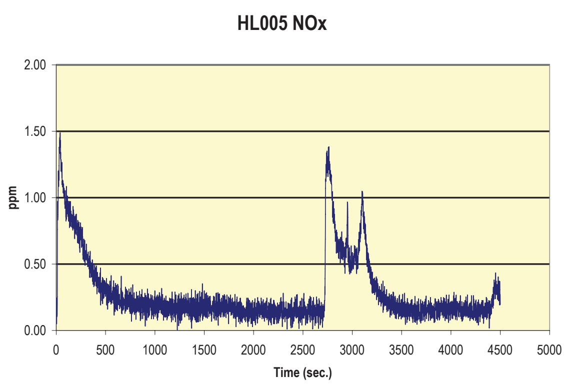
ppm
Time (sec.)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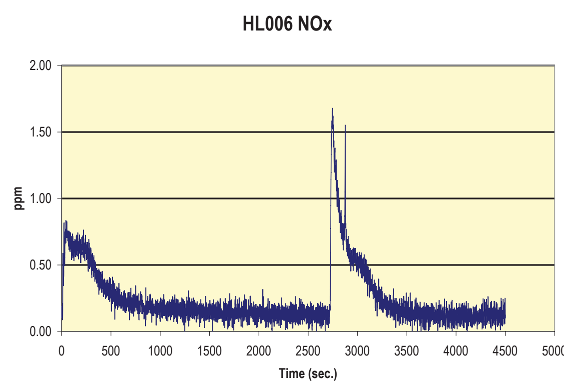
ppm
Time (sec.)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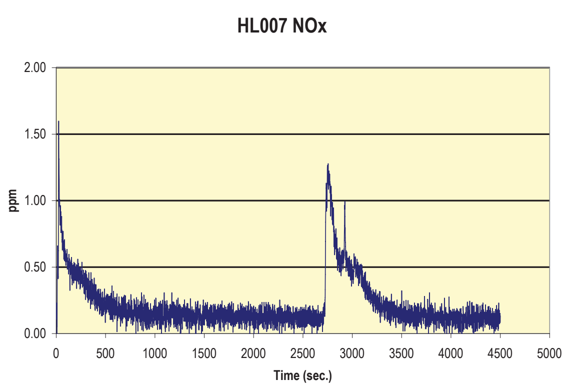
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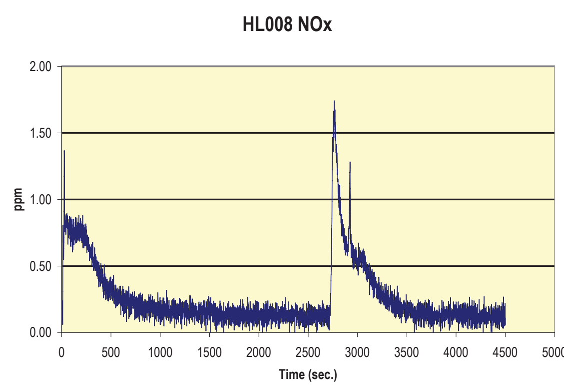
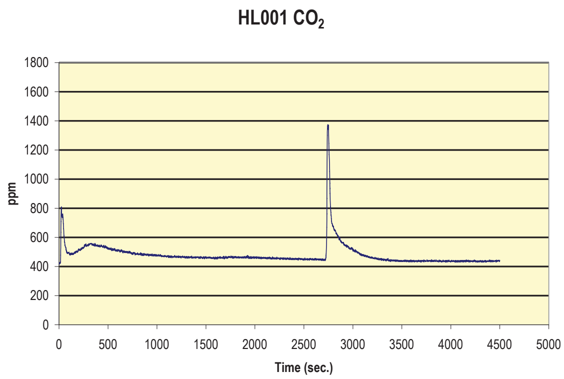
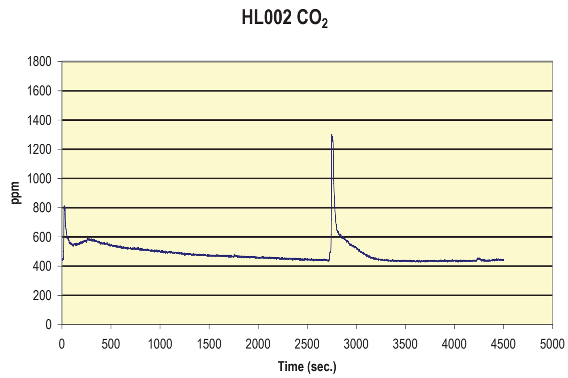
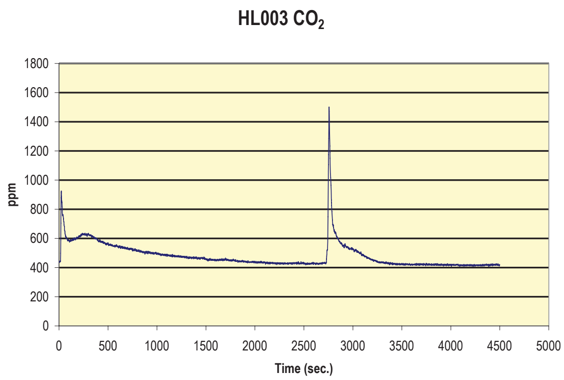
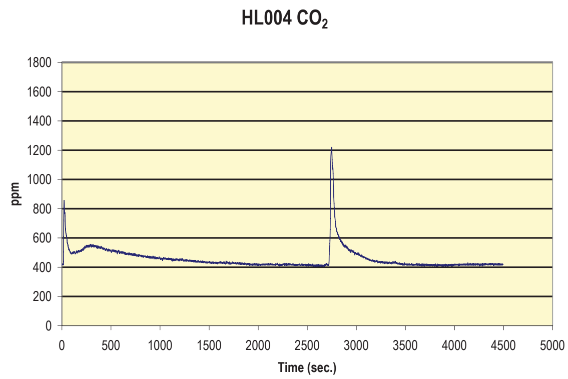
ppm
Time (sec.)


HL008 NOx
ppm
Time (sec.)


HL001 CO_2
ppm
Time (sec.)


HL002 CO_2
ppm
Time (sec.)


HL003 CO_2
ppm
Time (sec.)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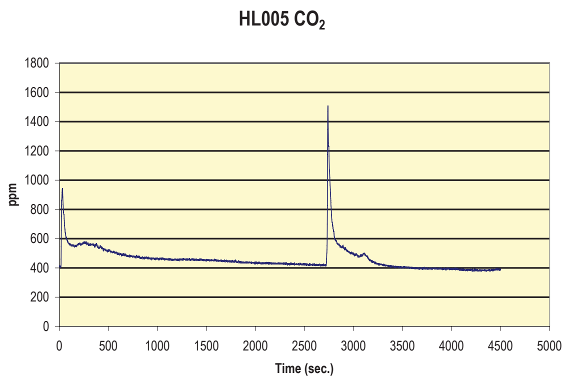
Time (sec.)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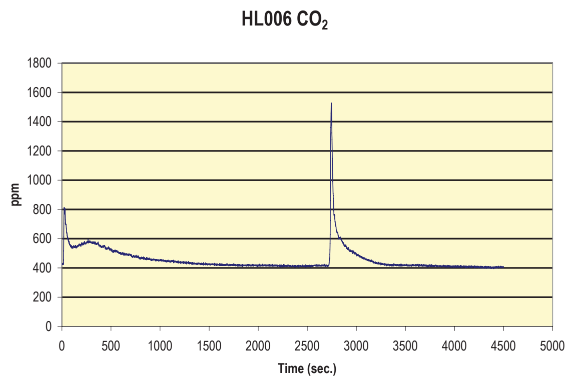
Time (sec.)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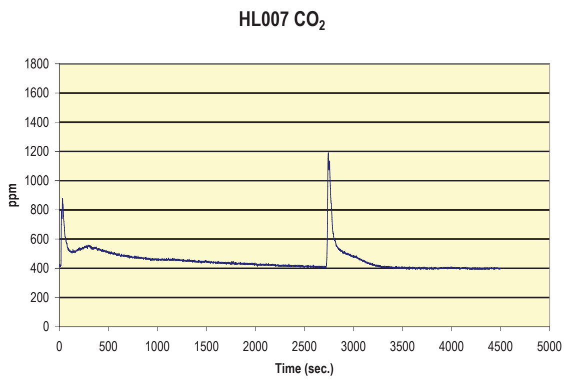
ppm
Time (sec.)


HL007 CO_2
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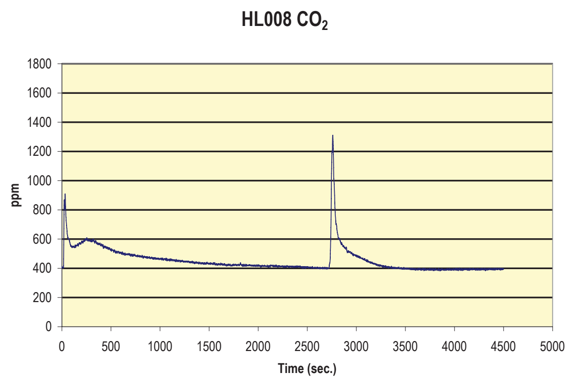
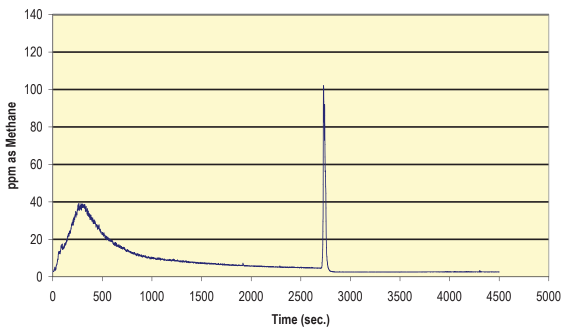
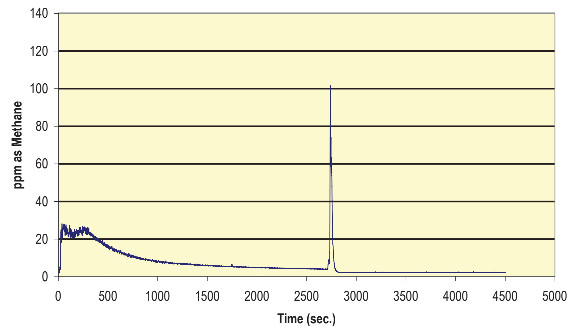
Time (sec.)


HL008 CO_2
ppm
Time (sec.)

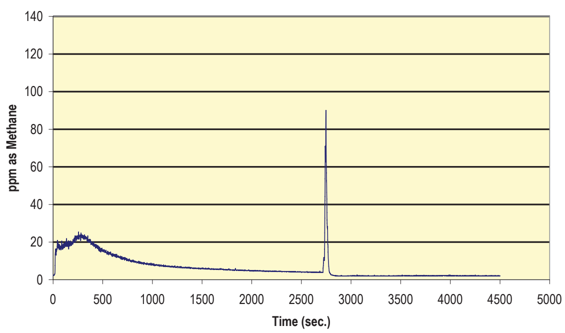
HL001 CH_4



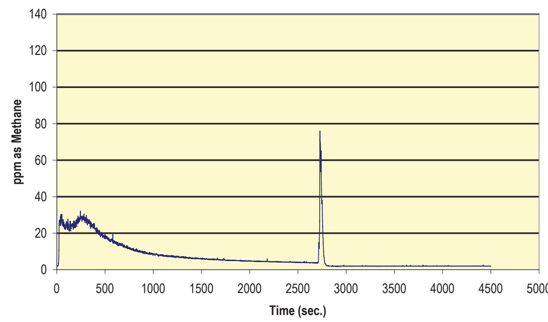
HL002 CH_4



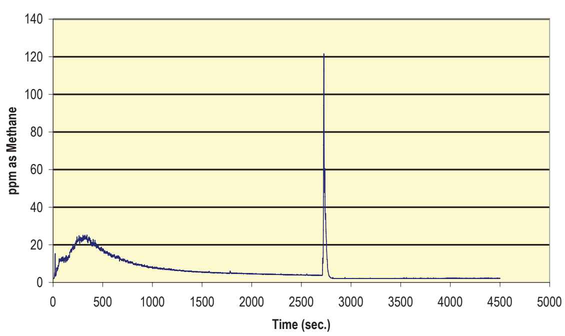
HL003 CH_4



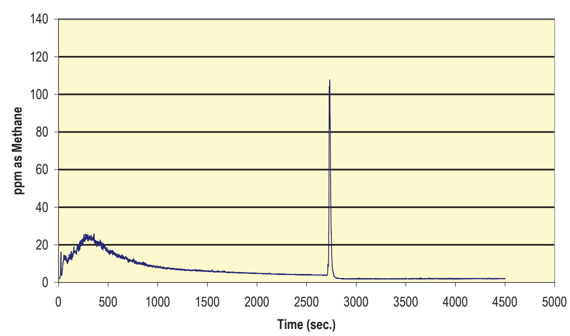
HL004 CH_4



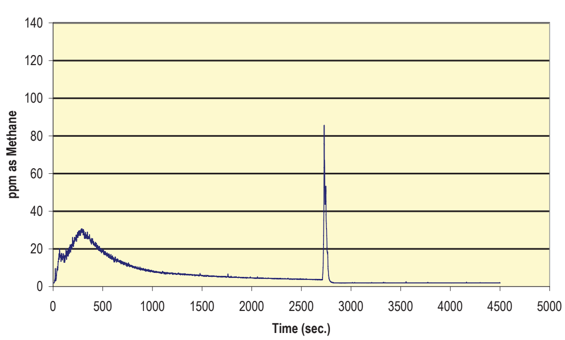
HL005 CH_4



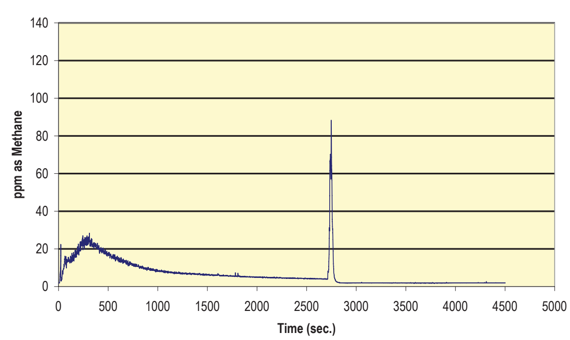
HL006 CH_4

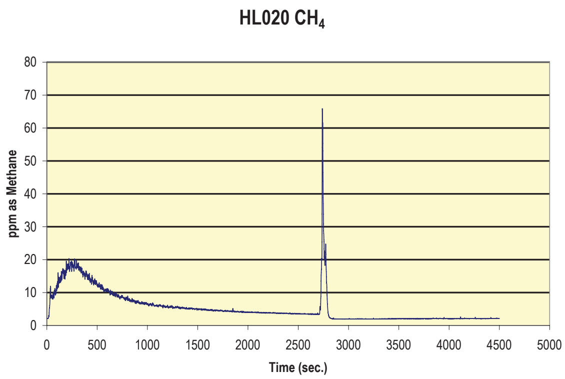


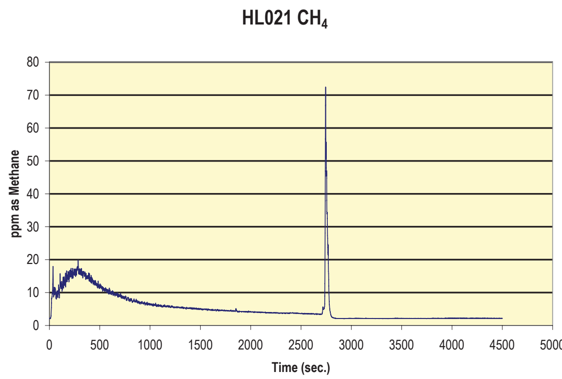
HL007 CH_4

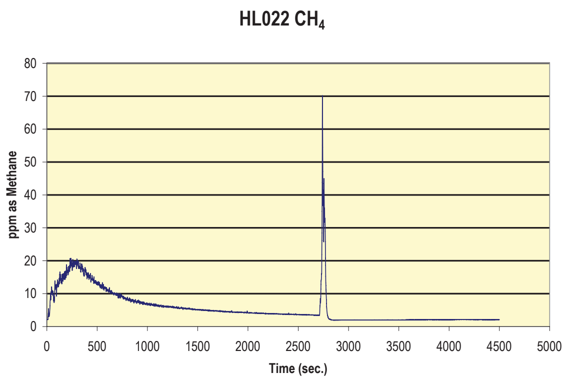


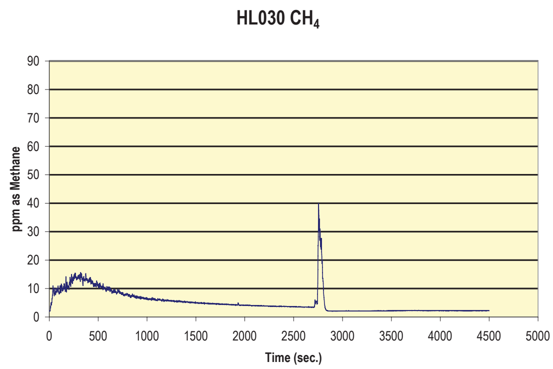
HL008 CH_4

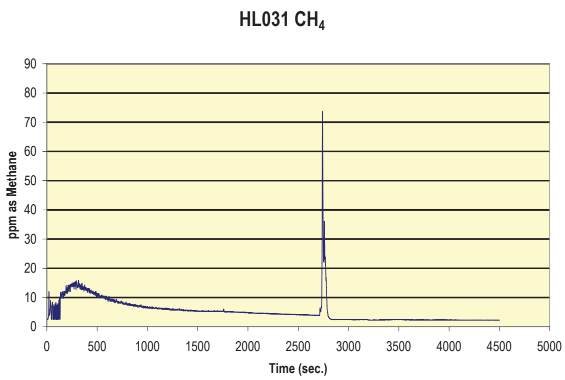



HL020 CH_4
ppm as Methane
Time (sec.)


HL021 CH_4
ppm as Methane
Time (sec.)


HL022 CH_4
ppm as Methane
Time (sec.)


HL030 CH_4
ppm as Methane
Time (sec.)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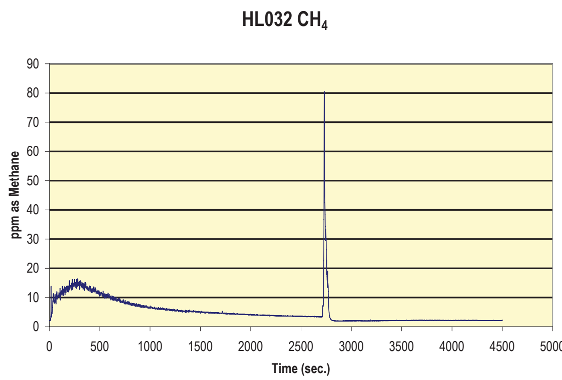
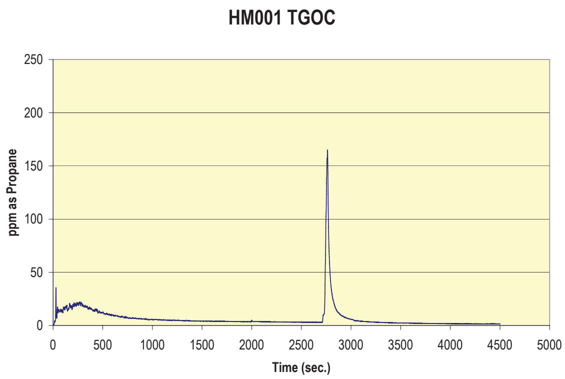
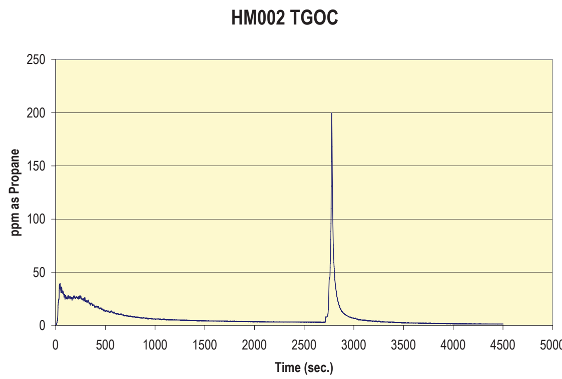
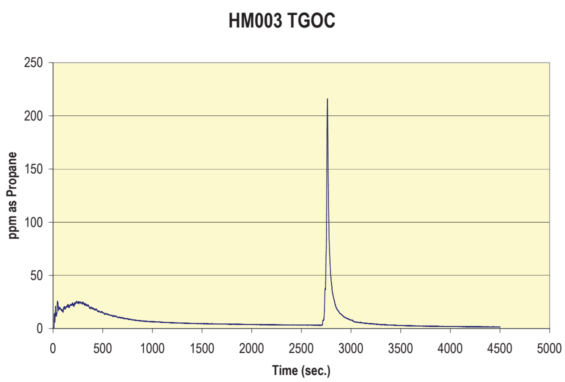
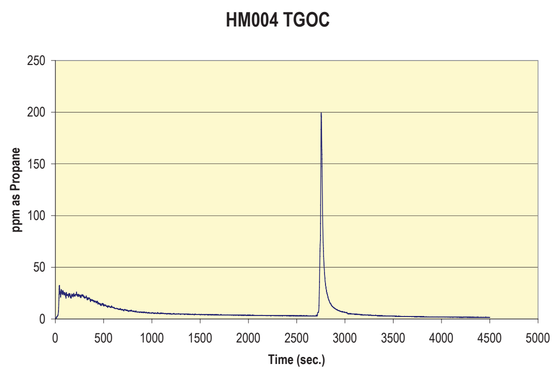
ppm as Methane
Time (sec.)

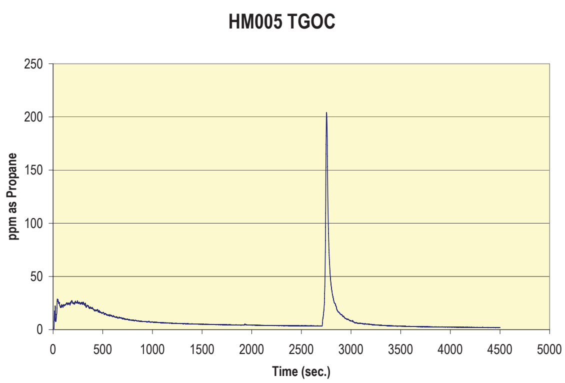

HL032 CH_4
ppm as Methane
Time (sec.)


HM001 TGOC
ppm as Propane
Time (sec.)


HM002 TGOC
ppm as Propane
Time (sec.)


HM003 TGOC
ppm as Propane
Time (sec.)


HM004 TGOC
ppm as Propane
Time (sec.)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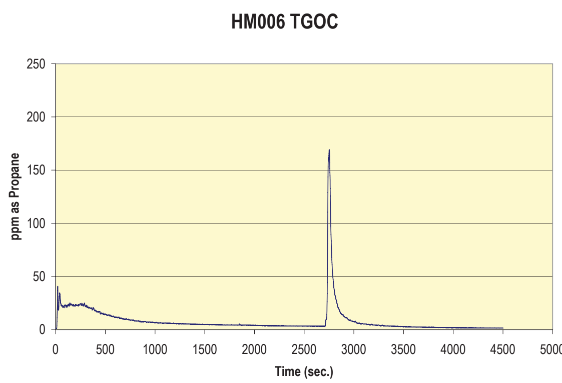
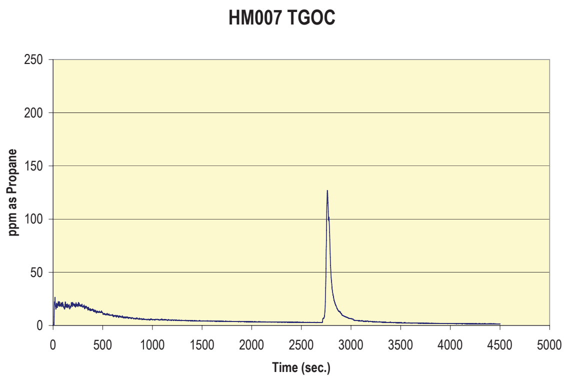
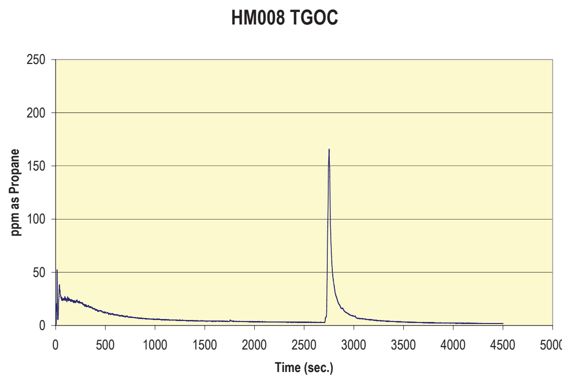
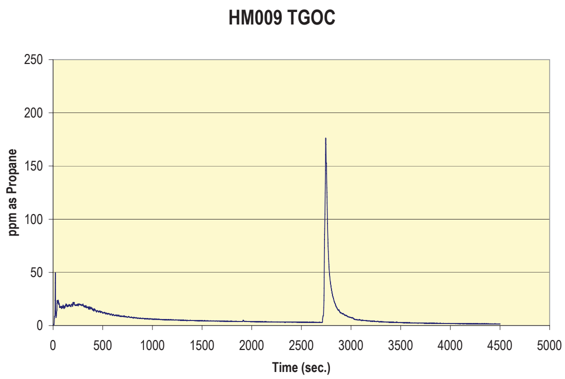
ppm as Propane
Time (sec.)


HM006 TGOC
ppm as Propane
Time (sec.)


HM007 TGOC
ppm as Propane
Time (sec.)
0
50
100
150
200
250
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


HM008 TGOC
ppm as Propane
Time (sec.)
0
50
100
150
200
250
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


HM009 TGOC
ppm as Propane
Time (sec.)
0
50
100
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200
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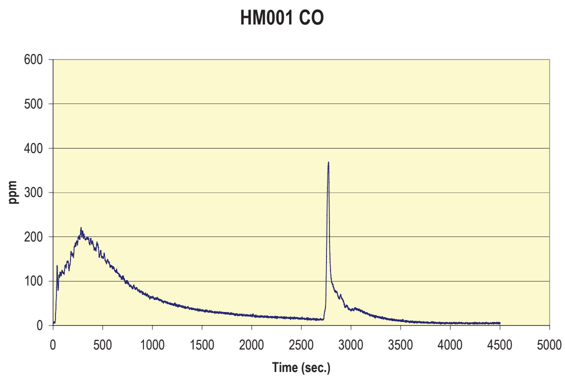
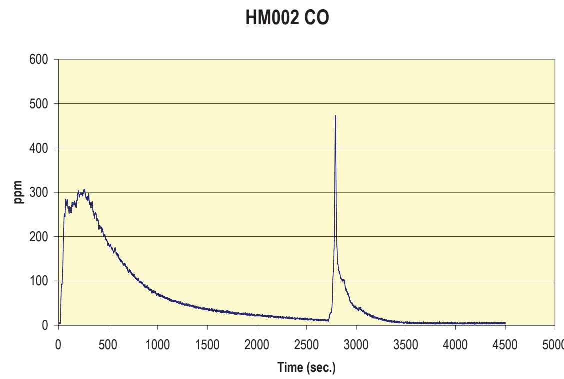
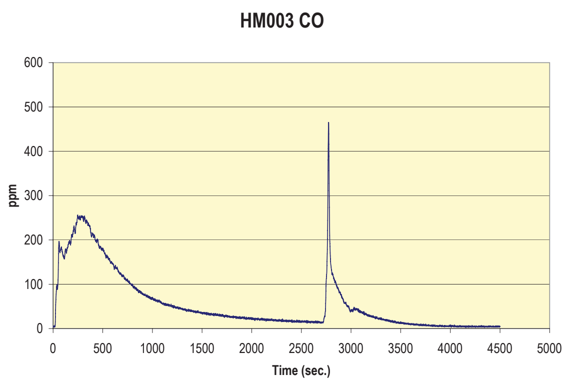
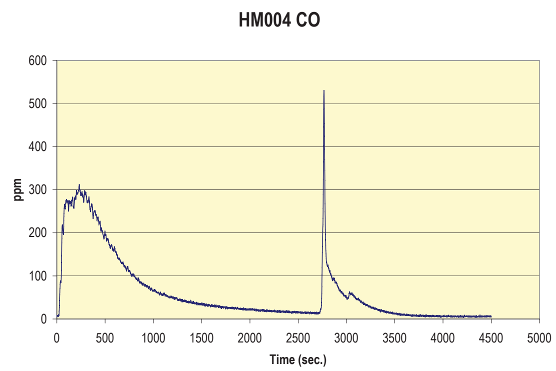
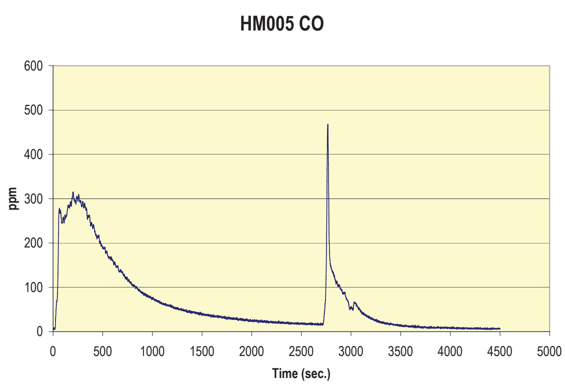
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

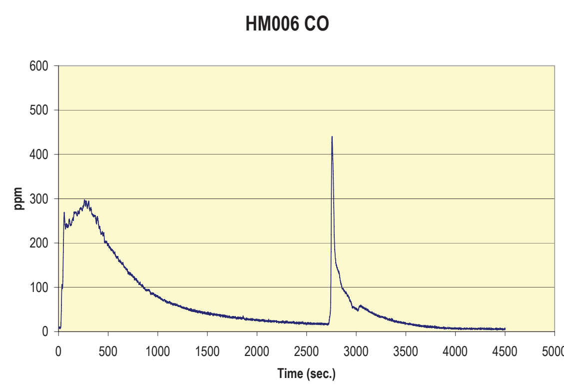

HM001 CO
ppm
Time (sec.)


HM002 CO
ppm
Time (sec.)


HM003 CO
ppm
Time (sec.)


HM004 CO
ppm
Time (sec.)


HM005 CO
ppm
Time (sec.)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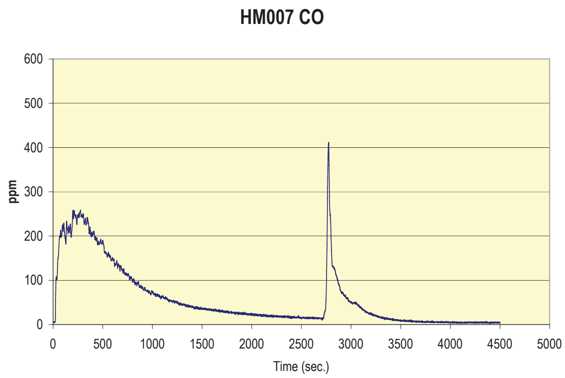
Time (sec.)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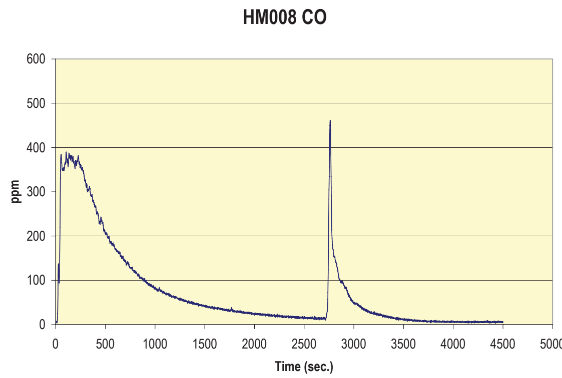
Time (sec.)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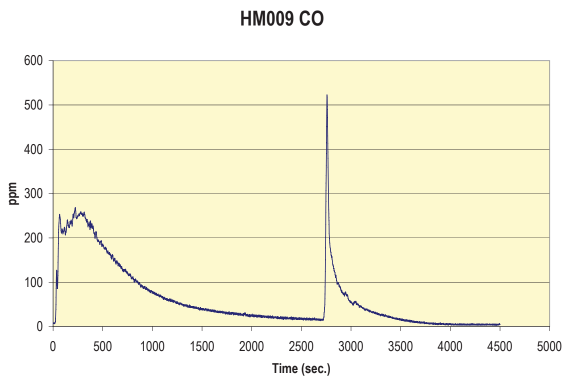
Time (sec.)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Time (sec.)

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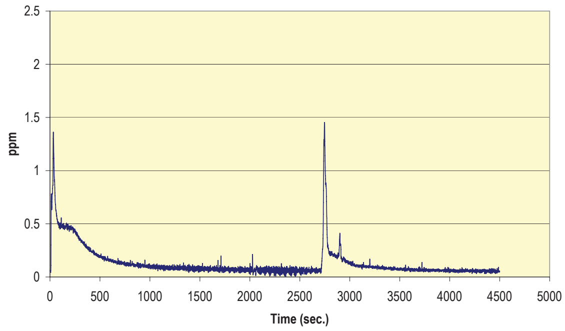

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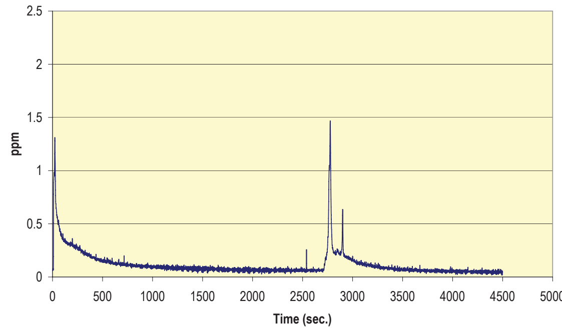

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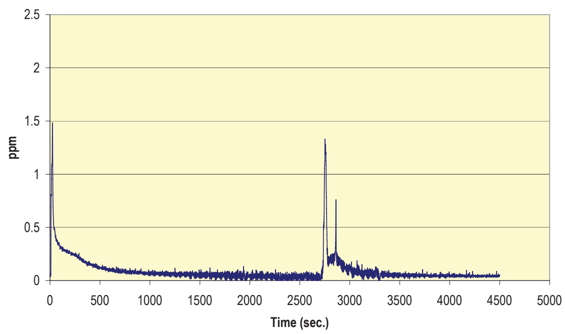

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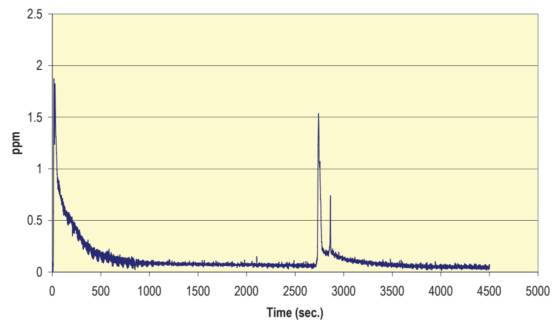

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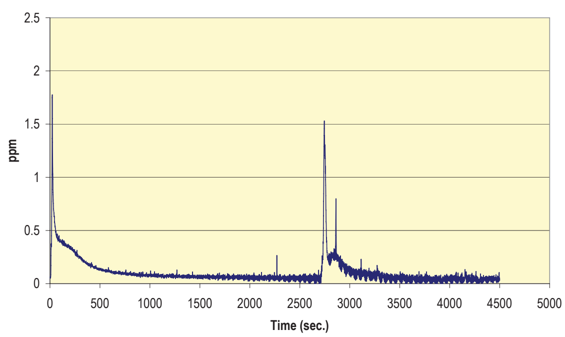

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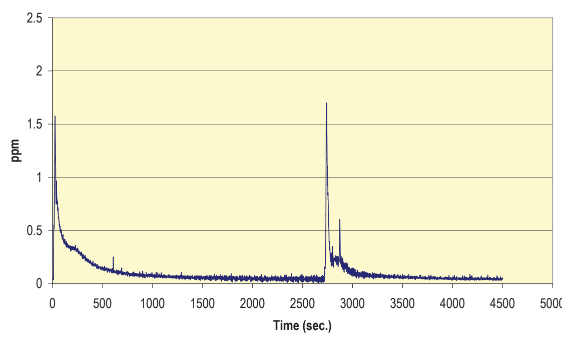

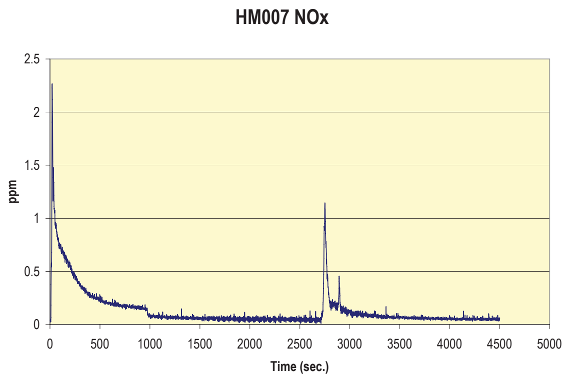
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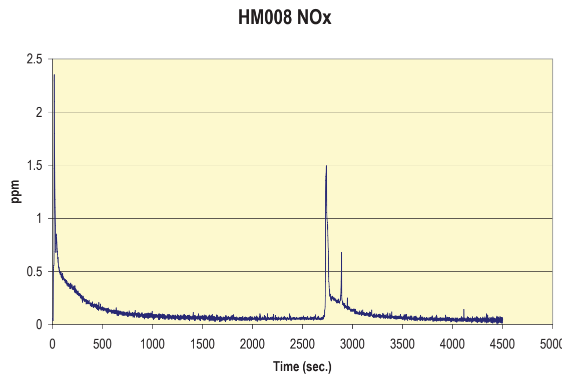
Time (sec.)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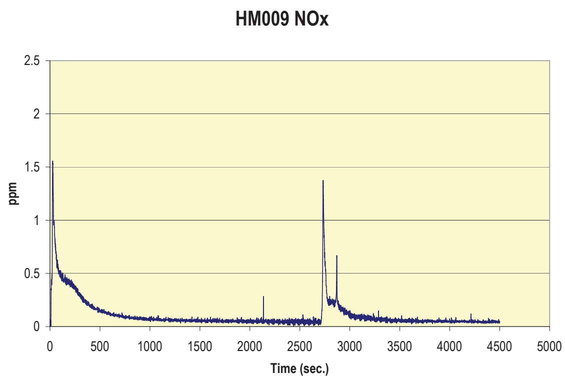
Time (sec.)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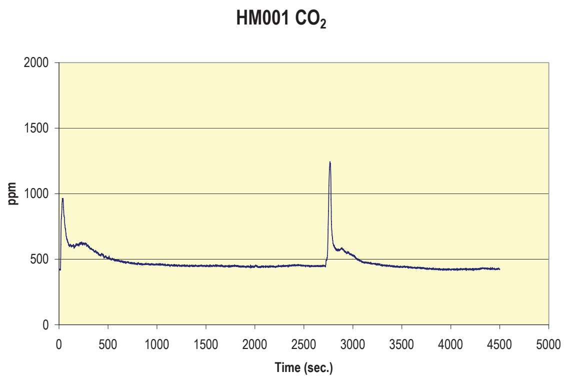
Time (sec.)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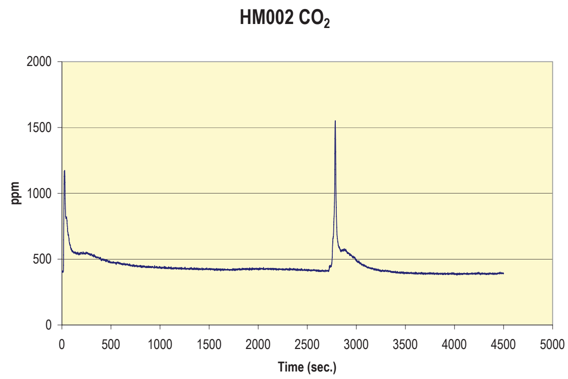
Time (sec.)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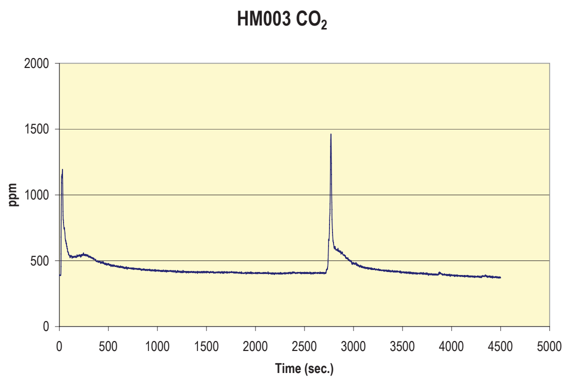
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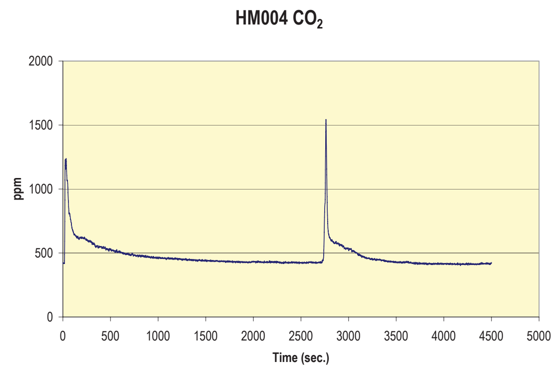
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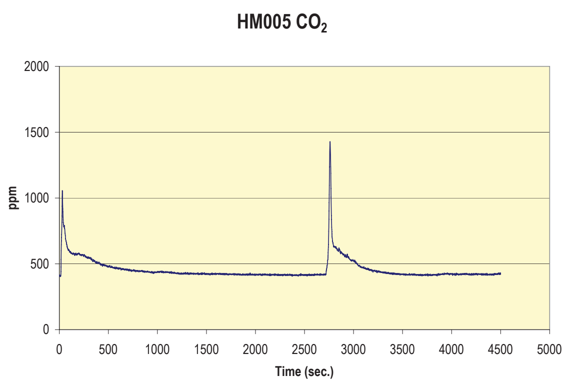
Time (sec.)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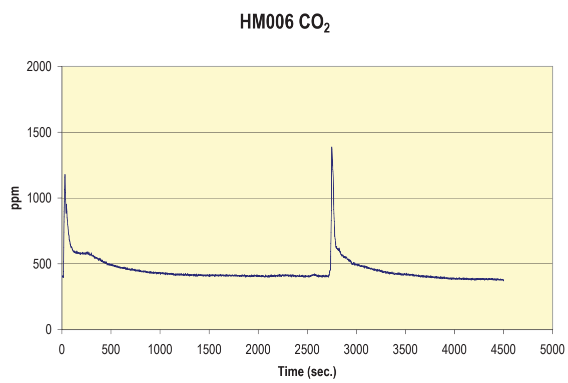
Time (sec.)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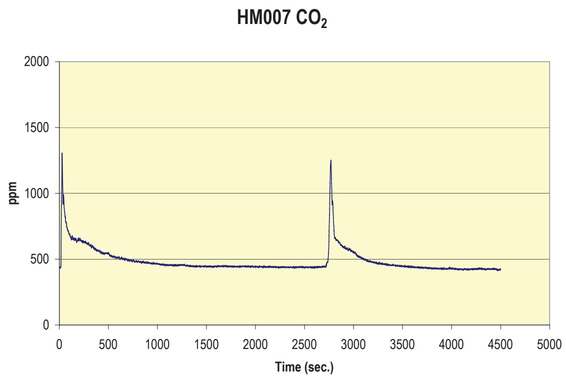
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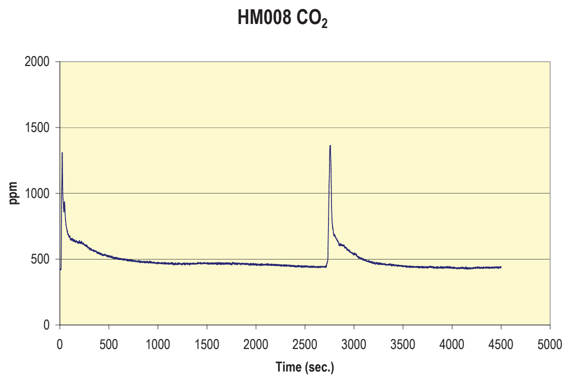
Time (sec.)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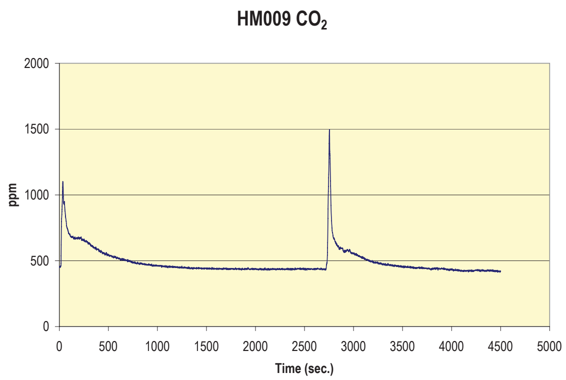
Time (sec.)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ppm
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2000
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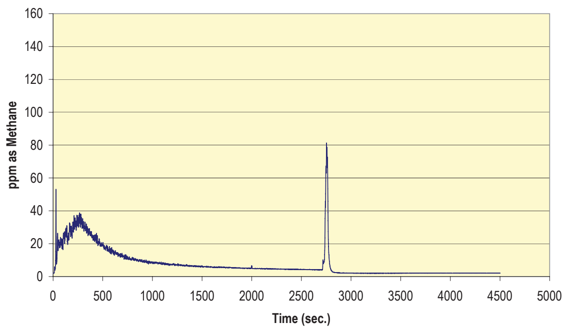
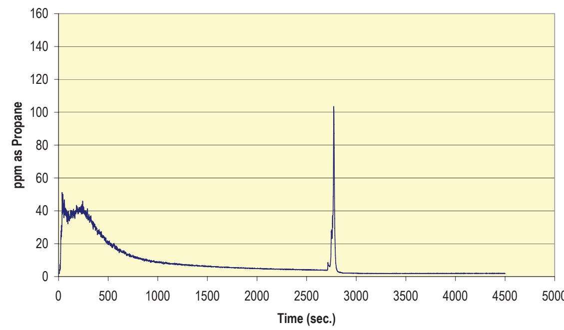
4000
4500
5000
Time (sec.)

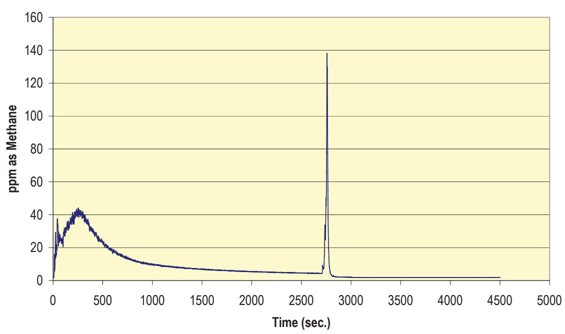
HM001 CH_4



HM002 CH_4



HM003 CH_4



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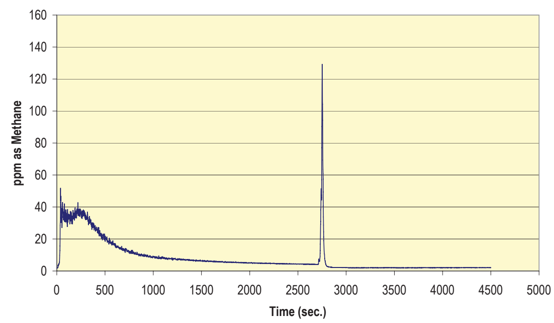
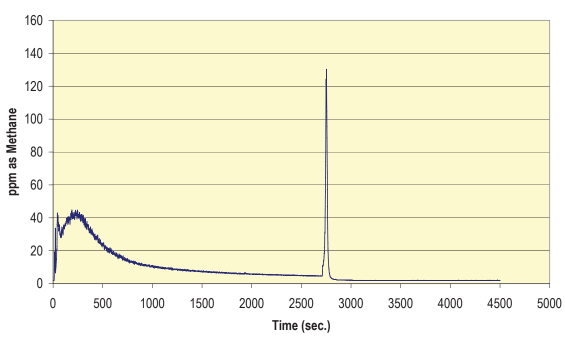


HM005 CH_4



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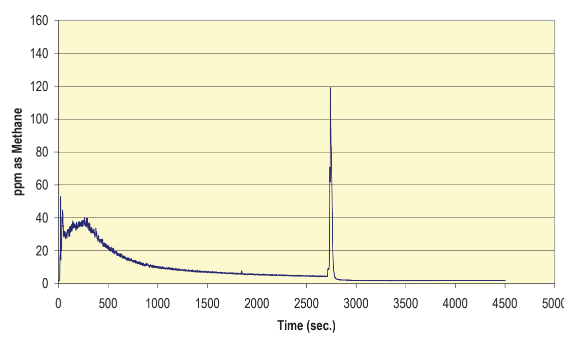

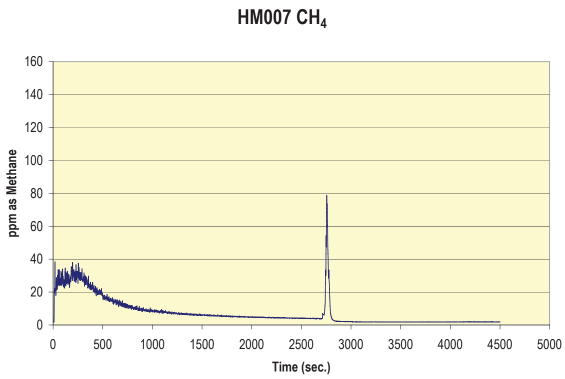
HM007 CH_4
ppm as Methane
Time (sec.)
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60
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100
120
140
160
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1500
2000
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3500
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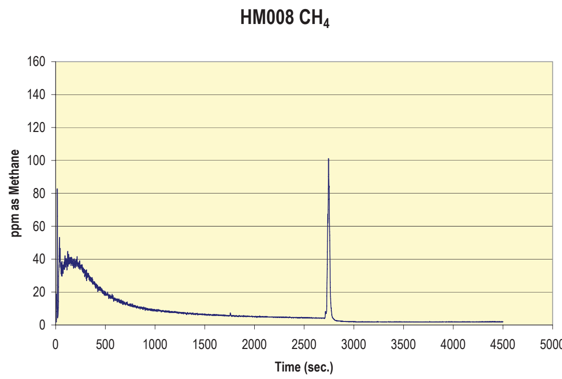
4500
5000


HM008 CH_4
ppm as Methane
Time (sec.)
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40
60
80
100
120
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2000
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4000
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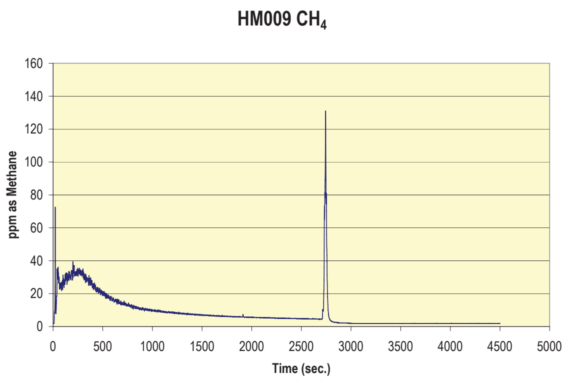
HM009 CH_4
ppm as Methane
Time (sec.)
0
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40
60
80
100
120
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160
500
1000
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2000
2500
3000
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4500
5000

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
CTM	Conditional Test Method
DOD	Department of Defense
DOE	Department of Energy
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
NOx	Oxides of Nitrogen
NMHC	Non-Methane Hydrocarbons
NT	Not Tested - Lab testing was not done

PCS	Pouring, Cooling, Shakeout
POM	Polycyclic Organic Matter
QA/QC	Quality Assurance/Quality Control
SO_2	Sulfur Dioxide
TA	Target Analyte
TEA	Triethylamine
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