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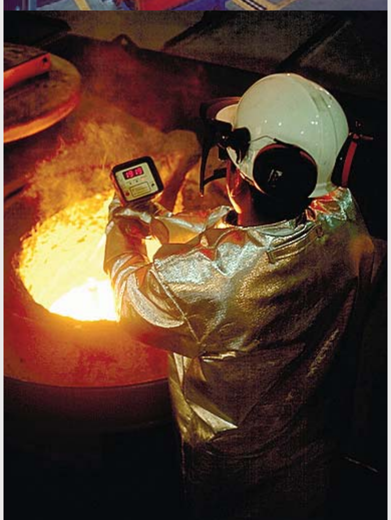
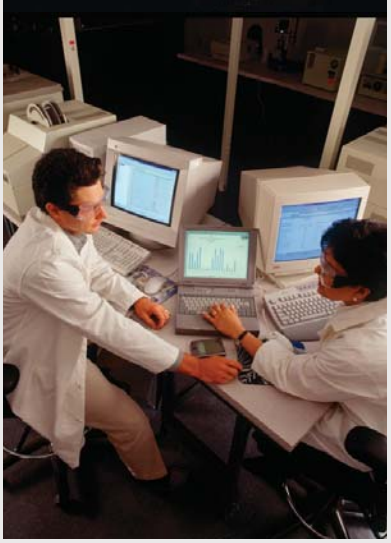

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TECHNIKON

5301 Price Avenue
McClellan, CA 95652
916-929-8001
www.technikonllc.com

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A Phenolic Urethane Binder System including Two Coated Core Tests for Pouring, Cooling, Shakeout Emissions in Iron

1413-121 HL

May 2007
(Revised for public distribution - November 2007)

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A Phenolic Urethane Binder System including Two Coated Core Tests for Pouring, Cooling, Shakeout Emissions in Iron

1413-121 HL

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

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

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

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Executive Summary

This report contains the results of Test HL, a quantitative evaluation of the pouring, cooling and shakeout airborne emissions and relative surface casting quality comparisons from coated core castings using a phenolic urethane coldbox core binder system for iron. Castings were made in greensand molds with no seacoal using the four-cavity step core pattern.

Eight molds containing uncoated cores were poured using Isocure® LF305/52-904GR (Ashland), after three initial sand conditioning runs. This system was considered the standard baseline reference for comparing emissions. Three molds containing cores coated with Rheotec® XL+ (Foseco Metallurgical, Inc), were poured and three more poured with cores coated with Rheotec® 204P core coating. Rheotec® XL+ is considered a thermally insulating core coating, and Rheotec® 204P is considered a thermally conductive coating.

The core binder concentration 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). Cores were coated by dipping into the coating solution and dried in a gas fired core oven.

Molds were poured with iron at 2630± 10°F. The pouring time of 13-15 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 average emission indicator results are reported in Tables 1a for pounds of analyte per ton of metal poured (lb/ton) and Table 1b for pounds of analyte per pound of binder (lb/lb). Although an insulating core coating was thought to lower emissions when compared to a conductive core coating due to the reduced temperature the core would reach during pouring, cooling and shakeout, both coated core tests resulted in lower emissions for all individual targeted analytes than those from the uncoated cores, by an average of approximately 40%. For criteria pollutant and greenhouse gas emissions, a slight increase of 30% for CO_2, and a decrease of 30% for CH_4 were found, while no statistically relevant change

in CO emissions was found. All NO_x emissions were less than the practical quantitative limit.

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

Analyte Name	Baseline Reference Uncoated Cores	Rheotec® XL+	Rheotec® 204P
Emission Indicators			
TGOC as Propane	1.23E+00	6.59E-01	6.19E-01
Non-Methane Hydrocarbons	1.08E+00	5.53E-01	5.27E-01
Sum of Target Analytes	6.24E-01	3.13E-01	3.17E-01
Sum of Target HAPs	5.42E-01	3.03E-01	3.07E-01
Sum of Target POMs	1.88E-01	5.57E-02	5.67E-02

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

Analyte Name	Baseline Reference Uncoated Cores	Rheotec® XL+	Rheotec® 204P
Emission Indicators			
TGOC as Propane	1.99E-01	1.03E-01	9.71E-02
Non-Methane Hydrocarbons	1.75E-01	8.62E-02	8.27E-02
Sum of Target Analytes	1.01E-01	4.88E-02	4.98E-02
Sum of Target HAPs	8.74E-02	4.72E-02	4.83E-02
Sum of Target POMs	3.05E-02	8.67E-03	8.92E-03

The most likely cause for reduced emissions from both the Rheotec® XL+ and the Rheotec® 204P coated cores was the drying of the cores at 275°F for one hour, which removed many of the volatile solvents in the binder system.

Benzene, phenol and naphthalene accounted for approximately 50% of the measured emissions from targeted analytes for the reference test containing uncoated cores at 19%, 18%, and 12% respectively. Benzene and phenol contributed 54% and 52% to total emissions for the Rheotec® XL+ and the Rheotec® 204P core coating tests, respectively.

A qualitative assessment was made between the surface quality of coated core castings from Test HL. A photographic record was made of the 12 castings produced from each of the coated core tests. Pictures of best, median and worst casting quality are shown in

Appendix C. The castings produced from coating with Rheotec® XL+ had better surface finish than those made from cores coated with Rheotec® 204P.

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

1.3. Report Organization

This report has been written to document the methodology and results of a specific test plan that was used to evaluate the pouring, cooling and shakeout airborne emissions from one uncoated and two coated core formulations using Ashland Isocure® LF305/52-904GR® core binder for iron applications. The 8-mold uncoated core test was used as the base-line reference to compare emissions from both the 3-mold test using cores coated with Rheotec® XL+ and the 3-mold test using cores coated with Rheotec® 204P. All cores were in greensand molds that did not contain seacoal. Binder amounts were at 1.4% BOS for all tests.

Section 2.0 of this report includes a summary of the methodologies used for data collection and analysis, procedures for emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test is summarized in Section 3.0 and detailed data appears in the appendices of this report. Section 3.1 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 HL consisted of three parts designed to evaluate airborne emissions from pouring, cooling and shakeout of a phenolic urethane core binder on uncoated and coated cores. All cores were made with Isocure® LF305/52-904GR in a 55/45 ratio, at 1.4 % BOS and cured with TEA. Cores for the first eight molds were uncoated, while cores for molds nine through eleven were coated with Rheotec® XL+, and cores for molds twelve through fourteen were coated with Rheotec® 204P.

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 and coated phenolic core in greensand without seacoal, PCS
Test Plan Number	1413-121-HL
Metal Poured	Iron
Casting Type	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
Core	1.4 % (BOS) Ashland Isocure® 305/904, TEA activated, Wedron 530 sand
Core Coating	Foseco Rheotec® XL+ and Foseco Rheotec® 204P
Number of Molds Poured	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, 8 sampling runs with uncoated cores
Test Dates	September 26, 2006 through October 4, 2006
Emissions Measured	69 target analytes
Process Parameters Measured	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate

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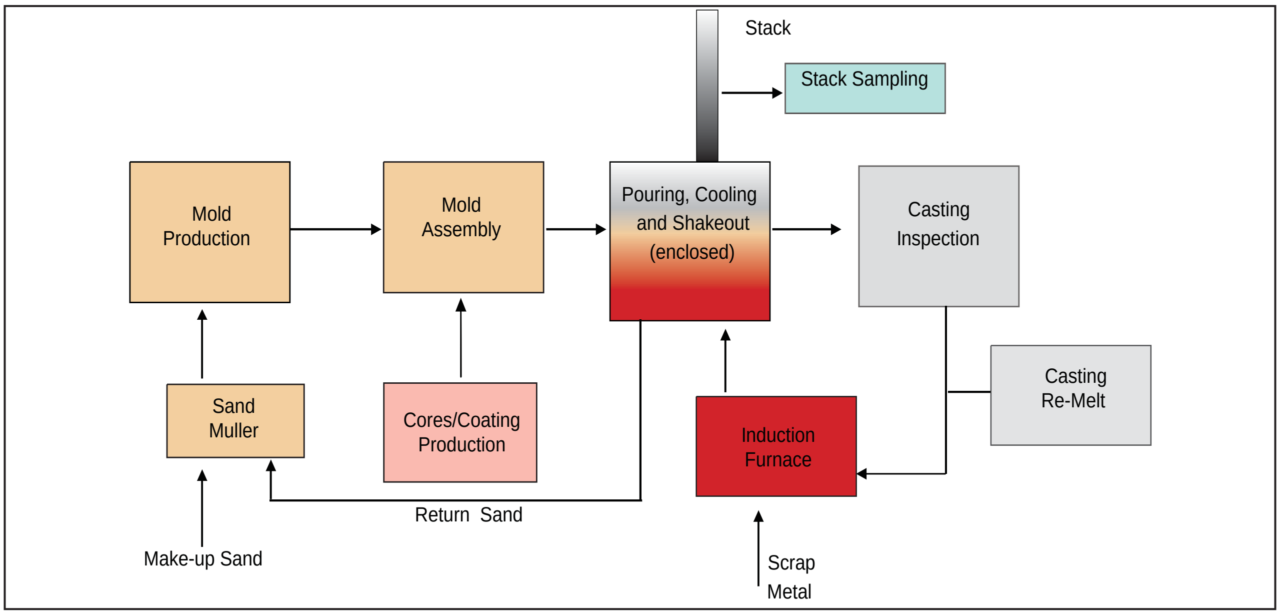
2.0 TEST METHODS, ASSUMPTIONS AND PROCEDURES

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 and Testing Process Diagram



2.2. Description of Testing Program

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

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

As described in the method, sampling can be conducted using a Volatile Organic Sampling Train (VOST), which was the technique used for sampling for the tests described herein. A sample gas stream was extracted from the source and then routed using the train through tubes containing adsorbents, which are the collection materials upon which the target analytes are deposited. Adsorption tube samples were collected and analyzed for sixty-four (64) target compounds using procedures based on approved federal methods, including those of the EPA.

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

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

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

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

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

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

2.2.1. Test Plan Review and Approval

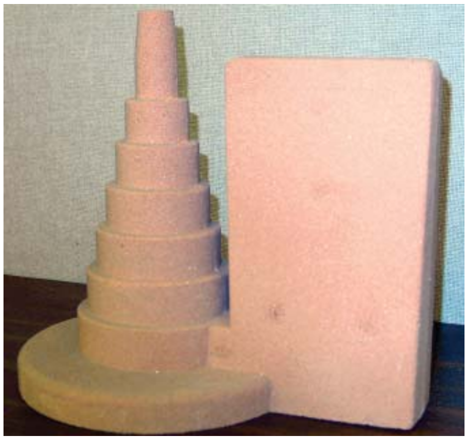
The proposed test plan was reviewed and approved by the Technikon staff and by CERP Working Group Chairs as appropriate.

2.2.2. Mold and Metal Preparation

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

Figure 2-2 Step Core Pattern

Figure 2-3 Step Core



2.2.3. Individual Sampling Events

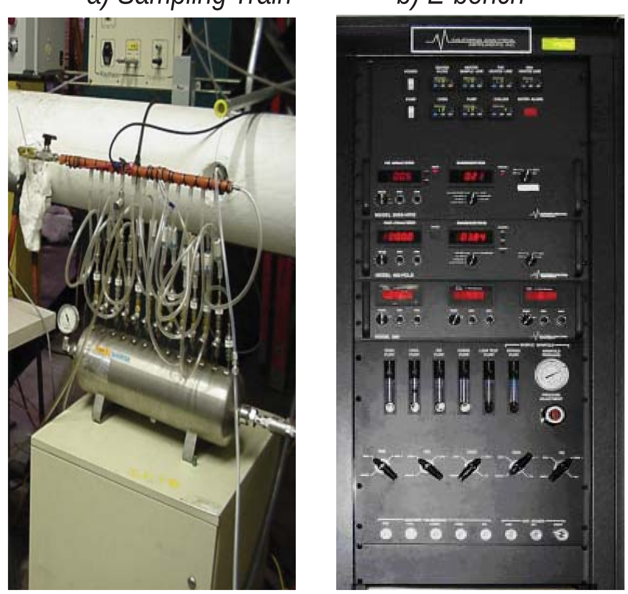
Test HL consisted of three separate tests to evaluate emissions from uncoated and coated cores made using a phenolic urethane core binder system. The uncoated core test consisted of eight (8) replicate runs using Isocure® LF305/52-904GR. The two coated core tests consisted of three (3) replicate runs each, and used two different Rheotec® coatings. Prior to pouring and emission sampling for each run in the three tests, a single mold package was placed onto a shake-out table contained within a hooded enclosure designed to meet the requirements of EPA Method 204 for a total temporary enclosure. The enclosed test stand was pre-heated to approximately 85°F. The flow rate of the emission capture air was nominally 600 scfm. 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 2-4).

Figure 2-4 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 2-5a). Another probe in the stack was used to continuously draw effluent samples and transport them via a forty-seven (47) ft heated sample line to the FID for methane measurement, and to an emissions console (Figure 2-5b) located in Technikon's laboratory, which contains a battery of gas analyzers. This console, or emissions bench, consists of a total hydrocarbon analyzer for TGOC analysis, two infra-red analyzers (for CO and CO_2) and a chemiluminescence analyzer for NOx.

Continuous air samples were collected during the 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 2-5 Stack Sampling Equipment
a) Sampling Train *b) E-bench*



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.

Table 2-1 Process Equipment and Methods

Process Parameters	Equipment (Method)
Mold Weight	Cardinal 748E Platform Scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
Binder Weight	Mettler SB12001 Digital Scale (Gravimetric)
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)

2.2.5. Air Emissions Analysis

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

Table 2-2 Emission Sampling and Analytical Methods

Measurement Parameter	Test Method(s)
Port Location	US EPA Method 1
Number of Traverse Points	US EPA Method 1
Gas Velocity and Temperature	US EPA Method 2
Gas Density and Molecular Weight	US EPA Method 3a
Gas Moisture	US EPA Method 4 (Gravimetric)
Target Analytes	US EPA Methods TO17, TO11; NIOSH Methods 1500, 2002, 2010
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

Some methods modified to meet specific CERP test objectives.

2.2.6. Data Reduction, Tabulation and Preliminary Report Preparation

Data calculations for determining emission concentrations resulting from the specific test plans outlined in Appendix A are based on process and emission parameters. The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample by the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the casting poured or weight of binder to provide emissions data in pounds of analyte per ton of metal or pounds of analyte per pound of binder.

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

2.2.7. Report Preparation and Review

The Preliminary Draft Report is created and reviewed by Process Team and Emissions Team members to ensure its completeness, consistency with the test plan, and adherence to QA/QC procedures. Appropriate observations, conclusions and recommendations are added to the report to produce a Draft Report. The Draft Report is then reviewed by senior management and comments are incorporated into a draft Final Report prior to final signature approval and distribution.

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

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

- Immediately following the individual sampling events performed for each test, specific process parameters are reviewed by the Process Engineer to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Manager of Process

Engineering and the Vice President of Operations determine whether the individual test samples should be invalidated or flagged for further analysis following review of the laboratory data.

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

3.0 TEST RESULTS

Average results for the relative pouring, cooling and shakeout airborne emissions for Test HL are presented in Tables 3-1a and 3-1b. An evaluation and comparison of emissions from testing an iron phenolic urethane cold box core binder system (Isocure®, Ashland) using both uncoated and coated cores was made. Results were divided into three sections corresponding to the uncoated and coated core tests that were run. The first eight molds poured contained the uncoated cores and were used as the baseline reference test. The results from the two coated core test sections were compared to the results obtained from the first section. The coated core tests used cores coated with Rheotec® XL+ for three core molds, and three core molds were coated with Rheotec® 204P. A total of fourteen four-cavity molds were poured.

Table 3-1a Summary Comparison of Two Rheotec® Coatings for Test HL, Average Emissions Results- Lb/Tn Metal

	Uncoated Cores	Rheotec® XL+		Rheotec® 204P	
Analyte Name	Reference Runs 001-008	Runs 020-022	Percent Change from Reference	Runs 030-032	Percent Change from Reference
Emission Indicators					
TGOC as Propane	1.23E+00	6.59E-01	**-46**	6.19E-01	**-50**
Non-Methane Hydrocarbons	1.08E+00	5.53E-01	**-49**	5.27E-01	**-51**
Sum of Target Analytes	6.24E-01	3.13E-01	**-50**	3.17E-01	**-49**
Sum of Target HAPs	5.42E-01	3.03E-01	**-44**	3.07E-01	**-43**
Sum of Target POMs	1.88E-01	5.57E-02	**-70**	5.67E-02	**-70**
Selected Target HAPs and POMs					
Benzene	1.20E-01	9.61E-02	**-20**	8.34E-02	**-30**
Phenol	1.14E-01	7.16E-02	**-37**	8.04E-02	**-29**
Naphthalene	7.18E-02	1.38E-02	**-81**	1.31E-02	**-82**
Methylnaphthalene, 2-	5.79E-02	1.75E-02	**-70**	1.71E-02	**-70**
Cresol, o-	3.25E-02	1.99E-02	**-39**	2.12E-02	**-35**
Aniline	3.06E-02	1.76E-02	**-42**	2.27E-02	**-26**
Methylnaphthalene, 1-	2.60E-02	9.26E-03	**-64**	9.50E-03	**-63**
Toluene	1.98E-02	1.83E-02	-7	1.68E-02	**-15**
Dimethylnaphthalene, 1,3-	9.85E-03	4.85E-03	**-51**	5.24E-03	**-47**
Acetaldehyde	9.51E-03	7.29E-03	**-23**	6.79E-03	**-29**
Xylene, mp-	6.84E-03	5.45E-03	**-20**	5.24E-03	**-23**
o-Toluidine	6.60E-03	3.22E-03	**-51**	4.33E-03	**-34**
Cresol, mp-	5.89E-03	3.55E-03	**-40**	4.22E-03	**-28**
Dimethylnaphthalene, 2,7-	5.74E-03	2.11E-03	-63	1.94E-03	**-66**
Dimethylnaphthalene, 1,6-	4.61E-03	2.28E-03	**-50**	2.48E-03	**-46**
Dimethylnaphthalene, 2,6-	3.47E-03	2.70E-03	-22	2.56E-03	-26
Selected Target Analytes					
Trimethylbenzene, 1,2,4-	2.80E-02	1.94E-03	**-93**	1.97E-03	**-93**
Ethyltoluene, 3-	1.32E-02	≤PQL	NA	≤PQL	NA
Ethyltoluene, 2-	5.85E-03	4.85E-04	**-92**	5.04E-04	**-91**
Dodecane	5.37E-03	≤PQL	NA	≤PQL	NA
Dimethylphenol, 2,4-	4.89E-03	1.69E-03	**-65**	1.48E-03	**-70**
Indene	4.36E-03	1.15E-03	**-74**	1.17E-03	**-73**
Propylbenzene, n-	4.08E-03	≤PQL	NA	≤PQL	NA
Dimethylphenol, 2,6-	4.04E-03	2.69E-03	-33	2.11E-03	**-48**
Undecane	3.71E-03	≤PQL	NA	≤PQL	NA
Tetradecane	2.58E-03	≤PQL	NA	≤PQL	NA
2-Butanone (MEK)	2.33E-03	1.53E-03	**-34**	1.65E-03	**-29**
Butyraldehyde/Methacrolein	4.77E-04	4.78E-04	0	4.57E-04	-4
Crotonaldehyde	2.75E-04	2.30E-04	**-16**	2.36E-04	**-14**
Criteria Pollutants and Greenhouse Gases					
Carbon Dioxide	3.50E+00	4.58E+00	**31**	4.27E+00	**22**
Carbon Monoxide	2.01E+00	2.19E+00	9	2.04E+00	1
Methane	1.46E-01	1.06E-01	**-27**	9.21E-02	**-37**
Nitrogen Oxides	≤PQL	≤PQL	NA	≤PQL	NA
Sulfur Dioxide	1.12E-02	1.34E-02	**20**	1.13E-02	2

NA= Not Applicable

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

Table 3-1b Summary comparison of Two Rheotec® Coatings for Test HL, Average Emissions Results- Lb/Lb Binder

	Uncoated Cores	Rheotec® XL+		Rheotec® 204P	
Analyte Name	**Reference Runs 001-008**	**Runs 020-022**	**Percent Change from Reference**	**Runs 030-032**	**Percent Change from Reference**
Emission Indicators					
TGOC as Propane	1.99E-01	1.03E-01	**-48**	9.71E-02	**-51**
Non-Methane Hydrocarbons	1.75E-01	8.62E-02	**-51**	8.27E-02	**-53**
Sum of Target Analytes	1.01E-01	4.88E-02	**-51**	4.98E-02	**-51**
Sum of Target HAPs	8.74E-02	4.72E-02	**-46**	4.83E-02	**-45**
Sum of Target POMs	3.05E-02	8.67E-03	**-72**	8.92E-03	**-71**
Selected Target HAPs and POMs					
Benzene	1.94E-02	1.50E-02	**-23**	1.31E-02	**-33**
Phenol	1.85E-02	1.12E-02	**-40**	1.26E-02	**-32**
Naphthalene	1.17E-02	2.14E-03	**-82**	2.06E-03	**-82**
Methylnaphthalene, 2-	9.39E-03	2.72E-03	**-71**	2.69E-03	**-71**
Cresol, o-	5.28E-03	3.11E-03	**-41**	3.32E-03	**-37**
Aniline	4.49E-03	2.75E-03	**-39**	3.57E-03	-20
Methylnaphthalene, 1-	4.21E-03	1.44E-03	**-66**	1.50E-03	**-65**
Toluene	3.21E-03	2.86E-03	**-11**	2.63E-03	**-18**
Dimethylnaphthalene, 1,3-	1.60E-03	7.55E-04	**-53**	8.24E-04	**-48**
Acetaldehyde	1.54E-03	1.14E-03	**-26**	1.06E-03	**-31**
Xylene, mp-	1.11E-03	8.50E-04	**-23**	8.22E-04	**-26**
o-Toluidine	9.71E-04	5.02E-04	**-48**	6.81E-04	**-30**
Cresol, mp-	9.58E-04	5.54E-04	**-42**	6.63E-04	**-31**
Dimethylnaphthalene, 2,7-	9.32E-04	3.23E-04	**-65**	3.02E-04	**-68**
Dimethylnaphthalene, 1,6-	7.48E-04	3.55E-04	**-53**	3.90E-04	**-48**
Dimethylnaphthalene, 2,6-	5.65E-04	4.25E-04	-25	4.06E-04	-28
Selected Target Analytes					
Trimethylbenzene, 1,2,4-	4.55E-03	3.02E-04	**-93**	3.09E-04	**-93**
Ethyltoluene, 3-	2.14E-03	≤PQL	NA	≤PQL	NA
Ethyltoluene, 2-	9.50E-04	7.56E-05	**-92**	7.95E-05	**-92**
Dodecane	8.70E-04	≤PQL	NA	≤PQL	NA
Dimethylphenol, 2,4-	7.99E-04	2.64E-04	**-67**	2.32E-04	**-71**
Indene	7.08E-04	1.81E-04	**-74**	1.85E-04	**-74**
Propylbenzene, n-	6.63E-04	≤PQL	NA	≤PQL	NA
Dimethylphenol, 2,6-	6.61E-04	4.19E-04	-37	3.30E-04	**-50**
Undecane	6.05E-04	≤PQL	NA	≤PQL	NA
Tetradecane	4.18E-04	≤PQL	NA	≤PQL	NA
2-Butanone (MEK)	3.78E-04	2.39E-04	**-37**	2.59E-04	**-31**
Butyraldehyde/Methacrolein	7.74E-05	7.45E-05	-4	7.18E-05	-7
Crotonaldehyde	4.45E-05	3.61E-05	**-19**	3.74E-05	**-16**
Criteria Pollutants and Greenhouse Gases					
Carbon Dioxide	5.68E-01	7.14E-01	26	6.70E-01	18
Carbon Monoxide	3.27E-01	3.42E-01	5	3.19E-01	-2
Methane	2.37E-02	1.65E-02	**-30**	1.44E-02	**-39**
Nitrogen Oxides	≤PQL	≤PQL	NA	≤PQL	NA
Sulfur Dioxide	1.81E-03	2.08E-03	**15**	1.77E-03	-2

NA= Not Applicable

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

Compounds which were chosen for analysis 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 closely match the results for total hydrocarbons obtained by Method 25A, excluding exempt compounds such as methane, and including compounds such as formaldehyde, which are less responsive in the FID. For the results reported here, the Sum of Target Analytes averages 64% of adjusted TGOC as Propane results.

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

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 NMHC as determined by CTM-042. The second section of the table includes average emission results for select individual target analytes (including comparative results for the two uncoated core tests). In addition, average values for selected criteria and greenhouse gases including CO, CO_2, CH_4, SO_2, and NO_x are given in the third section of the tables. Individual isomers are reported in the tables, and have not been summed and reported as a group. If the reader chooses, isomers which have been targeted and analyzed may be summed using the information located in the tables in Section 3.0 or Appendix B.

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

3.1. Discussion of Results

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

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

Figure 3-1a Comparison of Emissions Indicators of Uncoated Cores to Coated Cores, Average Results- Lb/Ton Metal

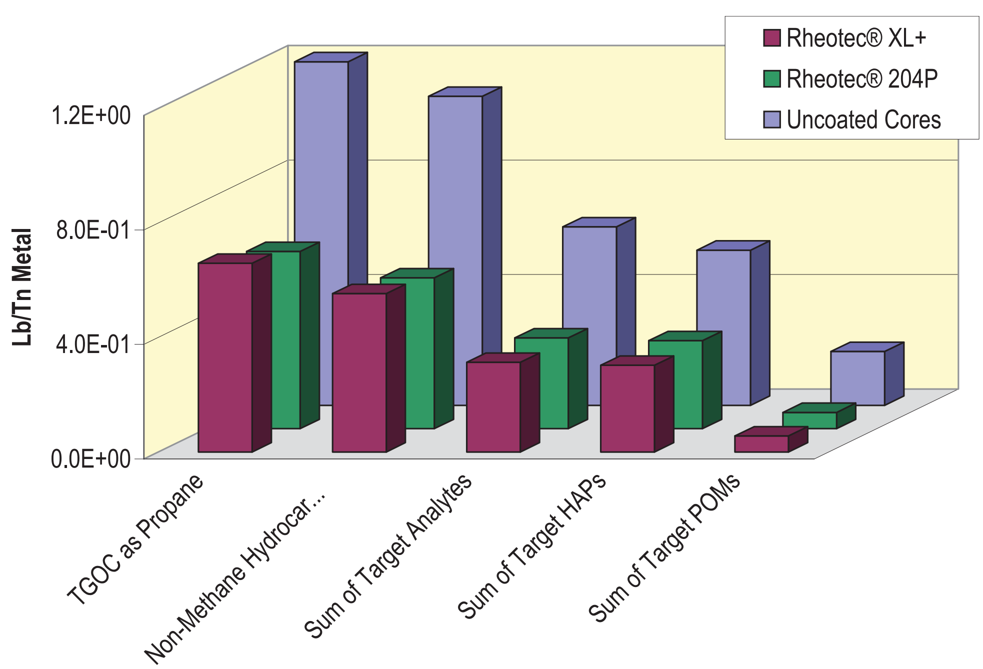


Figure 3-2a Comparison of Selected HAP and POM Emissions of Uncoated Cores to Coated Cores, Average Results- Lb/Ton Metal

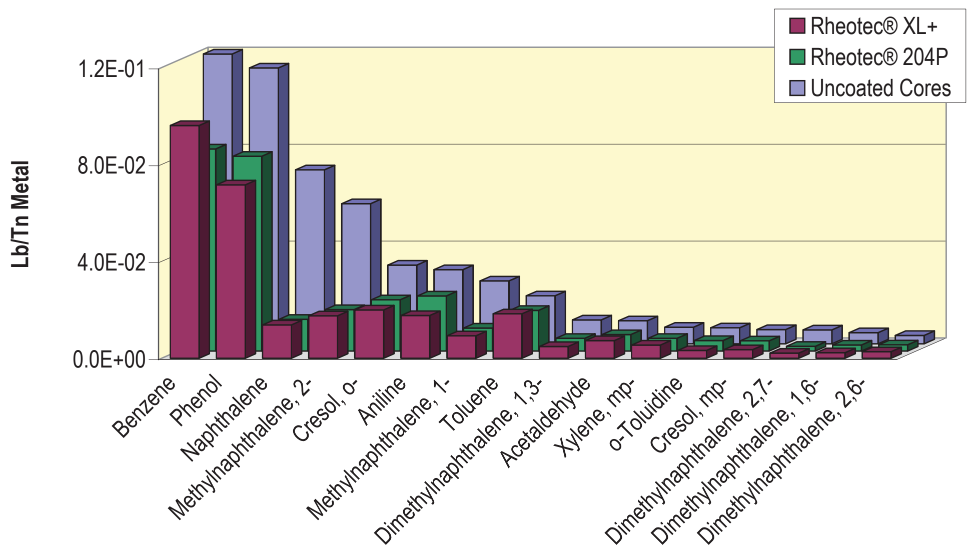


Figure 3-3a Comparison of Criteria Pollutants and Greenhouse Gas Emissions of Uncoated Cores to Coated Cores, Average Results- Lb/Ton Metal

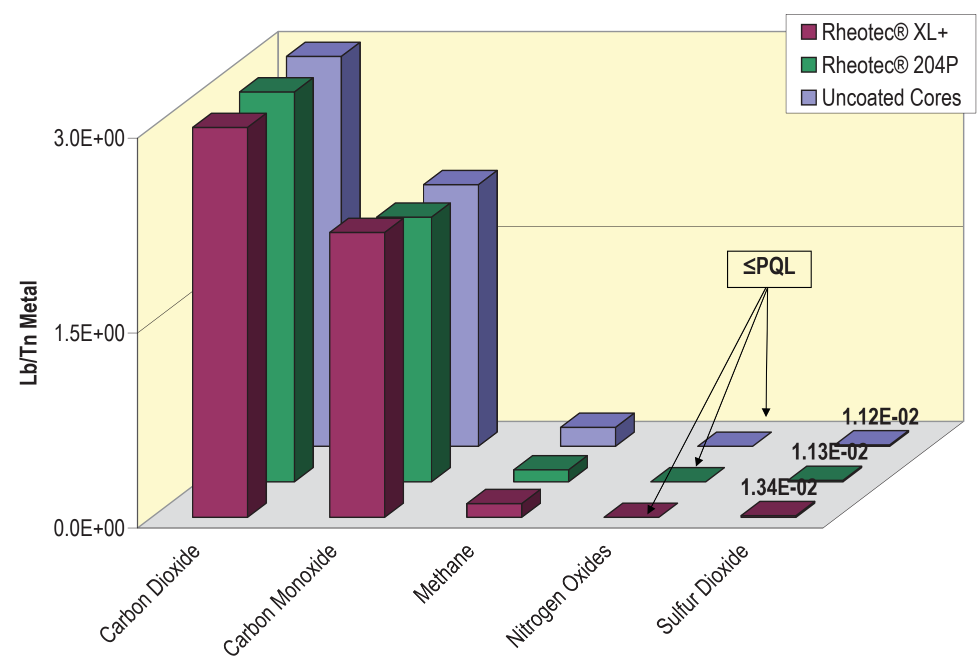


Figure 3-1b Comparison of Emissions Indicators of Uncoated Cores to Coated Cores, Average Results- Lb/Lb Binder

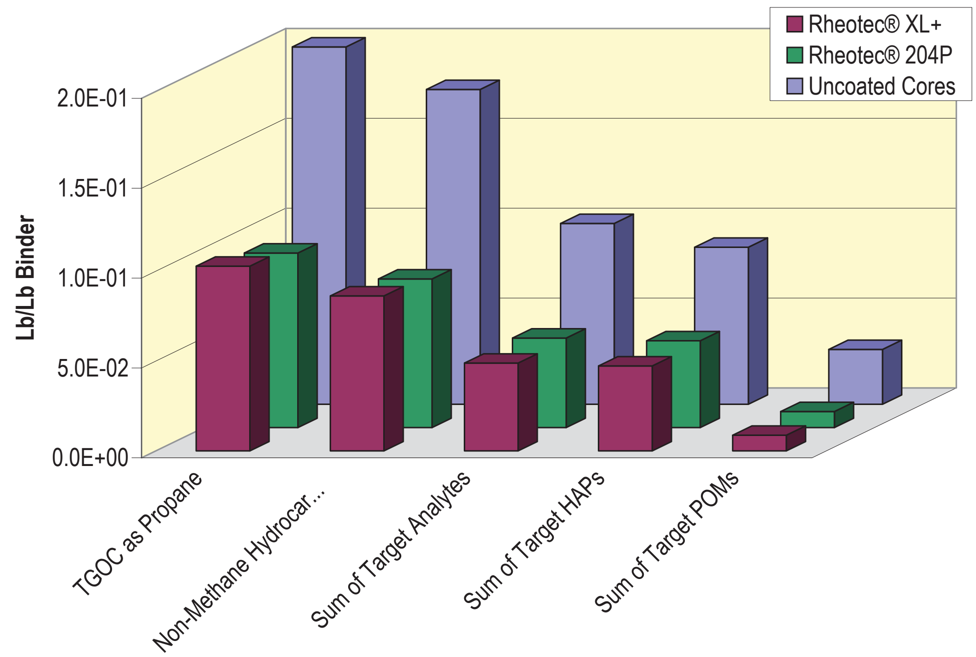


Figure 3-2b Comparison of Selected HAP and POM Emissions of Uncoated Cores to Coated Cores, Average Results- Lb/Lb Binder

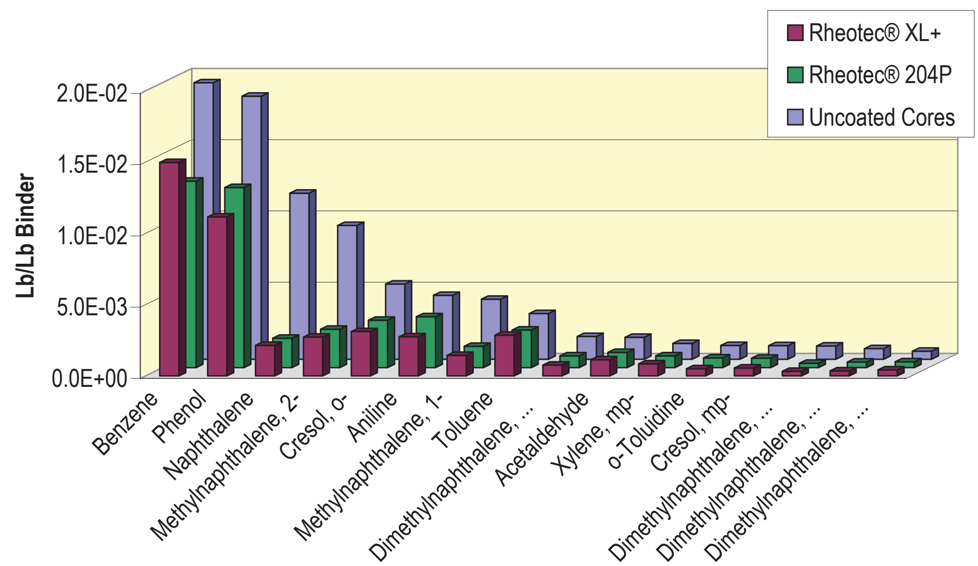
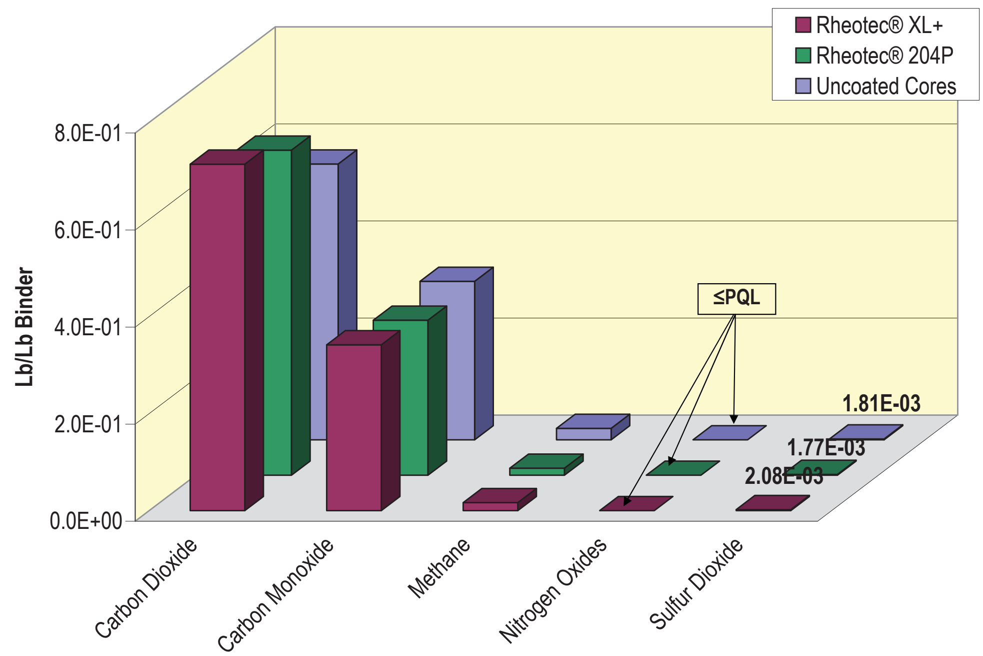


Figure 3-3b Comparison of Criteria Pollutants and Greenhouse Gas Emissions of Uncoated Cores to Coated Cores, Average Results- Lb/Lb Binder



Emission Indicators for both lb/ton metal and lb/lb binder for Test HL show statistically significant decreases of approximately 50% for the two uncoated cores tests when compared to the uncoated core test. The biggest change was in the Sum of Target POMs, which showed a relative decrease of approximately 70% for both the Rheotec® XL+ and the Rheotec® 204P core coatings.

An insulating core coating was thought to lower emissions when compared to a conductive core coating due to the reduced temperature the core would reach during pouring, cooling and shakeout, but both coated core tests resulted in lower emissions for all individual targeted analytes than those from the uncoated cores, by an average of approximately 40%. For criteria pollutant and greenhouse gas emissions, a slight increase of 30% for CO_2, and a decrease of 30% for CH_4 were found, while no statistically relevant change in CO emissions was found. NO_x also increased slightly by approximately 20% for the Rheotec® XL+ coated cores.

Although there are apparent large differences in some analytes, the concentrations are very close to the PQL levels, so there is inherently wider variation in the results. Lower emissions for the coated cores can be attributed in general to the fact that the core coating process includes a drying time at elevated temperature (275°F) for one hour. This process can drive off the more volatile components contained in the binder system prior to emissions being measured in pouring, cooling and shakeout.

Of the 33 HAPs targeted for analysis from Test HL, 28 contributed to emissions above the PQL for all test runs. Benzene, phenol and naphthalene accounted for approximately 50% of the measured emissions from targeted analytes for the reference test containing uncoated cores at 19%, 18%, and 12% respectively. Benzene and phenol together contributed 54% and 52% to total emissions for the Rheotec® XL+ and the Rheotec® 204P core coating tests, respectively. The naphthalene contribution dropped to only 4% of total targeted analyte emissions for the coated core tests.

These results indicate that both coatings were equally successful in decreasing overall emissions, while the relative contributions of benzene and phenol to the total target analyte sums increased.

The top 95% of emissions for the uncoated core reference test included eight non-HAP target analytes: 1,2,4-trimethylbenzene, 3-ethyltoluene, 2-ethyltoluene, dodecane, 2,4-dimethylphenol, indene, and n-propylbenzene. The top 95% of target analyte emissions for the Rheotec® XL+ section of Test HL consisted entirely of HAPs except for 2,6-dimethylphenol, while the only non-HAPs for the top 95% emissions using Rheotec® 204P were 2,6-dimethylphenol and 1,2,4-trimethylbenzene.

3.2. Process Data Comparisons

A comparison was made between the surface quality of the coated core castings from Test HL. The protocol for quality comparison of internal casting surface includes using coated cores only. Therefore, the castings from the uncoated cores from the reference test section of Test HL are not included in the casting comparisons or rankings.

The comparison consisted initially of a visual examination of major and minor surface defects such as burn-in and veining. Castings were first ranked according to those defects. To further differentiate surface quality among castings, the finish was tested by touch for smoothness.

The smoothest casting with the fewest visual surface defects received the highest ranking.

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

Table 3-2 Test HL Within Group Ranking of Surface Finish Quality for Two Core Coatings

	Rheotec® XL+		Rheotec® 204P		
Overall Rank Order of Appearance	Emissions Mold Number	Cavity Number	Emissions Mold Number	Cavity Number	Within Test Benchmark
Rank 1	HL022	2	HL030	2	Best
Rank 2	HL020	1	HL031	4	
Rank 3	HL022	3	HL030	3	
Rank 4	HL022	1	HL031	3	
Rank 5	HL022	4	HL032	3	
Rank 6	HL020	4	HL031	1	Median
Rank 7	HL020	3	HL030	1	
Rank 8	HL021	2	HL032	2	
Rank 9	HL020	2	HL032	4	
Rank 10	HL021	4	HL032	1	
Rank 11	HL021	3	HL030	4	
Rank 12	HL021	1	HL031	2	Worst

The castings from Test HL were divided into two groups corresponding to the coated core tests. The 12 castings produced from each test were compared and ranked individually within each casting group as shown in Table 3-2. The benchmark castings of median and worst from the two groups were then compared and ranked between each other, as reported in Table 3-3.

Table 3-3 Test HL Between Group Ranking of Relative Surface Finish Quality for Two Core Coatings

	Rheotec® XL+		Rheotec® 204P		
Overall Rank Order of Appearance	Emissions Mold number	Cavity Number	Emissions Mold number	Cavity Number	Between Test Benchmark
Rank 1	HL022	2			Best
Rank 2	HL020	4			
Rank 3	HL021	1			Median
Rank 4			HL030	2	
Rank 5			HL031	1	
Rank 6			HL031	2	Worst

The castings made from cores coated with Rheotec® 204P showed less burn-in and veining than the castings made from cores coated with

Rheotec® XL+, but did have more pock-marks. Overall, the worst casting made using cores coated with Rheotec® XL+ was better than the best casting made from cores coated with Rheotec® 204P.

The average process parameters are reported in Table 3-4 and Appendix C.

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

Table 3-4 Summary of Test Plan Average Process Parameters

Greensand PCS with Phenolic Urethane Ashland 305/904 Cores

Test HL	Coated with Foseco Rheotec® XL+	Coated with Foseco Rheotec® 204P-40	Uncoated Cores
Test Dates	**9/27/2006**	**9/28/2006**	**10/3/06-10/4/06**
Cast weight, lbs.	122.37	122.53	124.94
Pouring time, sec.	12	14	14
Pouring temp ,°F	2635	2631	2634
Pour hood process air temp at start of pour, °F	89	86	88
Mixer auto dispensed sand weight, Lbs	50.32	50.32	50.37
Core binder weight part 1, g	175.8	176.1	175.7
Core binder weight partt 2, g	143.8	145.5	144.2
Core binder weight, g	319.7	321.6	319.9
% core binder (BOS)	1.4	1.4	1.4
% core binder, actual	1.38	1.39	1.38
Total core weight in mold, lbs.	28.42	28.12	27.88
Total binder weight in mold, lbs.	0.39	0.39	0.38
Core LOI, %	1.09	1.09	1.11
2 hour core dogbone tensile, psi	224.5	224.5	224.5
Core age when poured, hrs.	49.62	71.60	38.82
Muller batch weight, lbs.	902	901	906
GS mold sand weight, lbs.	636	640	624
Mold temperature, °F	87	86	85
Average green compression , psi	20.94	21.29	21.94
GS compactability, %	43.0	42.7	43.8
GS moisture content, %	1.95	2.16	2.07
GS MB clay content, %	7.24	7.05	7.14
MB clay reagent, ml	38	37	37
1800°F LOI - mold sand, %	0.8978	0.8943	0.8498
900°F volatiles , %	0.39	0.35	0.43
Permeability index	236	242	245
Sand temperature, °F	89	86	85

APPENDIX A TEST & 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

RESEARCH FOUNDRY HL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: TEST SCRATCHED BECAUSE OF LACK OF PERSONNEL.
THC, CH4, CO, CO_2 & NOx	HL009	X									TOTAL
TO-17	HL00901		1						60	1	Carbopak charcoal
NIOSH 2002	HL00902		1						500	2	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL00903		1						800	3	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL00904		1						1000	4	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HL00905		1						1000	5	100/50 mg Charcoal (SKC 226-01)
TO11	HL00906		1						1000	6	DNPH Silica Gel (SKC 226-119)
	Excess								1000	7	Blocked
	Excess								1000	8	Blocked
	Excess								1500	9	Blocked
	Excess								1000	10	Blocked
	Excess								1500	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: RHEOTEC-XL Core Coating
9/27/2006											
THC, CH4, CO, CO_2 & NOx	HL020	X									TOTAL
TO-17	HL02001		1						60	1	Carbopak charcoal
TO-17	HL02002					1			60	1	Carbopak charcoal
TO-17 MS	HL02003		1						60	2	Carbopak charcoal
TO-17 MS	HL02004			1					60	3	Carbopak charcoal
NIOSH 2002	HL02005		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL02006			1					1000	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL02007		1						1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL02008		1						1000	7	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL02009		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL02010			1					1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HL02011		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HL02012			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: RHEOTEC-XL Core Coating
9/27/2006											
THC, CH4, CO, CO_2 & NOx	HL021	X									TOTAL
TO-17	HL02101		1						60	1	Carbopak charcoal
TO-17	HL02102			1					60	2	Carbopak charcoal
	Excess								60	3	BLOCKED
NIOSH 2002	HL02103		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL02104		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL02105			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL02106		1						1000	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL02107			1					1000	8	150/75 mg Silica Gel (SKC 226-10)
	Excess								1000	9	BLOCKED
OSHA ID200	HL02108		1						1000	10	100/50 mg Carbon Bead (SKC 226-80)
TO11	HL02109		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: RHEOTEC-XL Core Coating
9/27/2006											
THC, CH4, CO, CO_2 & NOx	HL022	X									TOTAL
TO-17	HL02201		1						60	1	Carbopak charcoal
	Excess								60	2	BLOCKED
	Excess								60	3	BLOCKED
NIOSH 2002	HL02202		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL02203		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL02204		1						1000	6	150/75 mg Silica Gel (SKC 226-10)
	Excess								1000	9	BLOCKED
OSHA ID200	HL02205		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HL02206		1						1000	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: RHEOTEC-204P Core Coating
9/28/2006											
THC, CH4, CO, CO_2 & NOx	HL030	X									TOTAL
TO-17	HL03001		1						60	1	Carbopak charcoal
TO-17	HL03002					1			60	1	Carbopak charcoal
TO-17 MS	HL03003		1						60	2	Carbopak charcoal
TO-17 MS	HL03004			1					60	3	Carbopak charcoal
NIOSH 2002	HL03005		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2002	HL03006			1					1000	5	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL03007		1						1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL03008		1						1000	7	150/75 mg Silica Gel (SKC 226-10)
OSHA ID200	HL03009		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HL03010			1					1000	9	100/50 mg Carbon Bead (SKC 226-80)
TO11	HL03011		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HL03012			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: RHEOTEC-204P Core Coating
9/28/2006											
THC, CH4, CO, CO_2 & NOx	HL031	X									TOTAL
TO-17	HL03101		1						60	1	Carbopak charcoal
TO-17	HL03102			1					60	2	Carbopak charcoal
	Excess								60	3	BLOCKED
NIOSH 2002	HL03103		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL03104		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HL03105			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL03106		1						1000	7	150/75 mg Silica Gel (SKC 226-10)
NIOSH 2010	HL03107			1					1000	8	150/75 mg Silica Gel (SKC 226-10)
	Excess								1000	9	BLOCKED
OSHA ID200	HL03108		1						1000	10	100/50 mg Carbon Bead (SKC 226-80)
TO11	HL03109		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: RHEOTEC-204P Core Coating
9/28/2006											
THC, CH4, CO, CO_2 & NOx	HL032	X									TOTAL
TO-17	HL03201		1						60	1	Carbopak charcoal
	Excess								60	2	BLOCKED
	Excess								60	3	BLOCKED
NIOSH 2002	HL03202		1						1000	4	150/75 mg Silica Gel (SKC 226-10)
NIOSH 1500	HL03203		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2010	HL03204		1						1000	6	150/75 mg Silica Gel (SKC 226-10)
	Excess								1000	7	BLOCKED
OSHA ID200	HL03205		1						1000	8	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	9	BLOCKED
TO11	HL03206		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	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

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	I	I	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		

Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 020 through 022 (Rheotec®-XL)

TA	POM	HAP		HL020	HL021	HL022	Average	Standard Deviation
			Test Dates	**27-Sep-06**	**27-Sep-06**	**27-Sep-06**	—	—
Emission Indicators								
			TGOC as Propane	6.68E-01	6.53E-01	6.57E-01	6.59E-01	7.89E-03
			Non-Methane Hydrocarbons	5.60E-01	5.47E-01	5.52E-01	5.53E-01	6.37E-03
			Sum of Target Analytes	3.12E-01	3.21E-01	3.07E-01	3.13E-01	6.76E-03
			Sum of Target HAPs	3.03E-01	3.10E-01	2.96E-01	3.03E-01	6.57E-03
			Sum of Target POMs	6.08E-02	5.97E-02	4.66E-02	5.57E-02	7.89E-03
Selected Target HAPs and POMs								
TA		H	Benzene	1.03E-01	9.38E-02	9.13E-02	9.61E-02	6.19E-03
TA		H	Phenol	6.47E-02	7.49E-02	7.50E-02	7.16E-02	5.91E-03
TA		H	Cresol, o-	1.75E-02	2.10E-02	2.13E-02	1.99E-02	2.13E-03
TA		H	Toluene	1.96E-02	1.80E-02	1.74E-02	1.83E-02	1.17E-03
TA		H	Aniline	1.45E-02	1.79E-02	2.06E-02	1.76E-02	3.06E-03
TA	P	H	Methylnaphthalene, 2-	1.90E-02	1.90E-02	1.44E-02	1.75E-02	2.65E-03
TA	P	H	Naphthalene	1.52E-02	1.45E-02	1.15E-02	1.38E-02	1.96E-03
TA	P	H	Methylnaphthalene, 1-	9.94E-03	9.98E-03	7.88E-03	9.26E-03	1.20E-03
TA		H	Acetaldehyde	7.23E-03	7.57E-03	7.07E-03	7.29E-03	2.55E-04
TA		H	Xylene, mp-	5.86E-03	5.34E-03	5.16E-03	5.45E-03	3.60E-04
TA	P	H	Dimethylnaphthalene, 1,3-	5.37E-03	5.14E-03	4.04E-03	4.85E-03	7.09E-04
TA		H	Cresol, mp-	2.73E-03	3.70E-03	4.22E-03	3.55E-03	7.57E-04
TA		H	o-Toluidine	≤PQL	3.15E-03	3.72E-03	3.22E-03	4.67E-04
TA	P	H	Dimethylnaphthalene, 2,6-	4.02E-03	≤PQL	2.94E-03	2.70E-03	1.46E-03
TA	P	H	Dimethylnaphthalene, 1,6-	2.54E-03	2.50E-03	1.81E-03	2.28E-03	4.08E-04
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	4.03E-03	≤PQL	2.11E-03	1.67E-03
TA	P	H	Dimethylnaphthalene, 2,3-	2.25E-03	2.06E-03	1.71E-03	2.01E-03	2.71E-04
TA	P	H	Dimethylnaphthalene, 1,2-	1.29E-03	1.29E-03	1.11E-03	1.23E-03	1.04E-04
TA		H	Xylene, o-	9.97E-04	9.76E-04	9.94E-04	9.89E-04	1.13E-05
TA		H	Formaldehyde	8.73E-04	1.05E-03	9.35E-04	9.52E-04	8.93E-05
TA		H	Ethylbenzene	6.83E-04	6.86E-04	6.90E-04	6.86E-04	3.45E-06
TA		H	Hexane	5.88E-04	7.99E-04	4.90E-04	6.26E-04	1.58E-04
TA		H	Styrene	5.95E-04	5.85E-04	5.64E-04	5.81E-04	1.59E-05
TA		H	Propionaldehyde (Propanal)	3.48E-04	3.81E-04	3.76E-04	3.69E-04	1.77E-05
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 020 through 022 (Rheotec®-XL)

TA	POM	HAP		HL020	HL021	HL022	Average	Standard Deviation
			Test Dates	**27-Sep-06**	**27-Sep-06**	**27-Sep-06**	—	—
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Biphenyl	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes								
TA			Dimethylphenol, 2,6-	1.68E-03	3.19E-03	3.20E-03	2.69E-03	8.75E-04
TA			Trimethylbenzene, 1,2,4-	2.11E-03	1.96E-03	1.75E-03	1.94E-03	1.81E-04
TA			Dimethylphenol, 2,4-	≤PQL	1.99E-03	1.95E-03	1.69E-03	4.79E-04
TA			2-Butanone (MEK)	1.50E-03	1.51E-03	1.59E-03	1.53E-03	4.51E-05
TA			Indene	≤PQL	≤PQL	1.18E-03	1.15E-03	1.95E-05
TA			Ethyltoluene, 2-	5.39E-04	4.81E-04	4.34E-04	4.85E-04	5.24E-05
TA			Butyraldehyde/Methacrolein	4.81E-04	4.72E-04	4.80E-04	4.78E-04	4.90E-06
TA			Crotonaldehyde	2.34E-04	≤PQL	2.36E-04	2.30E-04	8.94E-06
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases								
			Carbon Dioxide	3.80E+00	5.15E+00	4.81E+00	4.58E+00	7.04E-01
			Carbon Monoxide	2.35E+00	2.10E+00	2.13E+00	2.19E+00	1.38E-01
			Methane	1.08E-01	1.06E-01	1.04E-01	1.06E-01	1.92E-03
			Sulfur Dioxide	1.35E-02	1.32E-02	1.34E-02	1.34E-02	1.44E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 020 through 022 (Rheotec®-XL)

TA	POM	HAP		HL020	HL021	HL022	Average	Standard Deviation
			Test Dates	**27-Sep-06**	**27-Sep-06**	**27-Sep-06**	—	—
Emission Indicators								
			THC as Propane	1.04E-01	9.91E-02	1.05E-01	1.03E-01	3.10E-03
			Non-Methane Hydrocarbons	8.74E-02	8.31E-02	8.81E-02	8.62E-02	2.69E-03
			Sum of Target Analytes	4.87E-02	4.88E-02	4.90E-02	4.88E-02	1.61E-04
			Sum of Target HAPs	4.73E-02	4.71E-02	4.73E-02	4.72E-02	1.19E-04
			Sum of Target POMs	9.50E-03	9.09E-03	7.43E-03	8.67E-03	1.09E-03
Selected Target HAPs and POMs								
TA		H	Benzene	1.61E-02	1.43E-02	1.46E-02	1.50E-02	9.82E-04
TA		H	Phenol	1.01E-02	1.14E-02	1.20E-02	1.12E-02	9.49E-04
TA		H	Cresol, o-	2.73E-03	3.19E-03	3.40E-03	3.11E-03	3.44E-04
TA		H	Toluene	3.07E-03	2.74E-03	2.77E-03	2.86E-03	1.81E-04
TA		H	Aniline	2.26E-03	2.72E-03	3.28E-03	2.75E-03	5.11E-04
TA	P	H	Methylnaphthalene, 2-	2.97E-03	2.89E-03	2.30E-03	2.72E-03	3.66E-04
TA	P	H	Naphthalene	2.38E-03	2.21E-03	1.84E-03	2.14E-03	2.76E-04
TA	P	H	Methylnaphthalene, 1-	1.55E-03	1.52E-03	1.26E-03	1.44E-03	1.61E-04
TA		H	Acetaldehyde	1.13E-03	1.15E-03	1.13E-03	1.14E-03	1.32E-05
TA		H	Xylene, mp-	9.15E-04	8.12E-04	8.24E-04	8.50E-04	5.63E-05
TA	P	H	Dimethylnaphthalene, 1,3-	8.39E-04	7.82E-04	6.45E-04	7.55E-04	9.96E-05
TA		H	Cresol, mp-	4.26E-04	5.63E-04	6.72E-04	5.54E-04	1.24E-04
TA		H	o-Toluidine	≤PQL	4.80E-04	5.93E-04	5.02E-04	8.13E-05
TA	P	H	Dimethylnaphthalene, 2,6-	6.28E-04	≤PQL	4.69E-04	4.25E-04	2.28E-04
TA	P	H	Dimethylnaphthalene, 1,6-	3.96E-04	3.80E-04	2.89E-04	3.55E-04	5.78E-05
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	6.14E-04	≤PQL	3.23E-04	2.51E-04
TA	P	H	Dimethylnaphthalene, 2,3-	3.51E-04	3.13E-04	2.73E-04	3.13E-04	3.90E-05
TA	P	H	Dimethylnaphthalene, 1,2-	2.01E-04	1.97E-04	1.77E-04	1.92E-04	1.27E-05
TA		H	Xylene, o-	1.56E-04	1.49E-04	1.59E-04	1.54E-04	5.19E-06
TA		H	Formaldehyde	1.36E-04	1.60E-04	1.49E-04	1.48E-04	1.16E-05
TA		H	Ethylbenzene	1.07E-04	1.04E-04	1.10E-04	1.07E-04	2.88E-06
TA		H	Hexane	9.19E-05	1.22E-04	7.81E-05	9.72E-05	2.22E-05
TA		H	Styrene	9.30E-05	8.90E-05	8.99E-05	9.06E-05	2.09E-06
TA		H	Propionaldehyde (Propanal)	5.44E-05	5.80E-05	6.00E-05	5.75E-05	2.82E-06
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Biphenyl	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes								
TA			Dimethylphenol, 2,6-	2.62E-04	4.85E-04	5.11E-04	4.19E-04	1.37E-04
TA			Trimethylbenzene, 1,2,4-	3.29E-04	2.98E-04	2.79E-04	3.02E-04	2.55E-05
TA			Dimethylphenol, 2,4-	≤PQL	3.03E-04	3.11E-04	2.64E-04	7.46E-05
TA			2-Butanone (MEK)	2.35E-04	2.30E-04	2.53E-04	2.39E-04	1.21E-05
TA			Indene	≤PQL	≤PQL	1.87E-04	1.81E-04	5.45E-06
TA			Ethyltoluene, 2-	8.42E-05	7.32E-05	6.93E-05	7.56E-05	7.74E-06

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 020 through 022 (Rheotec®-XL)

TA	POM	HAP		HL020	HL021	HL022	Average	Standard Deviation
			Test Dates	**27-Sep-06**	**27-Sep-06**	**27-Sep-06**	—	—
TA			Butyraldehyde/Methacrolein	7.51E-05	7.18E-05	7.66E-05	7.45E-05	2.45E-06
TA			Crotonaldehyde	3.65E-05	≤PQL	3.76E-05	3.61E-05	1.73E-06
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases								
			Carbon Dioxide	5.93E-01	7.82E-01	7.67E-01	7.14E-01	1.05E-01
			Carbon Monoxide	3.67E-01	3.19E-01	3.39E-01	3.42E-01	2.42E-02
			Methane	1.69E-02	1.60E-02	1.67E-02	1.65E-02	4.40E-04
			Sulfur Dioxide	2.10E-03	2.01E-03	2.14E-03	2.08E-03	6.74E-05
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	NA

Practical Reporting Limits - Test HL - Runs 020 through 022 (Rheotec®-XL Core Coating)

Analyte	lb/ton Metal	Analyte	lb/ton Metal
Carbon Dioxide	8.65E-02	Ethylbenzene	2.28E-04
Carbon Monoxide	5.50E-02	Ethyltoluene, 2-	2.28E-04
Methane	3.14E-02	Ethyltoluene, 3-	1.14E-03
Nitrogen Oxides	5.90E-02	Formaldehyde	2.19E-04
Sulfur Dioxide	2.92E-03	Heptane	1.14E-03
THC as Propane	8.65E-02	Hexaldehyde	2.19E-04
2-Butanone (MEK)	2.19E-04	Hexane	2.28E-04
Acenaphthalene	1.14E-03	Indan	1.14E-03
Acetaldehyde	2.19E-04	Indene	1.14E-03
Acrolein	2.19E-04	Methylnaphthalene, 1-	2.28E-04
Aniline	2.79E-03	Methylnaphthalene, 2-	2.28E-04
Benzaldehyde	2.19E-04	N,N-Diethylaniline	2.79E-03
Benzene	2.28E-04	Naphthalene	2.28E-04
Biphenyl	1.14E-03	Nonane	1.14E-03
Butyraldehyde/Methacrolein	3.65E-04	o,m,p-Tolualdehyde	5.85E-04
Cresol, mp-	1.14E-03	Octane	1.14E-03
Cresol, o-	1.14E-03	o-Toluidine	2.79E-03
Crotonaldehyde	2.19E-04	Pentanal (Valeraldehyde)	2.19E-04
Cumene	1.40E-03	Phenol	1.14E-03
Cyclohexane	1.14E-03	Phenyl Isopropyl Alcohol	1.40E-03
Decane	1.14E-03	Propionaldehyde (Propanal)	2.19E-04
Diethylbenzene, 1,3-	1.14E-03	Propylbenzene, n-	1.14E-03
Dimethylaniline	4.88E-03	Styrene	2.28E-04
Dimethylnaphthalene, 1,2-	1.14E-03	Tetradecane	1.14E-03
Dimethylnaphthalene, 1,3-	2.28E-04	Toluene	2.28E-04
Dimethylnaphthalene, 1,5-	1.14E-03	Triethylamine	6.92E-04
Dimethylnaphthalene, 1,6-	1.14E-03	Trimethylbenzene, 1,2,3-	2.28E-04
Dimethylnaphthalene, 1,8-	1.14E-03	Trimethylbenzene, 1,2,4-	2.28E-04
Dimethylnaphthalene, 2,3-	1.14E-03	Trimethylbenzene, 1,3,5-	2.28E-04
Dimethylnaphthalene, 2,6-	1.14E-03	Trimethylnaphthalene, 2,3,5-	1.14E-03
Dimethylnaphthalene, 2,7-	1.14E-03	Undecane	2.28E-04
Dimethylphenol, 2,4-	1.14E-03	Xylene, mp-	2.28E-04
Dimethylphenol, 2,6-	1.14E-03	Xylene, o-	2.28E-04
Dodecane	1.14E-03		

Analyte	lb/lb Binder	Analyte	lb/lb Binder
Carbon Dioxide	1.35E-02	Ethylbenzene	3.56E-05
Carbon Monoxide	8.58E-03	Ethyltoluene, 2-	3.56E-05
Methane	4.90E-03	Ethyltoluene, 3-	1.78E-04
Nitrogen Oxides	9.20E-03	Formaldehyde	3.42E-05
Sulfur Dioxide	4.55E-04	Heptane	1.78E-04
THC as Propane	1.35E-02	Hexaldehyde	3.42E-05
2-Butanone (MEK)	3.42E-05	Hexane	3.56E-05
Acenaphthalene	1.78E-04	Indan	1.78E-04
Acetaldehyde	3.42E-05	Indene	1.78E-04
Acrolein	3.42E-05	Methylnaphthalene, 1-	3.56E-05
Aniline	4.35E-04	Methylnaphthalene, 2-	3.56E-05
Benzaldehyde	3.42E-05	N,N-Diethylaniline	4.35E-04
Benzene	3.56E-05	Naphthalene	3.56E-05
Biphenyl	1.78E-04	Nonane	1.78E-04
Butyraldehyde/Methacrolein	5.70E-05	o,m,p-Tolualdehyde	9.12E-05
Cresol, mp-	1.78E-04	Octane	1.78E-04
Cresol, o-	1.78E-04	o-Toluidine	4.35E-04
Crotonaldehyde	3.42E-05	Pentanal (Valeraldehyde)	3.42E-05
Cumene	2.18E-04	Phenol	1.78E-04
Cyclohexane	1.78E-04	Phenyl Isopropyl Alcohol	2.18E-04
Decane	1.78E-04	Propionaldehyde (Propanal)	3.42E-05
Diethylbenzene, 1,3-	1.78E-04	Propylbenzene, n-	1.78E-04
Dimethylaniline	7.61E-04	Styrene	3.56E-05
Dimethylnaphthalene, 1,2-	1.78E-04	Tetradecane	1.78E-04
Dimethylnaphthalene, 1,3-	3.56E-05	Toluene	3.56E-05
Dimethylnaphthalene, 1,5-	1.78E-04	Triethylamine	1.08E-04
Dimethylnaphthalene, 1,6-	1.78E-04	Trimethylbenzene, 1,2,3-	3.56E-05
Dimethylnaphthalene, 1,8-	1.78E-04	Trimethylbenzene, 1,2,4-	3.56E-05
Dimethylnaphthalene, 2,3-	1.78E-04	Trimethylbenzene, 1,3,5-	3.56E-05
Dimethylnaphthalene, 2,6-	1.78E-04	Trimethylnaphthalene, 2,3,5-	1.78E-04
Dimethylnaphthalene, 2,7-	1.78E-04	Undecane	3.56E-05
Dimethylphenol, 2,4-	1.78E-04	Xylene, mp-	3.56E-05
Dimethylphenol, 2,6-	1.78E-04	Xylene, o-	3.56E-05
Dodecane	1.78E-04		

Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 030 through 032 (Rheotec®-204P Core Coating)

TA	POM	HAP		HL030	HL031	HL032	Average	Standard Deviation
			Test Dates	28-Sep-06	28-Sep-06	28-Sep-06	—	—
Emission Indicators								
			THC as Propane	6.08E-01	6.12E-01	6.36E-01	6.19E-01	1.49E-02
			Non-Methane Hydrocarbons	5.12E-01	5.26E-01	5.42E-01	5.27E-01	1.54E-02
			Sum of Target Analytes	3.00E-01	3.12E-01	3.39E-01	3.17E-01	1.98E-02
			Sum of Target HAPs	2.90E-01	3.02E-01	3.29E-01	3.07E-01	2.01E-02
			Sum of Target POMs	4.78E-02	5.38E-02	6.85E-02	5.67E-02	1.07E-02
Selected Target HAPs and POMs								
TA		H	Benzene	8.57E-02	8.05E-02	8.41E-02	8.34E-02	2.66E-03
TA		H	Phenol	7.40E-02	8.13E-02	8.59E-02	8.04E-02	5.98E-03
TA		H	Aniline	2.05E-02	2.33E-02	2.45E-02	2.27E-02	2.03E-03
TA		H	Cresol, o-	2.01E-02	2.17E-02	2.16E-02	2.12E-02	8.91E-04
TA	P	H	Methylnaphthalene, 2-	1.41E-02	1.62E-02	2.10E-02	1.71E-02	3.51E-03
TA		H	Toluene	1.71E-02	1.61E-02	1.71E-02	1.68E-02	5.77E-04
TA	P	H	Naphthalene	1.14E-02	1.22E-02	1.57E-02	1.31E-02	2.28E-03
TA	P	H	Methylnaphthalene, 1-	7.97E-03	9.16E-03	1.14E-02	9.50E-03	1.73E-03
TA		H	Acetaldehyde	6.92E-03	6.49E-03	6.95E-03	6.79E-03	2.59E-04
TA		H	Xylene, mp-	5.15E-03	5.11E-03	5.46E-03	5.24E-03	1.95E-04
TA	P	H	Dimethylnaphthalene, 1,3-	4.56E-03	4.95E-03	6.20E-03	5.24E-03	8.58E-04
TA		H	o-Toluidine	3.76E-03	4.42E-03	4.82E-03	4.33E-03	5.34E-04
TA		H	Cresol, mp-	3.85E-03	4.21E-03	4.59E-03	4.22E-03	3.73E-04
TA	P	H	Dimethylnaphthalene, 2,6-	1.40E-03	1.76E-03	4.52E-03	2.56E-03	1.70E-03
TA	P	H	Dimethylnaphthalene, 1,6-	2.19E-03	2.16E-03	3.08E-03	2.48E-03	5.22E-04
TA	P	H	Dimethylnaphthalene, 2,3-	1.86E-03	2.00E-03	2.62E-03	2.16E-03	4.03E-04
TA	P	H	Dimethylnaphthalene, 2,7-	1.92E-03	2.77E-03	≤PQL	1.94E-03	8.14E-04
TA	P	H	Dimethylnaphthalene, 1,2-	1.21E-03	1.44E-03	1.69E-03	1.45E-03	2.40E-04
TA		H	Biphenyl	≤PQL	≤PQL	1.26E-03	1.18E-03	6.92E-05
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	1.25E-03	1.17E-03	6.29E-05
TA		H	Xylene, o-	9.50E-04	9.57E-04	1.00E-03	9.70E-04	2.77E-05
TA		H	Hexane	4.84E-04	8.43E-04	9.96E-04	7.74E-04	2.63E-04
TA		H	Formaldehyde	8.78E-04	6.67E-04	7.17E-04	7.54E-04	1.10E-04
TA		H	Ethylbenzene	6.91E-04	6.67E-04	7.28E-04	6.95E-04	3.05E-05
TA		H	Propionaldehyde (Propanal)	6.12E-04	6.17E-04	6.63E-04	6.31E-04	2.83E-05
TA		H	Styrene	4.94E-04	5.02E-04	5.13E-04	5.03E-04	9.90E-06
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes								
TA			Dimethylphenol, 2,6-	2.38E-03	2.29E-03	1.66E-03	2.11E-03	3.95E-04
TA			Trimethylbenzene, 1,2,4-	1.88E-03	1.94E-03	2.08E-03	1.97E-03	9.92E-05
TA			2-Butanone (MEK)	1.69E-03	1.58E-03	1.69E-03	1.65E-03	6.04E-05
TA			Dimethylphenol, 2,4-	1.51E-03	1.79E-03	1.14E-03	1.48E-03	3.29E-04
TA			Indene	≤PQL	≤PQL	1.24E-03	1.17E-03	5.65E-05
TA			Ethyltoluene, 2-	3.81E-04	5.37E-04	5.95E-04	5.04E-04	1.11E-04

Test HL - Detailed Emission Results - Lb/Tn Metal - Runs 030 through 032 (Rheotec®-204P Core Coating)

TA	POM	HAP		HL030	HL031	HL032	Average	Standard Deviation
			Test Dates	28-Sep-06	28-Sep-06	28-Sep-06	—	—
TA			Butyraldehyde/Methacrolein	4.14E-04	4.59E-04	4.98E-04	4.57E-04	4.22E-05
TA			Crotonaldehyde	≤PQL	2.47E-04	2.41E-04	2.36E-04	1.47E-05
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases								
			Carbon Dioxide	4.12E+00	4.62E+00	4.07E+00	4.27E+00	3.08E-01
			Carbon Monoxide	2.08E+00	1.96E+00	2.07E+00	2.04E+00	6.70E-02
			Methane	9.67E-02	8.61E-02	9.34E-02	9.21E-02	5.44E-03
			Sulfur Dioxide	1.39E-02	9.61E-03	1.05E-02	1.13E-02	2.26E-03
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	NA

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 030 through 032 (Rheotec®-204P)

TA	POM	HAP		HL030	HL031	HL032	Average	Standard Deviation
			Test Dates	**28-Sep-06**	**28-Sep-06**	**28-Sep-06**	—	—
Emission Indicators								
			THC as Propane	9.22E-02	9.67E-02	1.02E-01	9.71E-02	5.13E-03
			Non-Methane Hydrocarbons	7.75E-02	8.31E-02	8.74E-02	8.27E-02	4.94E-03
			Sum of Target Analytes	4.54E-02	4.93E-02	5.46E-02	4.98E-02	4.59E-03
			Sum of Target HAPs	4.40E-02	4.77E-02	5.31E-02	4.83E-02	4.59E-03
			Sum of Target POMs	7.25E-03	8.49E-03	1.10E-02	8.92E-03	1.93E-03
Selected Target HAPs and POMs								
TA		H	Benzene	1.30E-02	1.27E-02	1.36E-02	1.31E-02	4.38E-04
TA		H	Phenol	1.12E-02	1.28E-02	1.38E-02	1.26E-02	1.33E-03
TA		H	Aniline	3.11E-03	3.67E-03	3.94E-03	3.57E-03	4.27E-04
TA		H	Cresol, o-	3.05E-03	3.43E-03	3.49E-03	3.32E-03	2.37E-04
TA	P	H	Methylnaphthalene, 2-	2.14E-03	2.56E-03	3.38E-03	2.69E-03	6.31E-04
TA		H	Toluene	2.60E-03	2.54E-03	2.76E-03	2.63E-03	1.12E-04
TA	P	H	Naphthalene	1.73E-03	1.93E-03	2.53E-03	2.06E-03	4.17E-04
TA	P	H	Methylnaphthalene, 1-	1.21E-03	1.45E-03	1.83E-03	1.50E-03	3.16E-04
TA		H	Acetaldehyde	1.05E-03	1.02E-03	1.12E-03	1.06E-03	5.01E-05
TA	P	H	Dimethylnaphthalene, 1,3-	6.92E-04	7.81E-04	1.00E-03	8.24E-04	1.59E-04
TA		H	Xylene, mp-	7.81E-04	8.06E-04	8.81E-04	8.22E-04	5.22E-05
TA		H	o-Toluidine	5.70E-04	6.97E-04	7.76E-04	6.81E-04	1.04E-04
TA		H	Cresol, mp-	5.83E-04	6.65E-04	7.40E-04	6.63E-04	7.89E-05
TA	P	H	Dimethylnaphthalene, 2,6-	2.12E-04	2.78E-04	7.28E-04	4.06E-04	2.81E-04
TA	P	H	Dimethylnaphthalene, 1,6-	3.32E-04	3.41E-04	4.97E-04	3.90E-04	9.24E-05
TA	P	H	Dimethylnaphthalene, 2,3-	2.81E-04	3.16E-04	4.22E-04	3.40E-04	7.31E-05
TA	P	H	Dimethylnaphthalene, 2,7-	2.90E-04	4.37E-04	≤PQL	3.02E-04	1.29E-04
TA	P	H	Dimethylnaphthalene, 1,2-	1.83E-04	2.27E-04	2.72E-04	2.28E-04	4.45E-05
TA		H	Biphenyl	≤PQL	≤PQL	2.03E-04	1.87E-04	1.40E-05
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	2.01E-04	1.86E-04	1.30E-05
TA		H	Xylene, o-	1.44E-04	1.51E-04	1.61E-04	1.52E-04	8.78E-06
TA		H	Hexane	7.34E-05	1.33E-04	1.61E-04	1.22E-04	4.46E-05
TA		H	Formaldehyde	1.33E-04	1.05E-04	1.16E-04	1.18E-04	1.40E-05
TA		H	Ethylbenzene	1.05E-04	1.05E-04	1.17E-04	1.09E-04	7.09E-06
TA		H	Propionaldehyde (Propanal)	9.27E-05	9.74E-05	1.07E-04	9.90E-05	7.24E-06
TA		H	Styrene	7.48E-05	7.93E-05	8.28E-05	7.89E-05	3.99E-06
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cumene	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Dimethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	0	H	Triethylamine	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes								
TA			Dimethylphenol, 2,6-	3.61E-04	3.61E-04	2.67E-04	3.30E-04	5.43E-05
TA			Trimethylbenzene, 1,2,4-	2.85E-04	3.07E-04	3.35E-04	3.09E-04	2.49E-05
TA			2-Butanone (MEK)	2.56E-04	2.50E-04	2.72E-04	2.59E-04	1.16E-05
TA			Dimethylphenol, 2,4-	2.29E-04	2.83E-04	1.83E-04	2.32E-04	4.99E-05
TA			Indene	≤PQL	≤PQL	1.99E-04	1.85E-04	1.20E-05
TA			Ethyltoluene, 2-	5.77E-05	8.47E-05	9.59E-05	7.95E-05	1.96E-05

Test HL - Detailed Emission Results - Lb/Lb Binder - Runs 030 through 032 (Rheotec®-204P)

TA	POM	HAP		HL030	HL031	HL032	Average	Standard Deviation
			Test Dates	**28-Sep-06**	**28-Sep-06**	**28-Sep-06**	—	—
TA			Butyraldehyde/Methacrolein	6.27E-05	7.24E-05	8.03E-05	7.18E-05	8.83E-06
TA			Crotonaldehyde	≤PQL	3.90E-05	3.88E-05	3.74E-05	2.63E-06
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Ethyltoluene, 3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Heptane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Octane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			N,N-Diethylaniline	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Phenyl Isopropyl Alcohol	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases								
			Carbon Dioxide	6.24E-01	7.30E-01	6.55E-01	6.70E-01	5.44E-02
			Carbon Monoxide	3.15E-01	3.09E-01	3.34E-01	3.19E-01	1.27E-02
			Methane	1.47E-02	1.36E-02	1.51E-02	1.44E-02	7.56E-04
			Sulfur Dioxide	2.11E-03	1.52E-03	1.69E-03	1.77E-03	3.02E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	NA

Practical Reporting Limits - Test HL - Runs 030 through 032 (Rheotec®-204P Core Coating)

Analyte	lb/ton Metal	Analyte	lb/ton Metal
Carbon Monoxide	5.48E-02	Ethylbenzene	2.28E-04
Methane	3.13E-02	Ethyltoluene, 2-	2.28E-04
Carbon Dioxide	8.61E-02	Ethyltoluene, 3-	1.14E-03
Nitrogen Oxides	5.87E-02	Formaldehyde	2.19E-04
Sulfur Dioxide	2.91E-03	Heptane	1.14E-03
THC as Propane	8.61E-02	Hexaldehyde	2.19E-04
2-Butanone (MEK)	2.19E-04	Hexane	2.28E-04
Acenaphthalene	1.14E-03	Indan	1.14E-03
Acetaldehyde	2.19E-04	Indene	1.14E-03
Acrolein	2.19E-04	Methylnaphthalene, 1-	2.28E-04
Aniline	2.78E-03	Methylnaphthalene, 2-	2.28E-04
Benzaldehyde	2.19E-04	N,N-Diethylaniline	2.78E-03
Benzene	2.28E-04	Naphthalene	2.28E-04
Biphenyl	1.14E-03	Nonane	1.14E-03
Butyraldehyde/Methacrolein	3.65E-04	o,m,p-Tolualdehyde	5.84E-04
Cresol, mp-	1.14E-03	Octane	1.14E-03
Cresol, o-	1.14E-03	o-Toluidine	2.78E-03
Crotonaldehyde	2.19E-04	Pentanal (Valeraldehyde)	2.19E-04
Cumene	2.28E-03	Phenol	1.14E-03
Cyclohexane	1.14E-03	Phenyl Isopropyl Alcohol	2.28E-03
Decane	1.14E-03	Propionaldehyde (Propanal)	2.19E-04
Diethylbenzene, 1,3-	1.14E-03	Propylbenzene, n-	1.14E-03
Dimethylaniline	4.87E-03	Styrene	2.28E-04
Dimethylnaphthalene, 1,2-	1.14E-03	Tetradecane	1.14E-03
Dimethylnaphthalene, 1,3-	2.28E-04	Toluene	2.28E-04
Dimethylnaphthalene, 1,5-	1.14E-03	Triethylamine	6.91E-04
Dimethylnaphthalene, 1,6-	1.14E-03	Trimethylbenzene, 1,2,3-	2.28E-04
Dimethylnaphthalene, 1,8-	1.14E-03	Trimethylbenzene, 1,2,4-	2.28E-04
Dimethylnaphthalene, 2,3-	1.14E-03	Trimethylbenzene, 1,3,5-	2.28E-04
Dimethylnaphthalene, 2,6-	1.14E-03	Trimethylnaphthalene, 2,3,5-	1.14E-03
Dimethylnaphthalene, 2,7-	1.14E-03	Undecane	2.28E-04
Dimethylphenol, 2,4-	1.14E-03	Xylene, mp-	2.28E-04
Dimethylphenol, 2,6-	1.14E-03	Xylene, o-	2.28E-04
Dodecane	1.14E-03		

Analyte	lb/lb Binder	Analyte	lb/lb Binder
Carbon Dioxide	1.35E-02	Ethylbenzene	3.57E-05
Carbon Monoxide	8.59E-03	Ethyltoluene, 2-	3.57E-05
Methane	4.91E-03	Ethyltoluene, 3-	1.79E-04
Nitrogen Oxides	9.21E-03	Formaldehyde	3.43E-05
Sulfur Dioxide	4.56E-04	Heptane	1.79E-04
THC as Propane	1.35E-02	Hexaldehyde	3.43E-05
2-Butanone (MEK)	3.43E-05	Hexane	3.57E-05
Acenaphthalene	1.79E-04	Indan	1.79E-04
Acetaldehyde	3.43E-05	Indene	1.79E-04
Acrolein	3.43E-05	Methylnaphthalene, 1-	3.57E-05
Aniline	4.37E-04	Methylnaphthalene, 2-	3.57E-05
Benzaldehyde	3.43E-05	N,N-Diethylaniline	4.37E-04
Benzene	3.57E-05	Naphthalene	3.57E-05
Biphenyl	1.79E-04	Nonane	1.79E-04
Butyraldehyde/Methacrolein	5.72E-05	o,m,p-Tolualdehyde	9.15E-05
Cresol, mp-	1.79E-04	Octane	1.79E-04
Cresol, o-	1.79E-04	o-Toluidine	4.37E-04
Crotonaldehyde	3.43E-05	Pentanal (Valeraldehyde)	3.43E-05
Cumene	2.19E-04	Phenol	1.79E-04
Cyclohexane	1.79E-04	Phenyl Isopropyl Alcohol	2.19E-04
Decane	1.79E-04	Propionaldehyde (Propanal)	3.43E-05
Diethylbenzene, 1,3-	1.79E-04	Propylbenzene, n-	1.79E-04
Dimethylaniline	7.64E-04	Styrene	3.57E-05
Dimethylnaphthalene, 1,2-	1.79E-04	Tetradecane	1.79E-04
Dimethylnaphthalene, 1,3-	3.57E-05	Toluene	3.57E-05
Dimethylnaphthalene, 1,5-	1.79E-04	Triethylamine	1.08E-04
Dimethylnaphthalene, 1,6-	1.79E-04	Trimethylbenzene, 1,2,3-	3.57E-05
Dimethylnaphthalene, 1,8-	1.79E-04	Trimethylbenzene, 1,2,4-	3.57E-05
Dimethylnaphthalene, 2,3-	1.79E-04	Trimethylbenzene, 1,3,5-	3.57E-05
Dimethylnaphthalene, 2,6-	1.79E-04	Trimethylnaphthalene, 2,3,5-	1.79E-04
Dimethylnaphthalene, 2,7-	1.79E-04	Undecane	3.57E-05
Dimethylphenol, 2,4-	1.79E-04	Xylene, mp-	3.57E-05
Dimethylphenol, 2,6-	1.79E-04	Xylene, o-	3.57E-05
Dodecane	1.79E-04		

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APPENDIX C DETAILED PROCESS DATA AND CASTING QUALITY PHOTOS

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Test HL - Detailed Process Data

	Sand Conditioning Runs with Uncoated Ashland 305/904 Phenolic Urethane Cores			Ashland 305/904 Phenolic Urethane Cores Coated with Foseco Rheotec® XL+			Averages
Test Dates	**09/26/06**	**09/26/06**	**09/26/06**	**09/27/06**	**09/27/06**	**09/27/06**	
Emissions Sample #	**HLCR1**	**HLCR2**	**HLCR3**	**HL020**	**HL021**	**HL022**	
Production Sample #	**HL001**	**HL002**	**HL003**	**HL004**	**HL005**	**HL006**	**01/00/00**
Cast weight, lbs.	117.10	119.10	122.45	121.85	119.25	126.00	122.37
Pouring time, sec.	14	13	13	14	12	11	12
Pouring temp ,°F	2632	2628	2639	2633	2633	2640	2635
Pour hood process air temp at start of pour, °F	86	86	86	87	87	91	89
Mixer auto dispensed sand weight, Lbs	50.32	50.32	50.32	50.32	50.32	50.32	50.32
Core binder weight part 1, g	175.9	175.3	176.3	175.5	175.3	176.7	175.8
Core binder weight partt 2, g	143.6	143.0	143.9	143.3	143.1	145.1	143.8
Core binder weight, g	319.5	318.3	320.2	318.8	318.4	321.8	319.7
% core binder (BOS)	1.40	1.39	1.40	1.40	1.39	1.41	1.40
% core binder, actual	1.38	1.38	1.38	1.38	1.38	1.39	1.38
Total core weight in mold, lbs.	29.02	28.94	28.87	28.32	28.52	28.43	28.42
Total binder weight in mold, lbs.	0.401	0.398	0.399	0.390	0.392	0.395	0.393
Core LOI, %	ND	ND	ND	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	224.5
Core age when poured, hrs.	24	27	29	47	50	52	49.62
Muller batch weight, lbs.	1200	906	896	900	906	901	902
GS mold sand weight, lbs.	642	640	628	634	638	636	636
Mold temperature, °F	79	85	91	84	88	89	87
Average green compression , psi	ND	ND	ND	20.37	21.44	21.03	20.94
GS compactability, %	36	41	38	42	47	40	43
GS moisture content, %	ND	ND	ND	1.98	2.02	1.86	1.95
GS MB clay content, %	ND	ND	ND	7.63	7.24	6.86	7.24
MB clay reagent, ml	ND	ND	ND	40.0	38.0	36.0	38.0
1800°F LOI - mold sand, %	ND	ND	ND	0.9770	0.8002	0.9162	0.8978
900°F volatiles , %	ND	ND	ND	0.38	0.40	0.40	0.39
Permeability index	ND	ND	ND	235	233	240	236
Sand temperature, °F	ND	ND	ND	87	91	88	89

Notes:
The weight of cores for pours HL020-HL033 was taken before the core were dipped and dried.

Test HL - Detailed Process Data

	Ashland 305/904 Phenolic Urethane Cores Coated with Foseco Rheotec® 204P-40			Averages
Test Dates	**09/28/06**	**09/28/06**	**09/28/06**	
Emissions Sample #	**HL030**	**HL031**	**HL032**	
Production Sample #	**HL007**	**HL008**	**HL009**	**01/00/00**
Cast weight, lbs.	119.70	122.80	125.10	122.53
Pouring time, sec.	16	13	12	14
Pouring temp ,°F	2637	2628	2627	2631
Pour hood process air temp at start of pour, °F	86	86	87	86
Mixer auto dispensed sand weight, Lbs	50.32	50.32	50.32	50.32
Core binder weight part 1, g	176.2	175.4	176.7	176.1
Core binder weight partt 2, g	149.3	144.1	143.0	145.5
Core binder weight, g	325.5	319.5	319.7	321.6
% core binder (BOS)	1.43	1.40	1.40	1.4
% core binder, actual	1.41	1.38	1.38	1.39
Total core weight in mold, lbs.	28.08	28.17	28.10	28.12
Total binder weight in mold, lbs.	0.395	0.389	0.388	0.391
Core LOI, %	1.0785	1.0757	1.1045	1.0862
2 hour core dogbone tensile, psi	224.50	224.50	224.50	224.5
Core age when poured, hrs.	70	72	73	72
Muller batch weight, lbs.	903	902	900	901
GS mold sand weight, lbs.	640	641	639	640
Mold temperature, °F	84	87	87	86
Average green compression , psi	22.67	21.16	20.04	21.29
GS compactability, %	40	42	46	43
GS moisture content, %	2.30	2.14	2.03	2.16
GS MB clay content, %	6.67	7.44	7.05	7.05
MB clay reagent, ml	35.0	39.0	37.0	37
1800°F LOI - mold sand, %	0.9583	0.8625	0.8623	0.8943
900°F volatiles , %	0.28	0.36	0.42	0.35
Permeability index	238	240	248	242
Sand temperature, °F	84	89	86	86

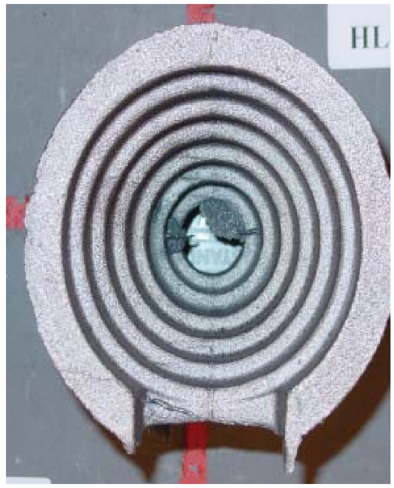
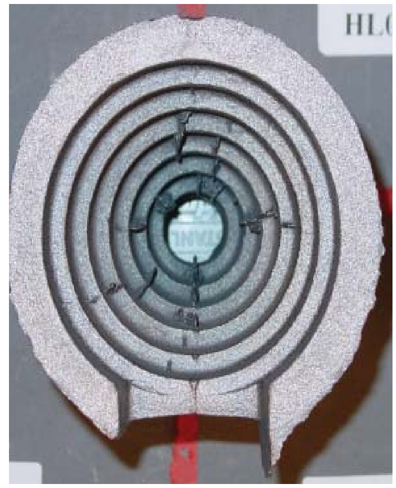
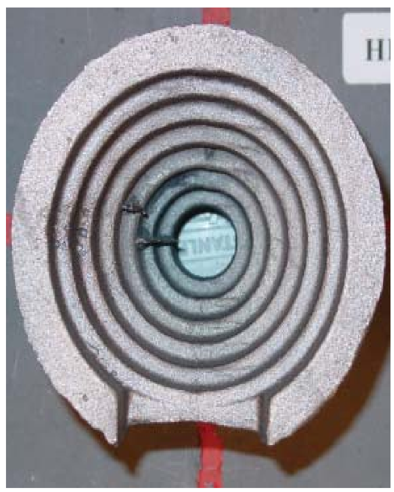
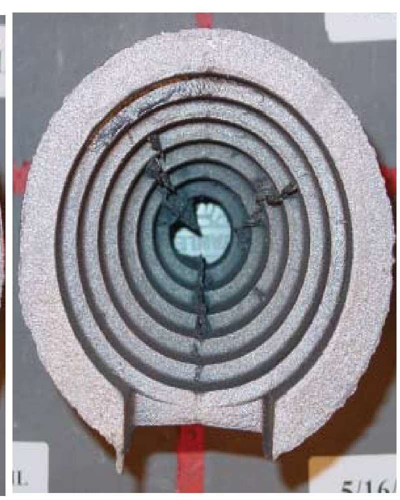
Notes:
The weight of cores for pours HL020-HL033 was taken before the core were dipped and dried.

Test HL - Detailed Process Data

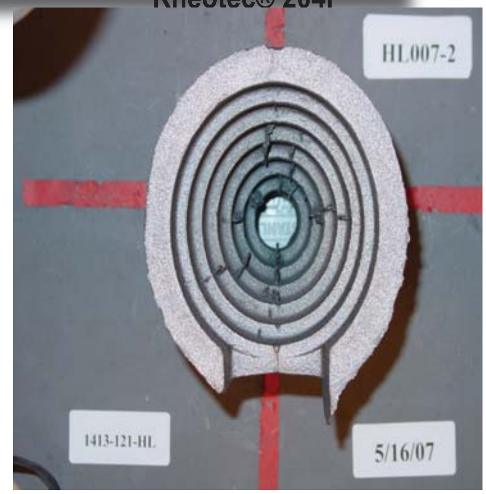
	Uncoated Ashland 305/904 Phenolic Urethane Cores								Averages
Test Dates	**10/03/06**	**10/03/06**	**10/03/06**	**10/03/06**	**10/04/06**	**10/04/06**	**10/04/06**	**10/04/06**	
Emissions Sample #	**HL001**	**HL002**	**HL003**	**HL004**	**HL005**	**HL006**	**HL007**	**HL008**	
Production Sample #	**HL010**	**HL011**	**HL012**	**HL013**	**HL014**	**HL015**	**HL016**	**HL017**	**01/00/00**
Cast weight, lbs.	126.85	123.75	130.60	126.50	125.30	123.00	120.00	123.55	124.94
Pouring time, sec.	14	14	12	14	14	14	15	15	14
Pouring temp ,°F	2636	2627	2626	2638	2630	2637	2637	2640	2634
Pour hood process air temp at start of pour, °F	88	87	89	86	87	86	89	91	88
Mixer auto dispensed sand weight, Lbs	50.37	50.37	50.37	50.37	50.37	50.37	50.37	50.37	50.37
Core binder weight part 1, g	175.6	174.9	173.7	177.3	176.5	177.6	175.2	175.1	175.7
Core binder weight partt 2, g	144.6	143.9	145.0	144.6	142.9	144.0	143.1	145.3	144.2
Core binder weight, g	320.2	318.8	318.7	321.9	319.4	321.6	318.3	320.4	319.9
% core binder (BOS)	1.40	1.40	1.39	1.41	1.40	1.4	1.4	1.4	1.4
% core binder, actual	1.38	1.38	1.38	1.39	1.38	1.39	1.37	1.38	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
Total binder weight in mold, lbs.	0.386	0.386	0.384	0.390	0.384	0.388	0.384	0.379	0.385
Core LOI, %	1.0721	1.0644	1.0931	1.1793	1.1390	1.1329	1.1069	1.1069	1.1118
2 hour core dogbone tensile, psi	224.50	224.50	224.50	224.50	224.50	224.50	224.50	224.50	224.5
Core age when poured, hrs.	24	26	28	30	47	49	51	54	39
Muller batch weight, lbs.	902	902	908	910	905	905	909	907	906
GS mold sand weight, lbs.	614	631	606	623	635	617	642	622	624
Mold temperature, °F	77	83	87	89	82	86	89	85	85
Average green compression , psi	21.89	22.80	21.85	20.59	23.28	23.10	21.18	20.85	21.94
GS compactability, %	40	41	45	45	47	47	45	40	44
GS moisture content, %	1.94	2.08	2.04	2.20	2.22	2.02	2.08	1.96	2.07
GS MB clay content, %	7.05	7.24	7.05	7.05	7.15	7.05	7.24	7.24	7.14
MB clay reagent, ml	37.0	38.0	37.0	37.0	37.5	37.0	38.0	38.0	37.4
1800°F LOI - mold sand, %	0.8590	0.8576	0.9034	0.8637	0.8655	0.7963	0.7923	0.8608	0.8498
900°F volatiles , %	0.42	0.38	0.48	0.58	0.30	0.38	0.42	0.44	0.43
Permeability index	238	245	265	248	245	245	230	240	245
Sand temperature, °F	78	85	87	85	83	86	87	85	85

Notes:
The weight of cores for pours HL020-HL033 was taken before the core were dipped and dried.

Casting Quality Photos

	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

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

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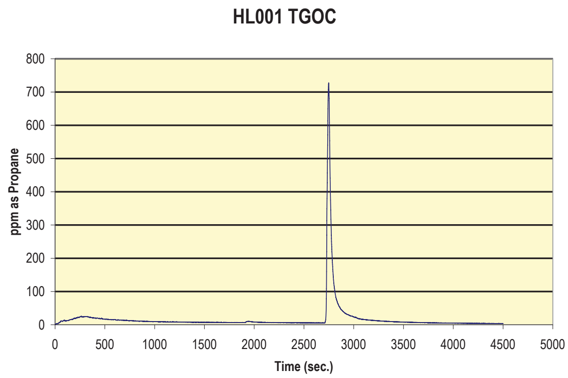
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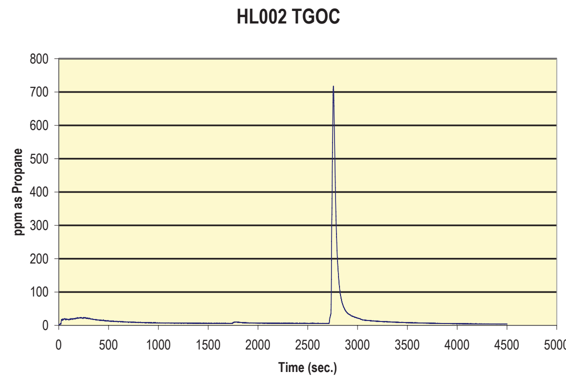
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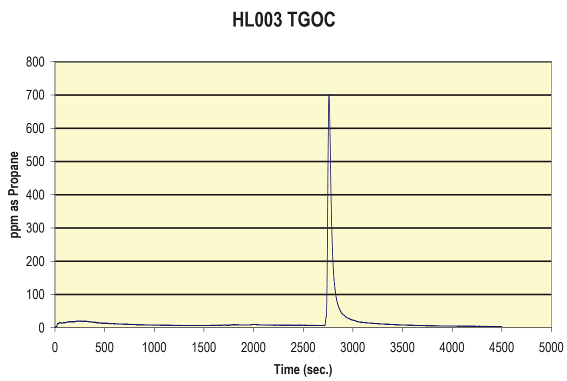
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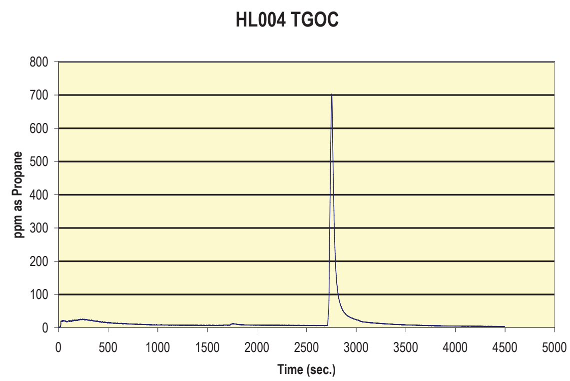
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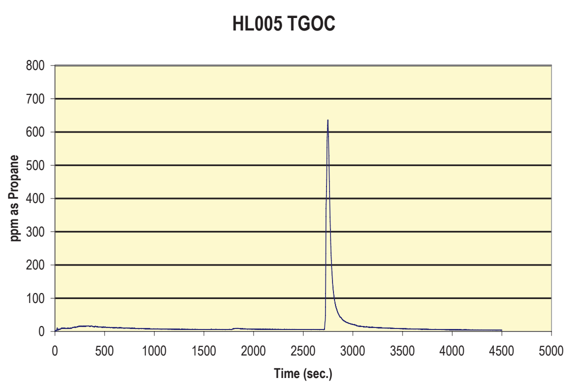
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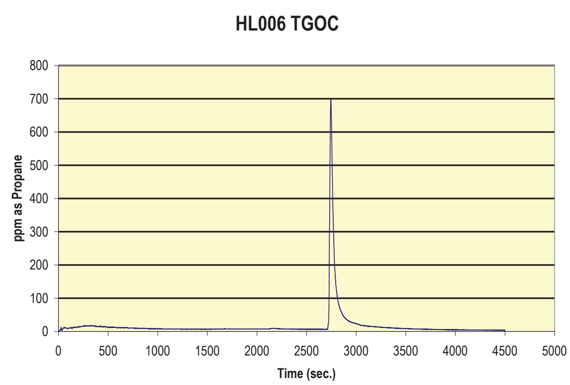
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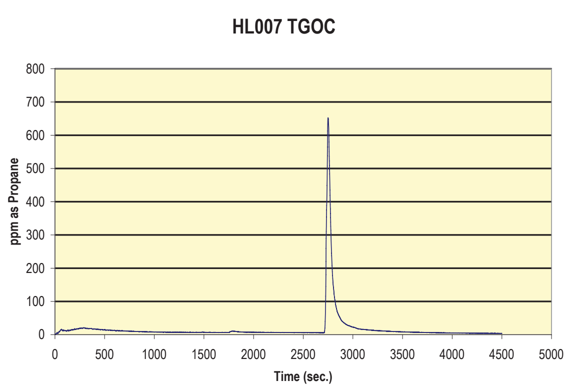
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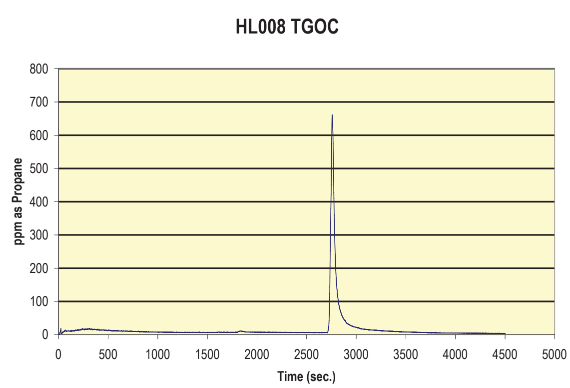
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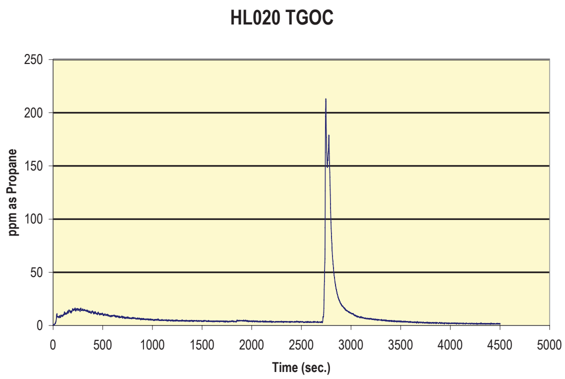
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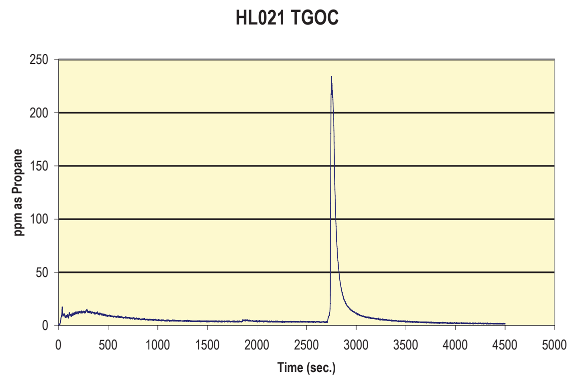
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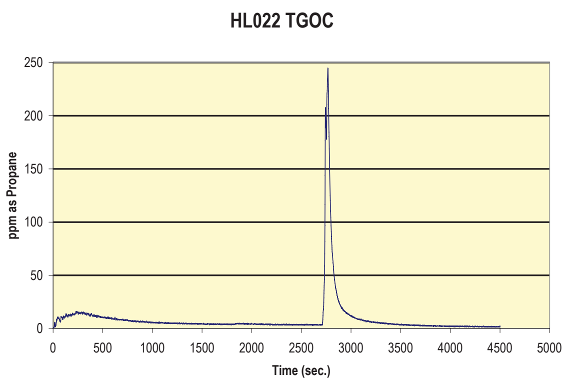
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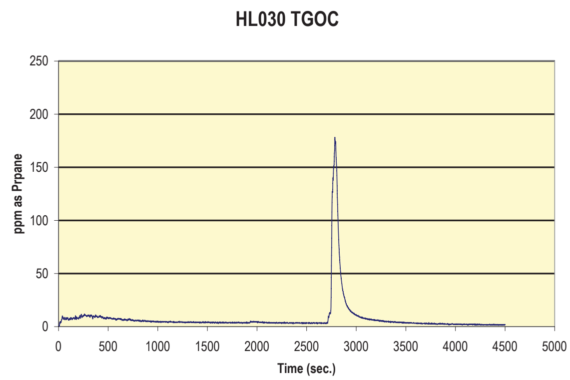
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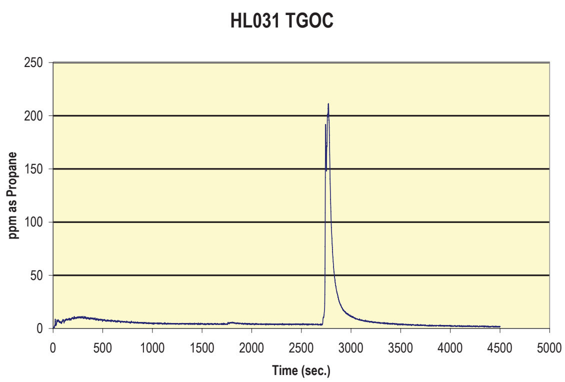
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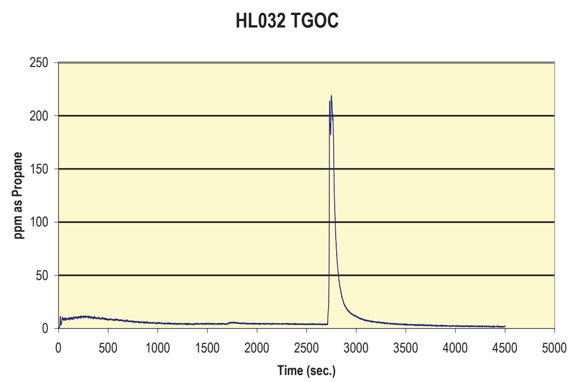
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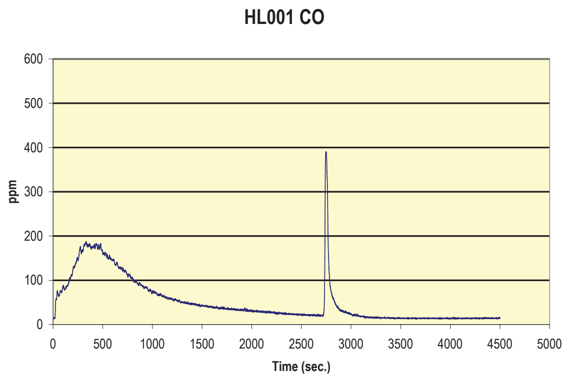
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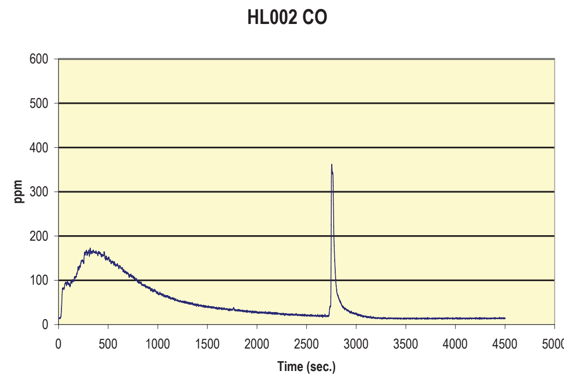
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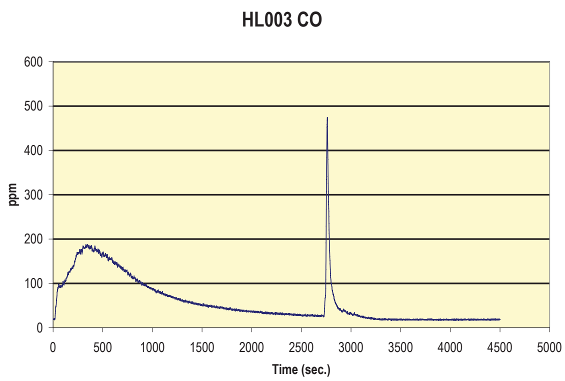
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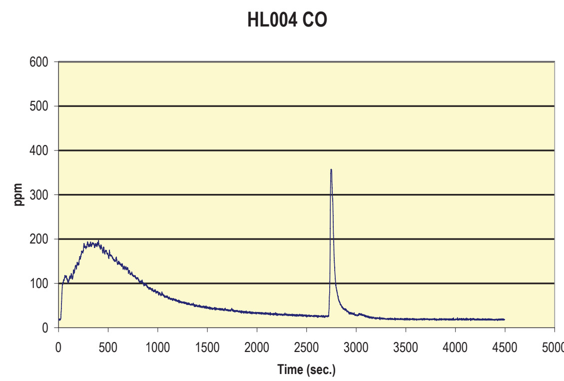
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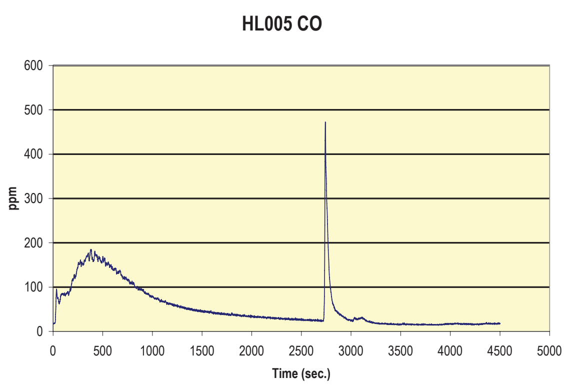
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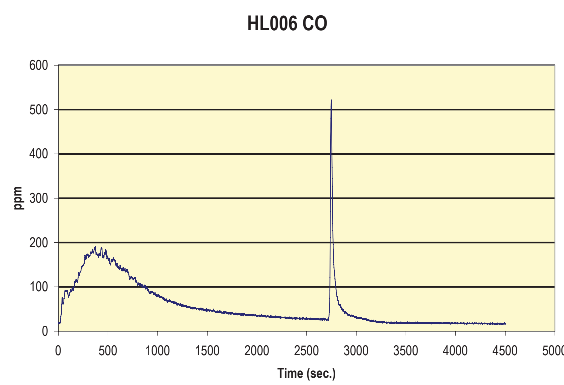
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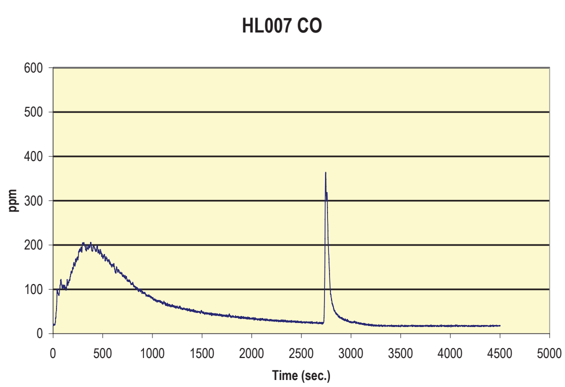
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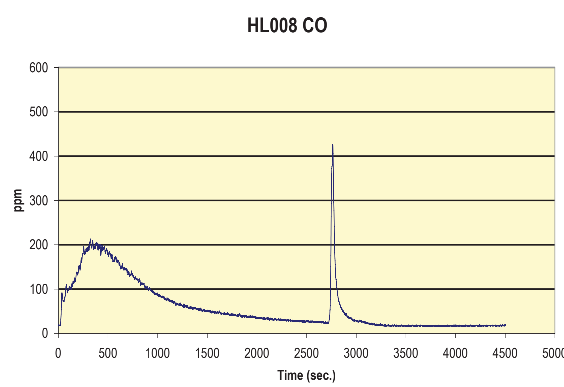
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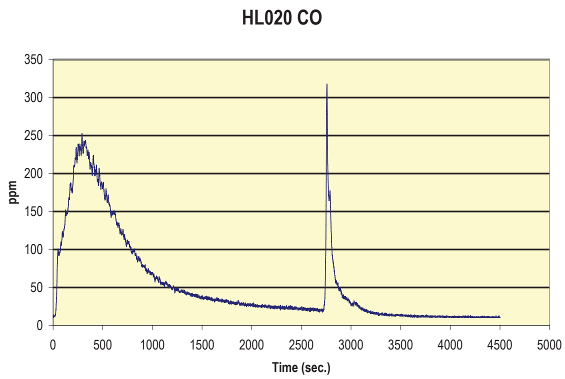
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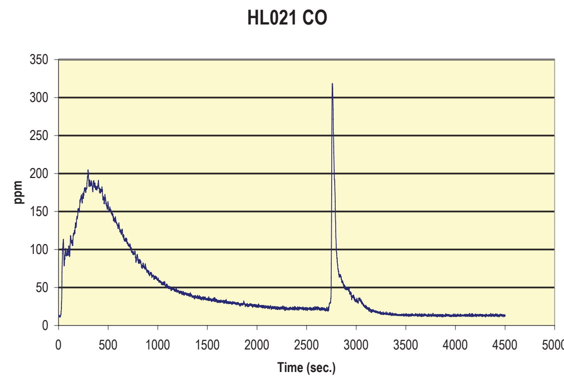
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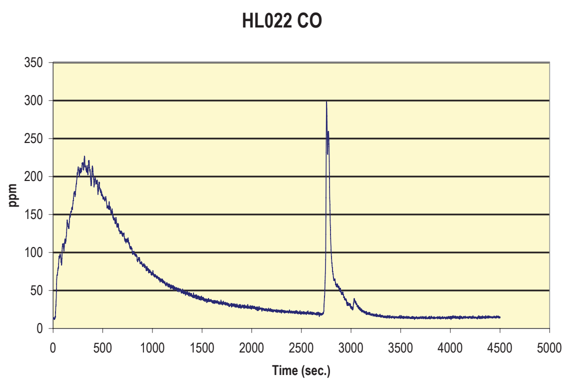
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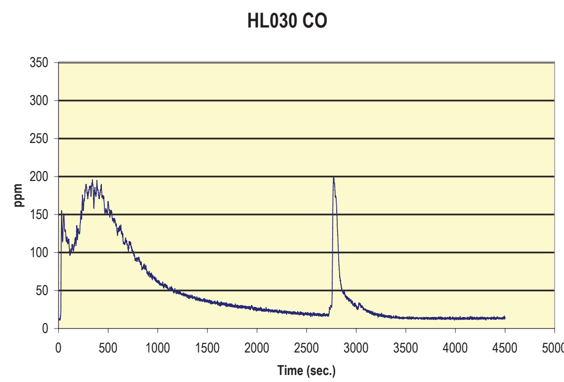
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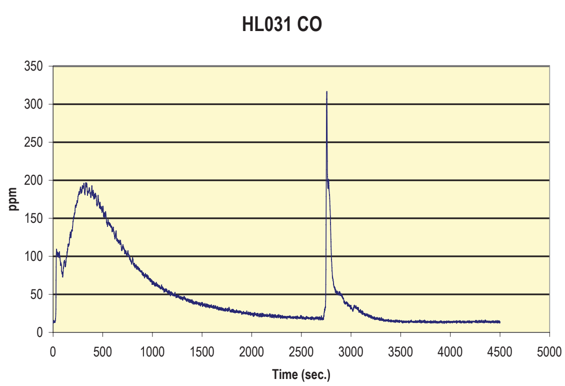
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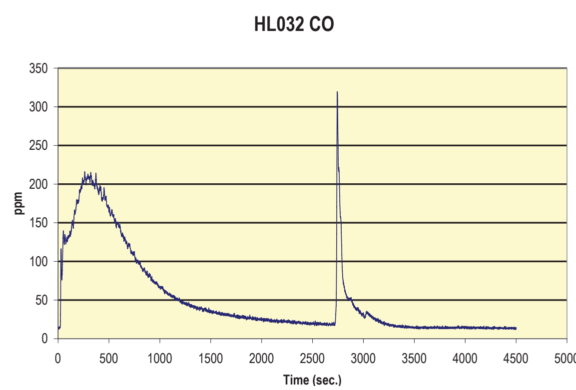
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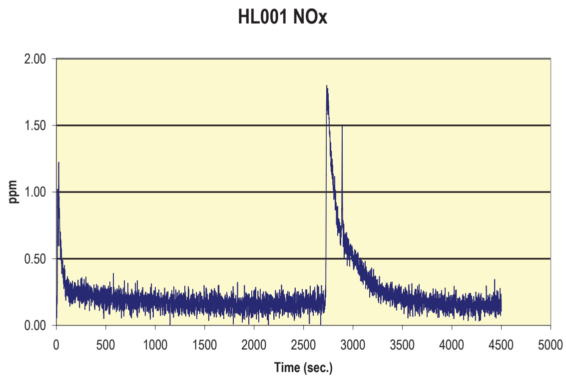
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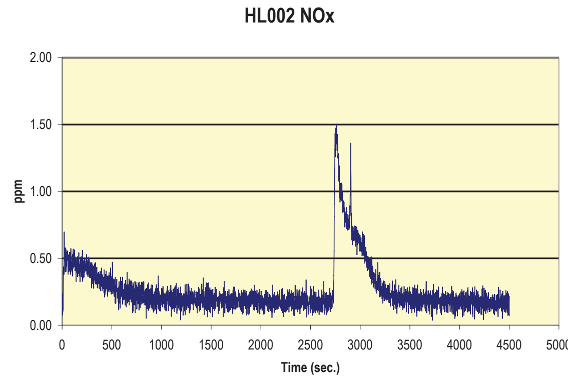
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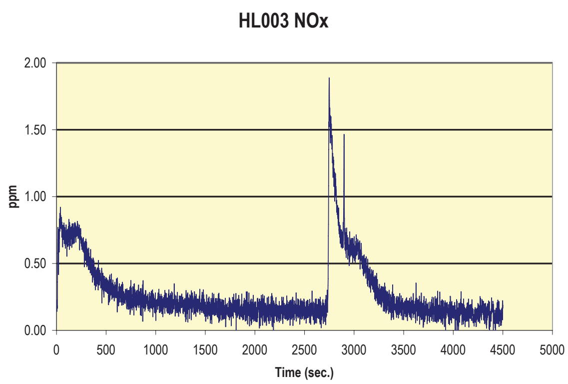
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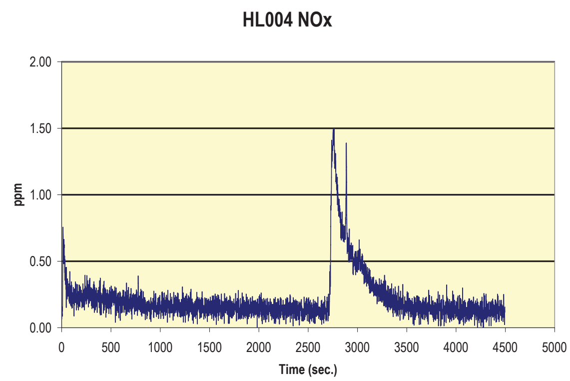
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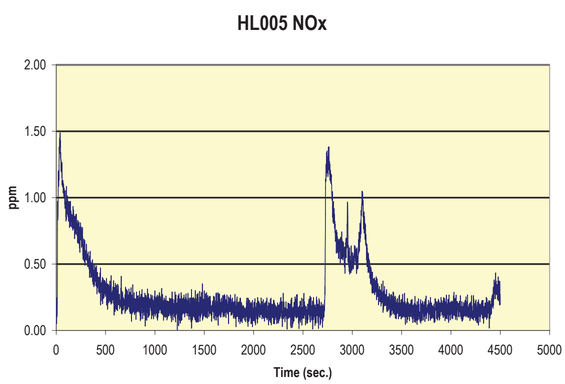
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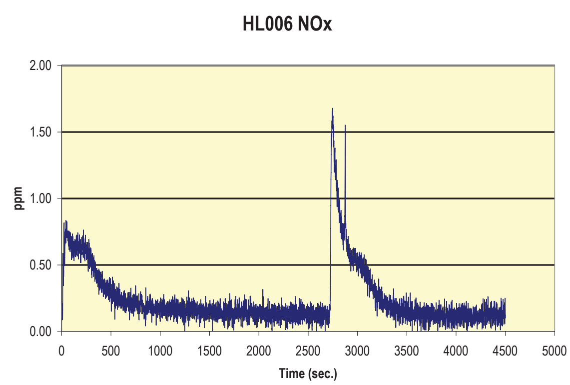
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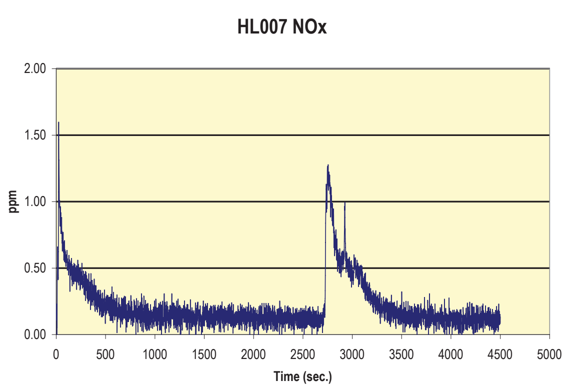
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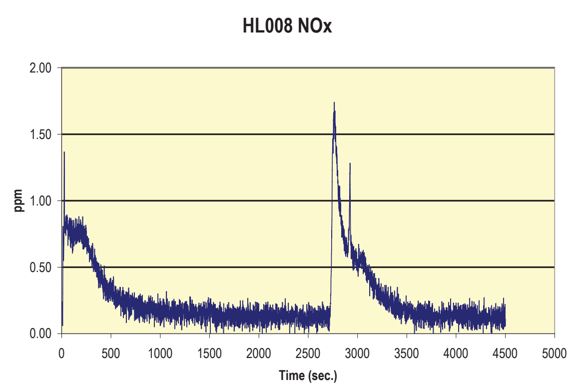
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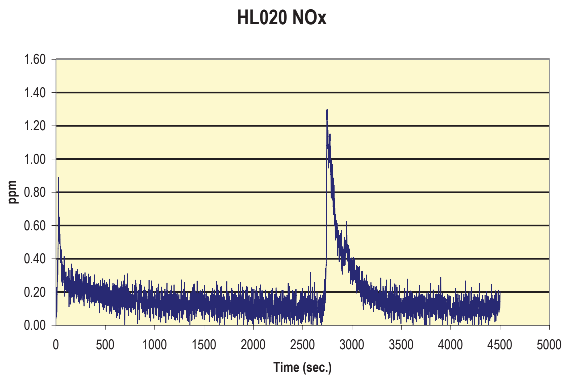
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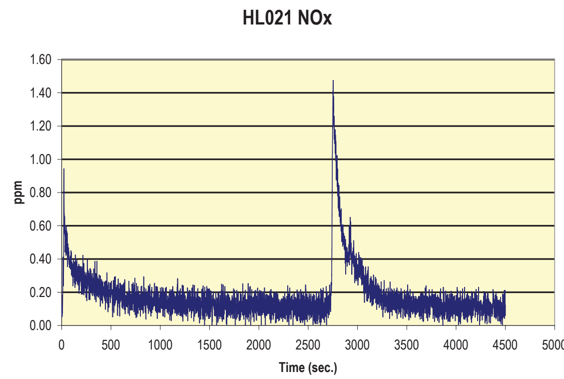
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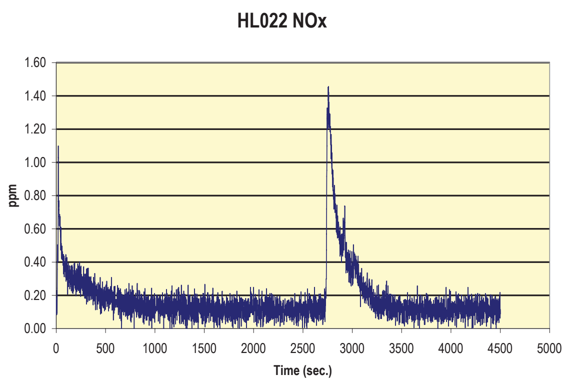
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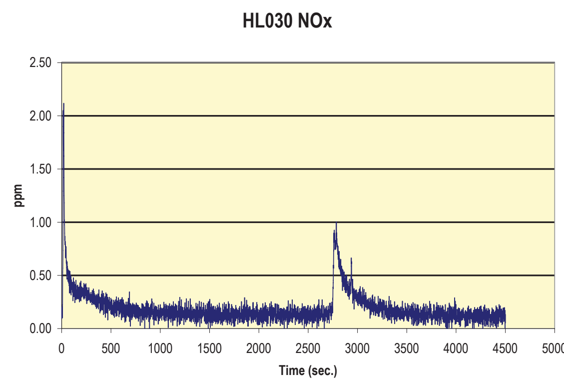
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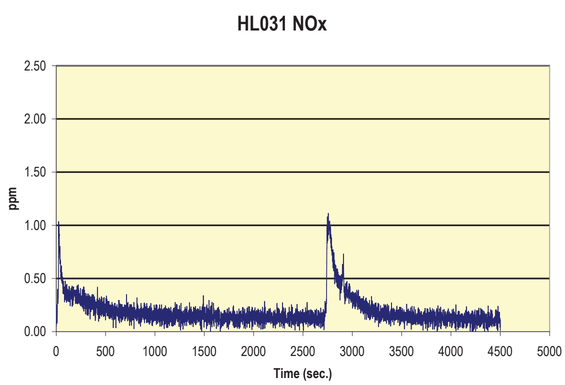
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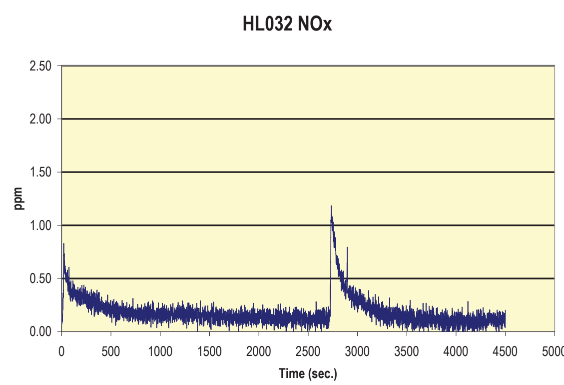
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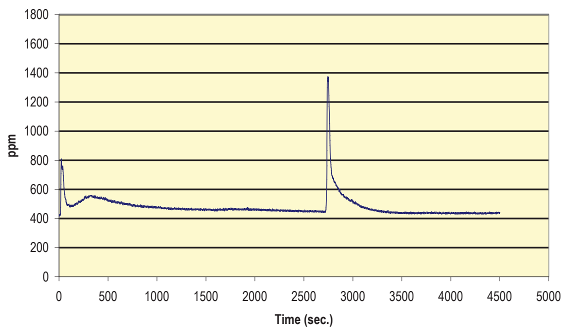
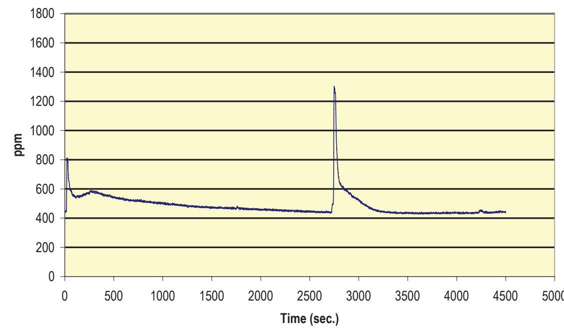
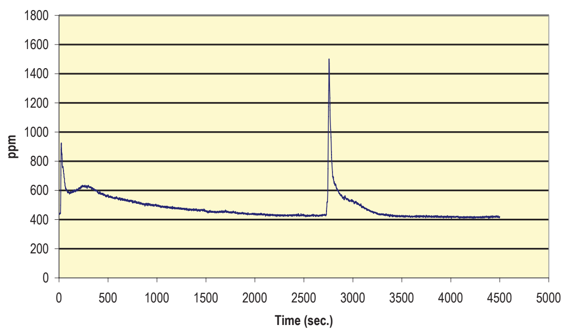
HL001 CO_2



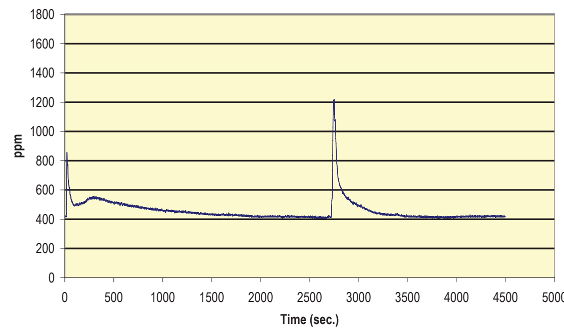
HL002 CO_2



HL003 CO_2



HL004 CO_2



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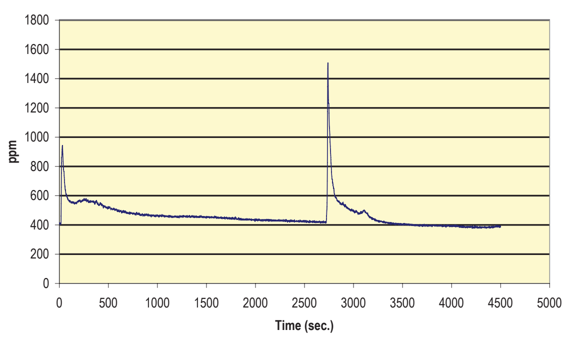

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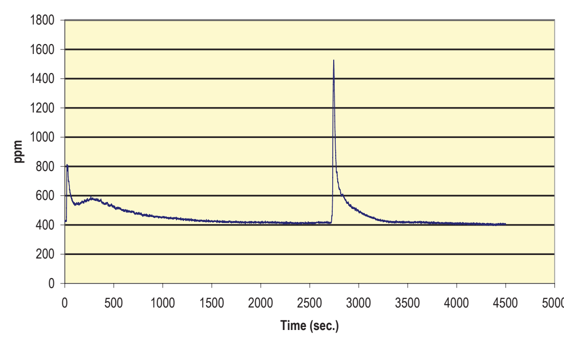

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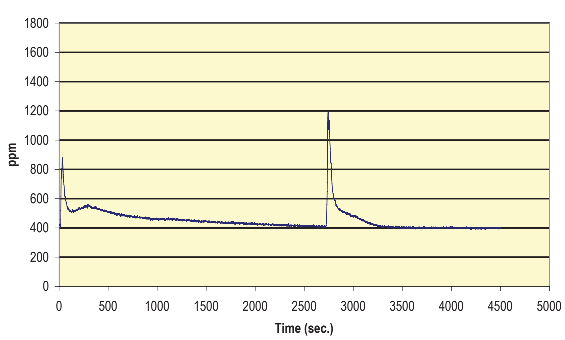

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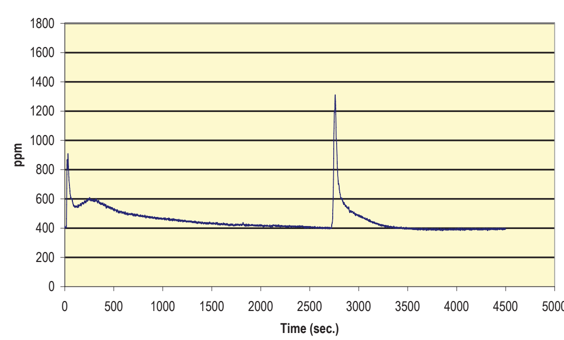

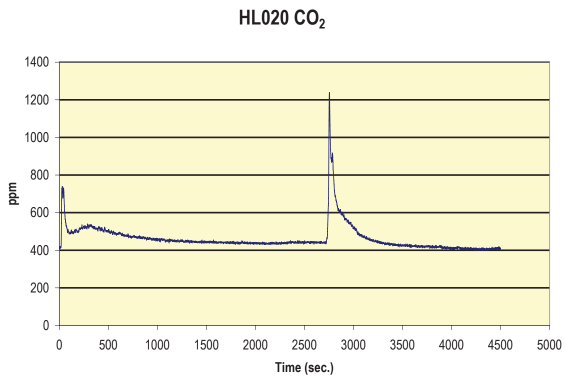
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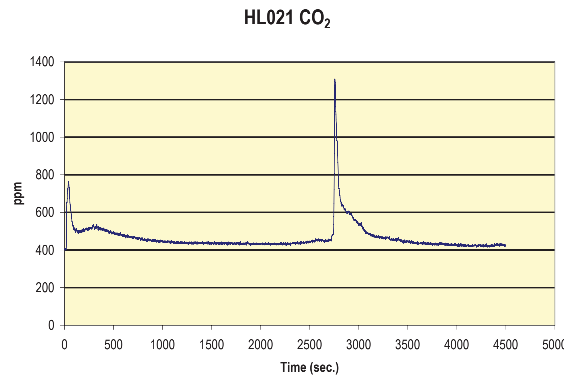
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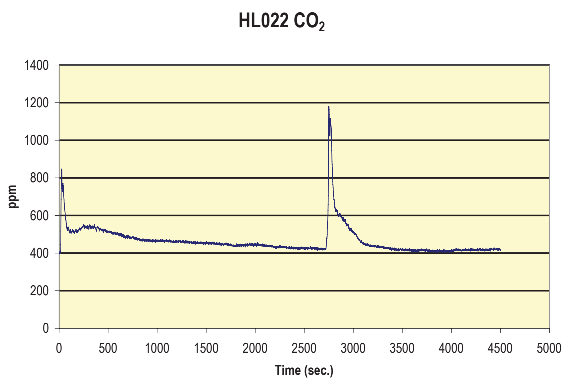
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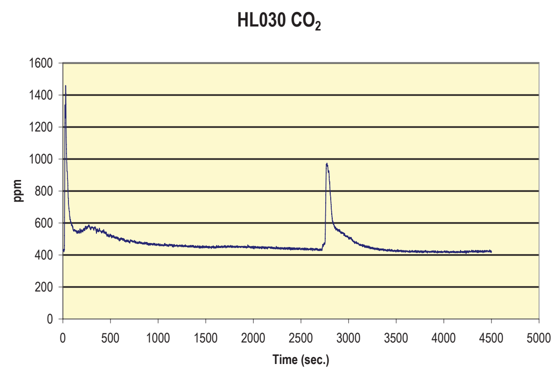
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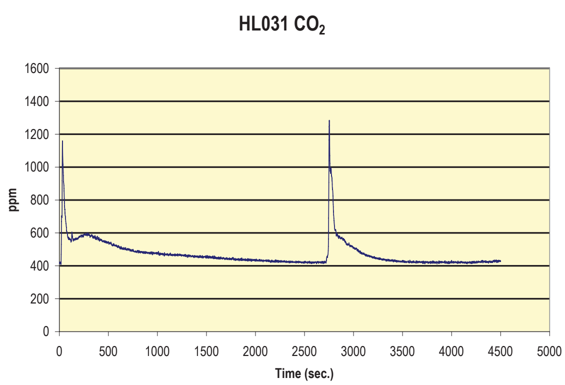
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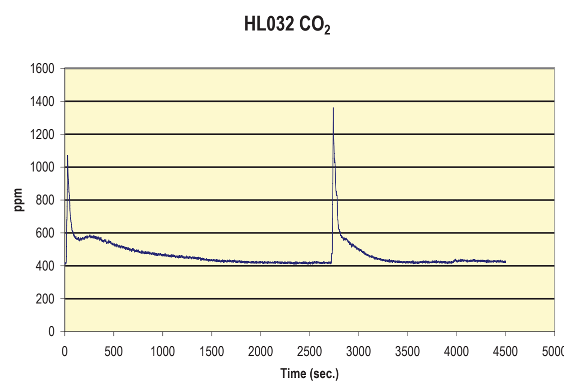
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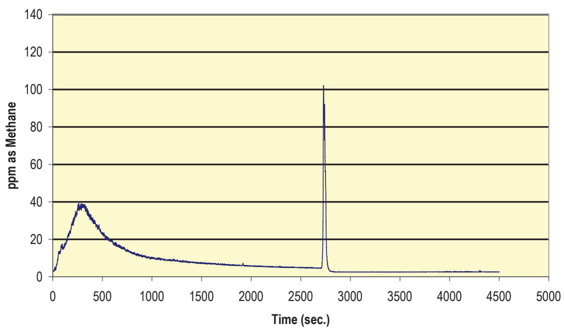
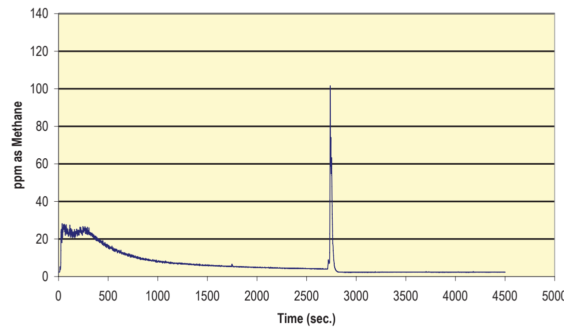
HL001 CH_4



HL002 CH_4



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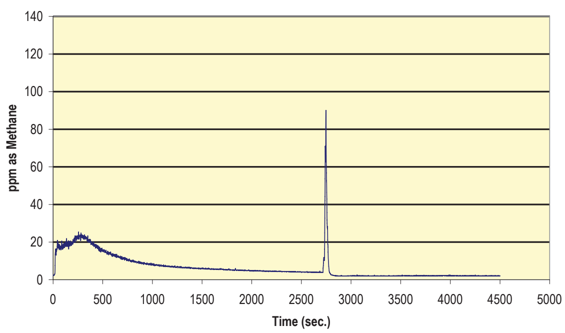

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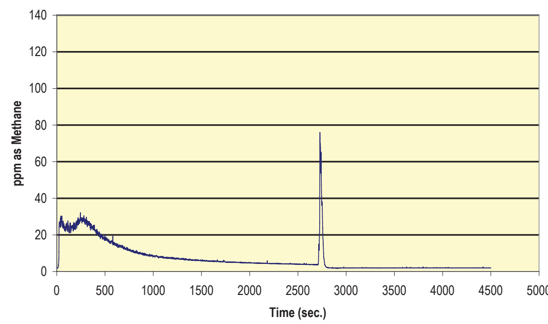

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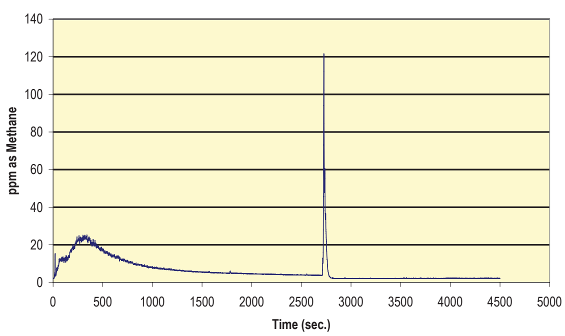
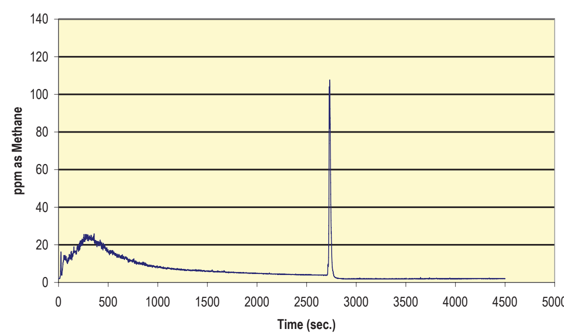


HL006 CH_4



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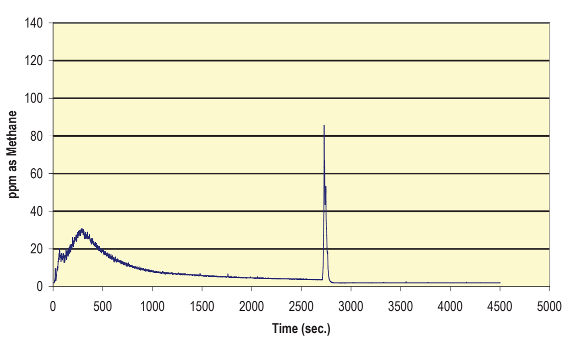

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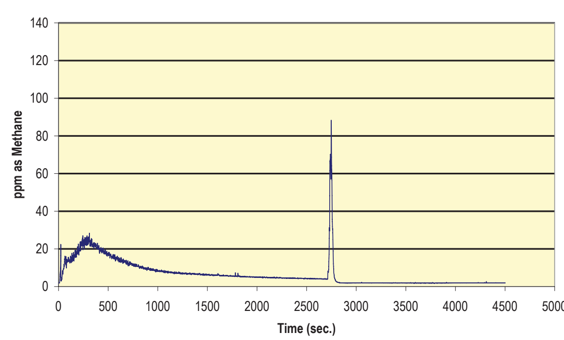

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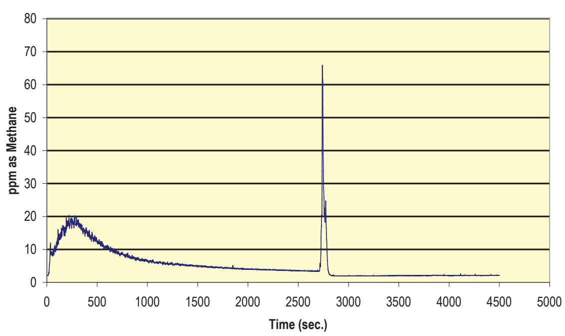

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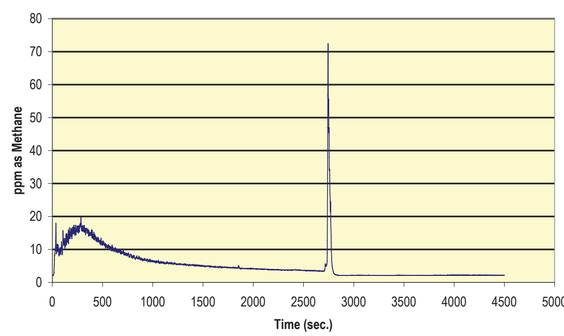

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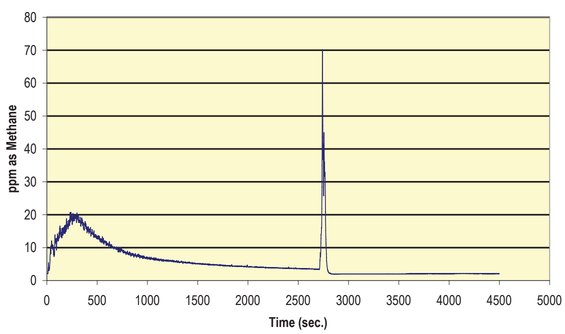

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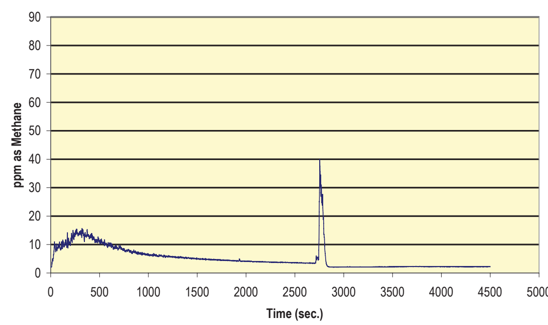
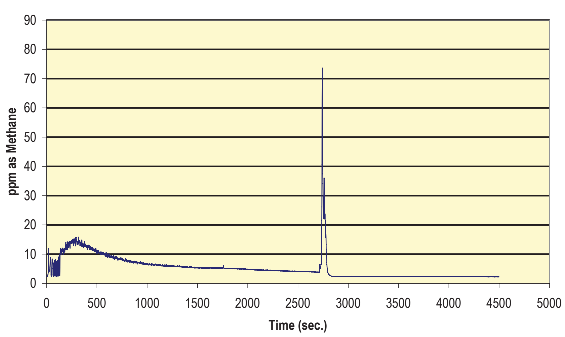
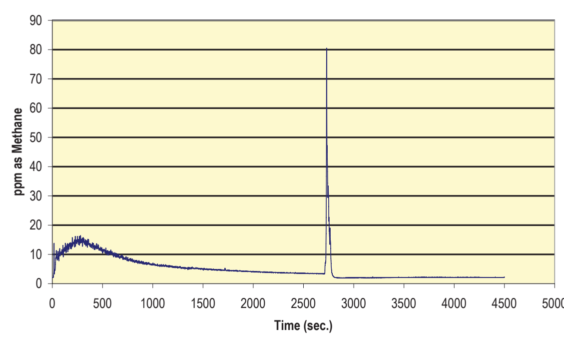


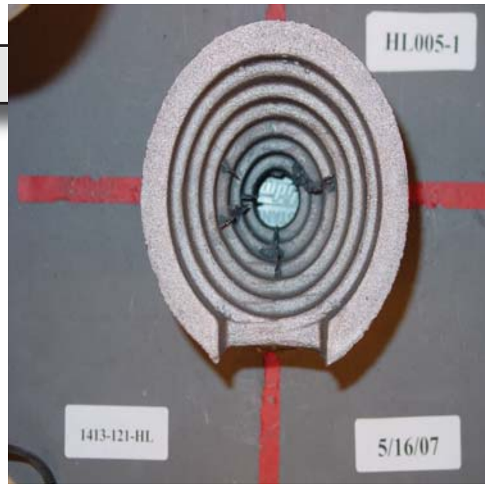
HL031 CH_4



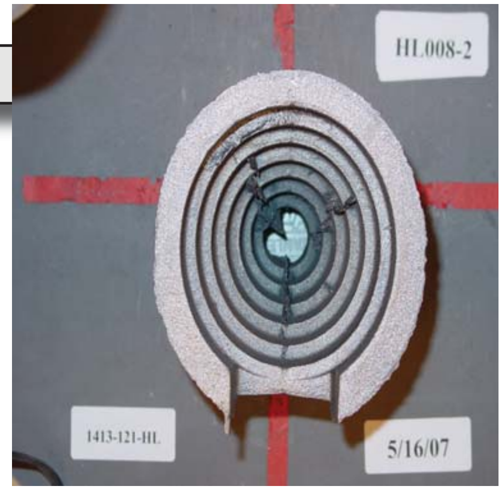
HL032 CH_4



Worst



HL021 Cavity 1



HL031 Cavity 2

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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