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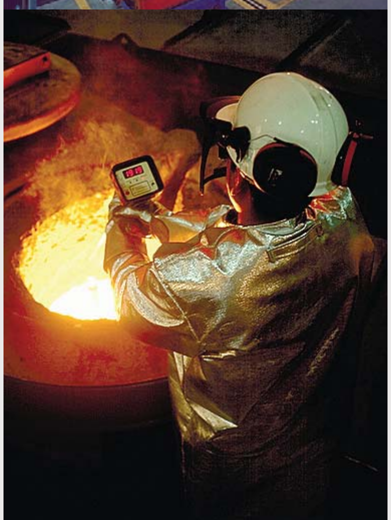

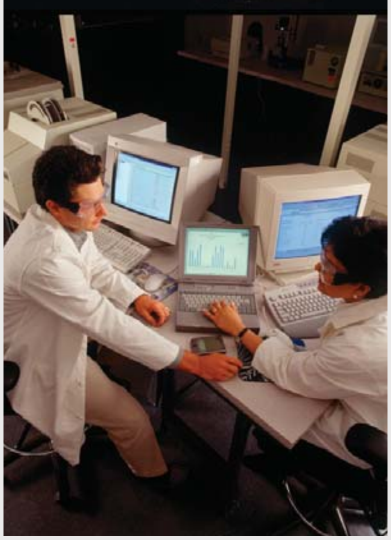

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US Army Contract W15QKN-05-D-0030
FY2006 Tasks
WBS # 1.1.8

Pouring, Cooling, and Shakeout Emissions from Coated Molds Poured with Iron

1413-118 HV

April 2008

(Revised for public distribution - June 2008)

CASTING INDUSTRY SUPPLIERS ASSOCIATION

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Pouring, Cooling, and Shakeout Emissions from Coated Molds, Poured with Iron

1413-118 HV

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

Director of Analytical Measurement Technologies	*//Original Signed//* Sue Anne Sheya, PhD	Date
Vice President of Operations	*//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 casting quality, cost, or producibility.

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

EXECUTIVE SUMMARY

This report contains the results of Test HV, a quantitative evaluation of the pouring, cooling and shakeout (PCS) airborne emissions from cored greensand molds with mold coating in place of seacoal, and poured with iron. The seacoal free molds were of the four-cavity step core pattern. The step cores were uncoated and made using sodium silicate binder. Nine molds were sampled after three sand conditioning runs were initially poured.

Emission results in pounds of pollutant per ton of metal poured (lb/ton) were compared to the most recent step core iron emissions test using seacoal in greensand molds, which has the designation 1411-619 Test GU, runs 7-12. Comparative results between the two tests are reported. All emissions have been background subtracted to provide accurate reporting of results for the tested materials.

The core binders chosen for both Test HV and Test GU were comparatively low emitting sodium silicate based binders so the results of the seacoal replacement mold coating on emissions could be assessed. The reference test, Test GU, used JB DeVenne Cast Clean® #1 sodium silicate binder at 5.0% concentration based on sand (BOS). The current test, Test HV, used an HA International Cordis® that was hot-air cured, at 2.0% BOS. The mold coating was Hill and Griffith EZ Kote™ G Plastic PM, and was sprayed on at an average loading of 0.24 lbs for each mold.

Molds were poured with iron at 2630 ± 10°F. The pouring time of 10-18 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.

With only a couple of exceptions, the speciated analytes targeted for Test HV showed decreases of 80% or greater when compared to Test GU. Emission Indicators had an average decrease of approximately 88% as shown in Table 1.

Table 1 Average Emission Indicators Summary Table, Test GU to Test HV – lb/tn metal

Analyte Name	Reference Test GU	Test HV	Percent Change from Reference
THC as Propane	1.65E+00	1.82E-01	-89
Non-Methane Hydrocarbons	NA	1.82E-01	NA
Sum of Target Analytes	2.33E-01	3.02E-02	-87
Sum of Target HAPs	1.88E-01	2.39E-02	-87
Sum of Target POMs	1.10E-02	1.12E-03	-90

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

1.0 INTRODUCTION

1.1. Background

Technikon, LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and point source emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Leadership Council of USCAR, a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC); the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). The US Environmental Protection Agency (US EPA) and the California Air Resources Board (CARB) also have been participants in the CERP program and rely on CERP published reports for regulatory compliance data. All published reports are available on the CERP web site at www.cerp-us.org.

1.2. CERP/Technikon Objectives

The primary objective of CERP is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was developed to evaluate alternative materials and production processes designed to achieve significant air emission reductions. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing facility enables the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. Report Organization

This report has been written to document the methodology and results of a specific test plan that was used to evaluate the pouring, cooling and shakeout airborne emissions from sodium silicate cores in coated molds, without seacoal, poured with iron and compared to sodium silicate cores in molds containing seacoal.

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

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

1.4. Specific Test Plan and Objectives

The objective of Test HV was to evaluate and compare the air emissions from cored greensand molds with mold coating in place of seacoal to greensand molds containing seacoal and poured with iron. All cores were uncoated and made with sodium silicate binders. The binder used for Test HV was an HA International Cordis® that was hot-air cured, at a concentration of 2.0% BOS. Emissions were then compared to those from seacoal containing greensand cored molds tested under Test GU, runs 7 through 10.

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

Table 1-1 Test Plan Summary

Type of Process Tested	Uncoated sodium silicate core in greensand with seacoal, iron	Uncoated low emissions core in greensand with mold wash, Iron, PCS
Test Plan Number	1411-619 GU	1413-118 HV
Metal Poured	Iron	Iron
Casting Type	4-on step core	4-on step core
Greensand System	Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 5.0 +/- 0.5 % MB clay, seacoal to yield 5.0 ± 0.5% LOI	Wexford 450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5 % MB clay, no seacoal
Core	5% (BOS) JB DeVenne Cast Clean® and Wedron 530 sand	2.0 % (BOS) HA International Cordis 4820BF, hot air cured, Wedron 530 sand
Core Coating	None	None
Number of Molds Poured	3 conditioning runs, 6 emissions measurement runs	3 conditioning runs, 9 emissions measurement runs
Test Dates	July 12, 2005 through July 19, 2005	August 6, 2007 through August 9, 2007
Process Parameters Measured	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate

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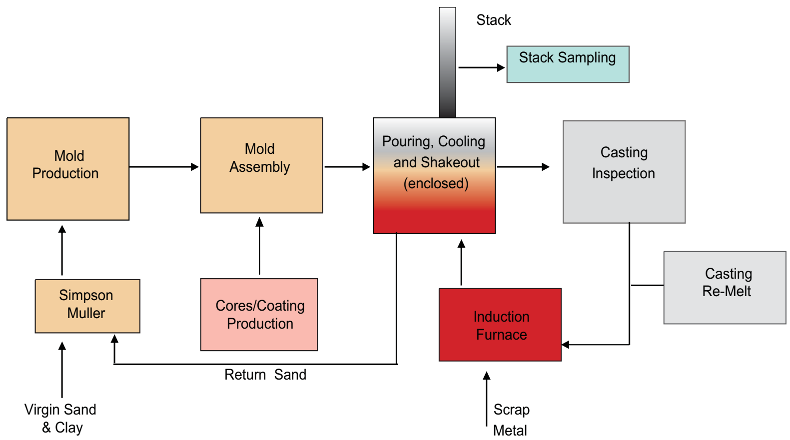
2.0 TEST METHODS, ASSUMPTIONS AND PROCEDURES

2.1. Description of Process and Testing Equipment

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

Figure 2-1 Mold/Core Making, Pouring, and Shakeout Process Diagram



2.2. Description of Testing Program

The testing program encompasses the foundry process and emissions testing, both of which are rigorously controlled. Parameters are monitored and recorded prior to and during the emission tests. Process measurements include 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 include stack temperature, pressure, volumetric flow rate, and moisture content. All parameters were maintained within prescribed ranges to ensure the reproducibility of the test runs.

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

As described in the method, sampling can be conducted using a Volatile Organic Sampling Train (VOST), which was the technique used for sampling emissions during the tests described herein. A sample gas stream was extracted from the source and then routed using the train through tubes containing adsorbents, which are the collection materials upon which the organic analytes are deposited. Adsorption tube samples were collected and analyzed for seventy-four (74) target compounds using specific collection and analysis procedures based on approved federal methods, including those of the EPA.

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

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

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

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

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

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

2.2.1. Test Plan Review and Approval

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

2.2.2. Mold and Metal Preparation

In Technikon's Research foundry, castings were produced individually in discrete manually constructed mold packages, each of which consists of four cavities. The 4-on step core pattern (Figure 2-2) built to evaluate core emissions was used for all runs. A photographic view of the cores embedded in the mold is shown in Figure 2-3. The greensand molds were prepared to the required composition as detailed in the test plan. After the molds were prepared, the cavities were sprayed with the mold coating as shown in Figure 2-4.

Figure** 2-2* ***Step Core

Figure** 2-3* *Step* ***Cores in Mold

Figure** 2-4* ***Spraying Mold Coating into Cavities

Iron was melted in a 1000 lb. Ajax induction furnace. The total amount of metal melted was determined from the expected poured weight of the castings and the number of molds to be poured. The weight of metal poured into each mold was recorded, as was the final casting weight.

2.2.3. Individual Sampling Events

Test HV was designed to determine emissions from coated molds poured with iron, and then compare the emissions to those from uncoated molds containing seacoal. Prior to pouring and emission sampling for each run, a single mold package was placed onto a shake-out table contained within a hooded enclosure designed to meet the requirements of EPA Method 204 for a total temporary enclosure (TTE). The enclosed test stand was pre-heated to 85° to 90°F. The flow rate of the emission capture air was nominally 600 scfm. Iron at approximately 2630°F was then poured through a door in the top of the emission enclosure into the mold, after which the opening was closed (Figure 2-5).

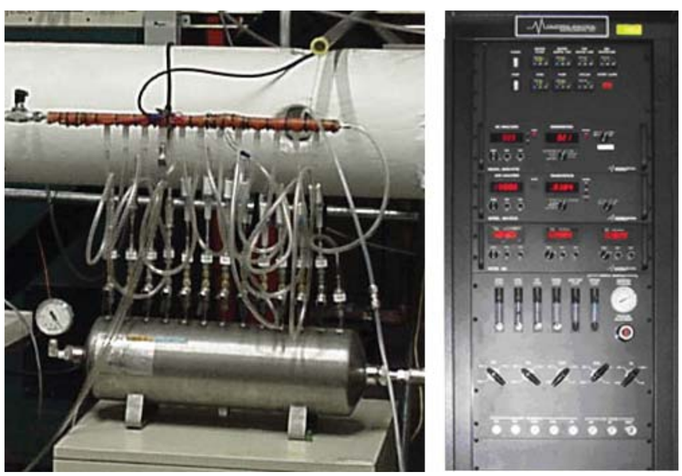
Figure 2-5 Pouring Iron into Mold through TTE

The emissions generated were transported through an insulated six (6) inch duct 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 2-6a). 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 2-6b) located in Technikon's laboratory. This console, or emissions bench, consists of an FID based total hydrocarbon analyzer for TGOC analysis, two infrared analyzers (for CO and CO_2) and a chemiluminescence analyzer for NOx.

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

Figure 2-6 Stack Sampling Equipment

a) Sampling Train *b) E-Bench*



2.2.4. Process Parameter Measurements

Table 2-1 lists the process parameters that were 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
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)
Mold Wash Weight	Ohaus MP2 Scale
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 including HAPs and POMs	US EPA Methods TO17FID, TO17MS, TO11; OSHA ID 200
TGOC	US EPA Method 25A
CO	US EPA Method 10
CO_2	US EPA Method 3A
NOx	US EPA Method 7E
SO_2	OSHA ID 200
CH_4	US EPA CTM 042

Some methods modified to meet specific CERP test objectives.

2.2.6. Data Reduction, Tabulation and Preliminary Report Preparation

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

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

2.2.7. Report Preparation and Review

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

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

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

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

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

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3.0 TEST RESULTS

Emission results from cored and coated seacoal-free greensand molds for Test HV are compared to those from the most recent cored seacoal-containing greensand molds poured with iron, which has the test designation Test GU, runs 7 through 12. Average results for the relative pouring, cooling and shakeout airborne emissions from these tests are presented in Table 3-1 as lb/ton metal.

Table 3-1 Comparison Summary of Selected Target Analytes from Test HV to Test GU, Average Results - lb/ton metal

Analyte Name	Reference Test GU	Test HV	Percent Change from Reference
Emission Indicators			
THC as Propane	1.65E+00	1.82E-01	-89
Non-Methane Hydrocarbons	NA	1.82E-01	NA
Sum of Target Analytes	2.33E-01	3.02E-02	-87
Sum of Target HAPs	1.88E-01	2.39E-02	-87
Sum of Target POMs	1.10E-02	1.12E-03	-90
Selected Target HAPs and POMs			
Benzene	6.73E-02	6.32E-03	-91
Toluene	4.23E-02	2.72E-03	-94
Xylene, mp-	1.83E-02	2.13E-03	-88
Xylene, o-	1.01E-02	6.93E-04	-93
Hexane	9.54E-03	5.11E-04	-95
Acetaldehyde	8.42E-03	5.62E-03	-33
Phenol	7.26E-03	1.16E-03	-84
Naphthalene	6.38E-03	8.68E-04	-86
Ethylbenzene	5.63E-03	4.54E-04	-92
Formaldehyde	2.89E-03	1.56E-03	-46
Cresol, o-	2.59E-03	1.10E-04	-96
Methylnaphthalene, 2-	2.40E-03	1.50E-04	-94
Methylnaphthalene, 1-	1.58E-03	1.04E-04	-93
Propionaldehyde (Propanal)	1.13E-03	5.75E-04	-49
Styrene	1.10E-03	3.00E-04	-73
Dimethylnaphthalene, 1,3-	6.39E-04	≤PQL	NA
Biphenyl	≤PQL	9.79E-05	NA
Cresol, mp-	≤PQL	3.25E-04	NA
Isopropylbenzene	NT	1.75E-04	NA
Additional Selected Target Analytes			
Heptane	8.31E-03	1.08E-03	-87
Octane	7.83E-03	7.03E-04	-91
Nonane	5.92E-03	≤PQL	NA
Decane	4.84E-03	≤PQL	NA
Undecane	4.33E-03	≤PQL	NA
Ethyltoluene, 3-	3.48E-03	4.41E-04	-87
Trimethylbenzene, 1,2,4-	3.37E-03	9.53E-04	-72
Cyclohexane	2.58E-03	≤PQL	NA
2-Butanone (MEK)	1.84E-03	2.73E-04	-85
Ethyltoluene, 2-	9.34E-04	2.37E-04	-75
Butyraldehyde/Methacrolein	6.17E-04	3.72E-04	-40
o,m,p-Tolualdehyde	5.72E-04	≤PQL	NA
Pentanal (Valeraldehyde)	3.62E-04	≤PQL	NA
Benzaldehyde	3.10E-04	≤PQL	NA
Hexaldehyde	2.99E-04	≤PQL	NA
Diethylbenzene, 1,3-	≤PQL	3.55E-04	NA
Indan	≤PQL	2.90E-04	NA
Propylbenzene, n-	≤PQL	2.22E-04	NA
Tetradecane	≤PQL	2.98E-04	NA
Trimethylbenzene, 1,2,3-	≤PQL	4.49E-04	NA
Trimethylbenzene, 1,3,5-	≤PQL	2.34E-04	NA
Isobutylbenzene	NT	9.46E-05	NA
Diethylbenzene, 1,2-	NT	9.51E-05	NA
Ethyltoluene, 4-	NT	2.76E-04	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	8.40E+00	2.50E+00	-70
Carbon Monoxide	5.60E+00	2.58E+00	-54
Sulfur Dioxide	1.15E-02	6.97E-03	-40
Nitrogen Oxides	≤PQL	≤PQL	NA
Methane	NT	≤PQL	NA

NT= Not Tested

NA= Not Applicable

I=Invalidated Data

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

Bold numbers indicate those compounds whose calculated t-statistics is significant at α =0.05

The core binders chosen for both Test HV and Test GU were comparatively low emitting sodium silicate based binders. The reference test, Test GU, used JB DeVenne Cast Clean® #1 sodium silicate binder at 5.0% concentration based on sand (BOS). The current test, Test HV, used an HA International Cordis® that was hot-air cured, at 2.0% BOS. The coating used to coat the mold cavities was Hill and Griffith EZ Kote™ G Plastic PM, and was sprayed on at an average loading of 0.24 lbs for each mold.

Emissions were also calculated on a lb/lb binder and lb/lb coating basis for Test HV, and results are given in Table 3-2a and Table 3-2b, respectively.

Table 3-2a Average Emissions, Test HV, lb/lb binder

Analyte Name	Average	Standard Deviation
Emission Indicators		
THC as Propane	2.00E-02	1.53E-03
Non-Methane Hydrocarbons	1.71E-02	1.16E-03
Sum of Target Analytes	3.34E-03	3.90E-04
Sum of Target HAPs	2.64E-03	2.88E-04
Sum of Target POMs	1.23E-04	3.93E-05
Selected Target HAPs and POMs		
Benzene	7.03E-04	1.19E-04
Acetaldehyde	6.22E-04	6.24E-05
Toluene	3.03E-04	5.02E-05
Xylene, mp-	2.37E-04	4.31E-05
Formaldehyde	1.72E-04	2.63E-05
Phenol	1.27E-04	4.11E-05
Naphthalene	9.46E-05	3.92E-05
Xylene, o-	7.70E-05	1.43E-05
Propionaldehyde (Propanal)	6.38E-05	8.03E-06
Hexane	5.66E-05	1.24E-05
Ethylbenzene	5.05E-05	8.28E-06
Cresol, mp-	3.66E-05	9.01E-06
Styrene	3.32E-05	5.61E-06
Isopropylbenzene	1.96E-05	1.34E-06
Methylnaphthalene, 2-	1.66E-05	4.33E-06
Methylnaphthalene, 1-	1.15E-05	2.39E-06
Biphenyl	1.01E-05	4.12E-06
Cresol, o-	9.94E-06	7.13E-06
Additional Selected Target Analytes		
Heptane	1.21E-04	2.80E-05
Trimethylbenzene, 1,2,4-	1.07E-04	5.58E-06
Octane	7.80E-05	9.60E-06
Trimethylbenzene, 1,2,3-	5.04E-05	2.18E-05
Ethyltoluene, 3-	4.89E-05	6.17E-06
Diethylbenzene, 1,3-	3.99E-05	1.51E-05
Tetradecane	3.29E-05	5.04E-06
Indan	3.13E-05	1.91E-05
Ethyltoluene, 4-	3.06E-05	4.80E-06
2-Butanone (MEK)	3.02E-05	5.24E-06
Butyraldehyde/Methacrolein	3.02E-05	2.03E-05
Ethyltoluene, 2-	2.62E-05	1.92E-06
Propylbenzene, n-	2.47E-05	1.35E-05
Trimethylbenzene, 1,3,5-	2.40E-05	1.78E-05
Isobutylbenzene	1.04E-05	1.93E-06
Diethylbenzene, 1,2-	8.19E-06	6.52E-06
Criteria Pollutants and Greenhouse Gases		
Carbon Monoxide	2.84E-01	2.16E-02
Carbon Dioxide	2.75E-01	4.91E-02
Methane	2.88E-03	5.15E-04
Sulfur Dioxide	7.67E-04	8.03E-05
Nitrogen Oxides	≤PQL	NA

NT= Not Tested

NA= Not Applicable

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

Table 3-2b Average Emissions, Test HV, lb/lb coating

Analyte Name	Average	Standard Deviation
Emission Indicators		
THC as Propane	4.54E-02	7.74E-03
Non-Methane Hydrocarbons	3.89E-02	6.39E-03
Sum of Target Analytes	7.55E-03	1.45E-03
Sum of Target HAPs	5.97E-03	1.07E-03
Sum of Target POMs	2.79E-04	1.08E-04
Selected Target HAPs and POMs		
Benzene	1.59E-03	3.72E-04
Acetaldehyde	1.40E-03	2.18E-04
Toluene	6.83E-04	1.37E-04
Xylene, mp-	5.34E-04	1.08E-04
Formaldehyde	3.88E-04	8.19E-05
Phenol	2.86E-04	9.49E-05
Naphthalene	2.15E-04	9.79E-05
Xylene, o-	1.73E-04	3.49E-05
Propionaldehyde (Propanal)	1.44E-04	2.40E-05
Hexane	1.27E-04	3.14E-05
Ethylbenzene	1.14E-04	2.20E-05
Cresol, mp-	8.31E-05	1.49E-05
Styrene	7.54E-05	2.05E-05
Isopropylbenzene	4.52E-05	5.17E-06
Methylnaphthalene, 2-	3.78E-05	1.23E-05
Methylnaphthalene, 1-	2.62E-05	8.13E-06
Biphenyl	2.26E-05	1.09E-05
Cresol, o-	2.04E-05	1.53E-05
Additional Selected Target Analytes		
Heptane	2.70E-04	6.14E-05
Trimethylbenzene, 1,2,4-	2.51E-04	3.55E-05
Octane	1.76E-04	3.24E-05
Trimethylbenzene, 1,2,3-	1.21E-04	6.38E-05
Ethyltoluene, 3-	1.08E-04	1.77E-05
Diethylbenzene, 1,3-	9.50E-05	4.52E-05
Tetradecane	7.45E-05	1.78E-05
Indan	7.12E-05	4.30E-05
Ethyltoluene, 4-	6.91E-05	1.56E-05
2-Butanone (MEK)	6.78E-05	1.31E-05
Butyraldehyde/Methacrolein	6.52E-05	4.71E-05
Ethyltoluene, 2-	5.92E-05	1.02E-05
Propylbenzene, n-	5.74E-05	3.53E-05
Trimethylbenzene, 1,3,5-	5.44E-05	4.10E-05
Isobutylbenzene	2.31E-05	3.92E-06
Diethylbenzene, 1,2-	1.97E-05	1.69E-05
Criteria Pollutants and Greenhouse Gases		
Carbon Monoxide	6.45E-01	1.01E-01
Carbon Dioxide	6.20E-01	1.25E-01
Methane	6.56E-03	1.55E-03
Sulfur Dioxide	1.73E-03	2.78E-04
Nitrogen Oxides	6.16E-04	1.24E-04

NT= Not Tested

NA= Not Applicable

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

Several different classifications of analytes are included in the tables. Compounds chosen for analysis from PCS emissions that are based on chemical and operational parameters are termed “target analytes” (TA). “Emissions Indicators” contain the undifferentiated hydrocarbon results and composite sums of speciated analytes. Included in this category are “TGOC as Propane” as determined by Method 25A, and non-methane hydrocarbons (NMHC) as determined by a procedure similar to that found in historic EPA CTM-042. Three analyte sums are also part of the “Emission Indicators” group. 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. The Sum of Target Analytes includes targeted compounds that may also be defined as hazardous air pollutants (HAPs) and polycyclic organic matter (POM).

By definition, HAPs are specific compounds listed in the Clean Air Act Amendments of 1990. POMs as a class are a listed HAP. The term POM defines a broad class of compounds based on chemical structure and boiling point. A subset of organic compounds from the current list of EPA HAPs was targeted for collection and analysis. The 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 targeted HAPs that are also defined as POMs.

Emissions Indicators are reported in the first section of the tables. The second section of the table includes average emission results for individual HAP and POM compounds selected as target analytes, while the third section contains results for additional speciated compounds that are not HAPs or POMs but may be on the EPA SARA 313 list of toxic chemicals. In addition, average values for selected criteria and greenhouse gases including CO, CO_2, CH_4, SO_2, and NO_x are given in the fourth section of the tables.

Speciated results presented in the tables of this report, including those gases measured continuously on-line in real time at Technikon during both Test HV and the reference Test GU, have been background corrected. This is because 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, or the instrumentation and equipment used during chemical analysis of the collected samples.

Table 3-1 also includes the relative percent change in emissions from the reference Test GU to Test HV. The relative percent change in this case is defined as the difference in concentrations between the current test and reference test, divided by the reference test concentration and expressed as a percentage.

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

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

Table 3-3 Summary of Test Plan Average Process Parameters

	Test GU	Test HV
Test Dates	7/18/05-7/19/05	8/6/07-8/9/07
Cast weight, lbs.	113.2	117.0
Pouring time, sec.	15	13
Pouring temp ,°F	2682	2631
Pour hood process air temp at start of pour, °F	87	87
Mixer auto dispensed sand weight, lbs	50.00	49.87
Core binder weight (Part 1), g	1135.5	453.1
% core binder (BOS)	5.0	2.0
% core binder, actual	4.8	2.0
Total core weight in mold, lbs.	30.0	26.9
Total binder weight in mold, lbs.	4.77	0.53
Sprayed coating sprayed, lbs	NA	0.24
Core LOI, %	NT	0.16
2-hour core dogbone tensile, psi	NT	NT
Core age when poured, hrs.	NT	357
Muller batch weight, lbs.	902	899
GS mold sand weight, lbs.	646	607
Mold temperature, °F	83	81
Average green compression , psi	22.86	24.70
GS compactability, %	41	40
GS moisture content, %	1.97	2.24
GS MB clay content, %	5.59	7.91
MB clay reagent, ml	27.8	40.3
1800°F LOI - mold sand, %	5.17	0.93
900°F volatiles , %	0.99	0.46
Permeability index	179	246

Test GU=Greensand PCS with sodium silicate cores

Test HM=Greensand PCS with cordis cores

Examination of measured process parameters indicated that Test HV was run within acceptable ranges and limits. The principal causes and secondary influences on emissions were identified, controlled, and monitored as much as feasibly possible for each individual run. This ensured that emissions produced during the test reflected only the influence of the material being tested and not the process itself.

A statistical analysis was made to determine whether the means of the emissions of the baseline reference test and the comparative test were different through calculating a T-test at a 95% significance level (α=0.05). Results at this significance level indicated that there is a 95% probability that the mean values for the comparison tests are not equivalent to those of the reference test. It may therefore be said that the differences in the average emission values are real differences, and not due to test, sampling, or analysis methodologies. This difference is indicated in Table 3-1 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

3.1.1. Emissions Results

The individual chemical compounds targeted for collection and analyses from airborne emissions for this test were chosen based on the chemistry of the binder under investigation as well as analytes historically targeted. The fundamental analyte lists were similar for Test HV and Test GU. Low flow rates for hydrocarbon collection for two runs of Test GU in the VOST caused plugging of the critical orifices used to control flow. Results for those two runs had to be invalidated.

For less complex samples with fewer individual analytes contributing to emissions, the target analyte sum would theoretically closely match the results for total hydrocarbons obtained by Method 25A, excluding exempt compounds such as methane, and including compounds such as formaldehyde, which are known to be less responsive in the FID. For the results reported here, the Sum of Target Analytes plus methane averages approximately 32% of TGOC as Propane results that have been adjusted by addition of less responsive target compounds such as aldehydes and ketones.

Confirmatory GC/MS (gas chromatography/mass spectrometry) analysis showed over 100 peaks in the chromatogram. The 65 total GC/MS compounds accounting for 90% of the peak area are summarized in Table 3-4. The majority of the hydrocarbon concentration, which is determined by peak area, was for an unknown compound, benzene, 2-furanmethanol, 2-methyl-2-butene, toluene, p-xylene, and naphthalene. These 7 compounds accounted for 38% of the peak area concentration. The next 58 compounds on the table accounted for approximately 52% of the remaining peak area. Of the 65 compounds, 11 were C_4 benzenes and 4 were furan based derivatives.

Table 3-4 Compounds Accounting for 90% of Emissions as Determined by Peak Area from GC/MS Analysis

Unknown	C4 Benzene
Benzene	C4 Benzene
2-Furanmethanol	Unknown
2-Butene, 2-methyl-	2,4-Dimethyl hexene-1
Toluene	Furan, 2,5-bis(2-furanylmethyl)-
p-Xylene	p-Dicyclohexylbenzene
Naphthalene	1H-Indene, 2,3-dihydro-4-methyl-
Pentanedioic acid, dimethyl ester	Acetic acid
C4 Benzene	Unknown
C4 Benzene	Benzene, 1,2,3-trimethyl-
Unknown	Hexadecane
Butane, 2-methyl-	3-Heptene, 3-methyl-
Pentane, 2-methyl-	Heptane, 3-methyl-
Benzene, 1,2,3-trimethyl-	C4 Benzene
3-Methyl-2-hexene (c,t)	Heptadecane
1-Butene, 2-methyl-	Unknown
C4 Benzene	1H-Indene, 2,3-dihydro-4-methyl-
Unknown	Hexane, 3-methyl-
C4 Benzene	2-Pentene, 3-methyl-, (Z)-
2-Pentene, 4-methyl-, (Z)-	Benzene, 1,3,5-trimethyl-
Unknown	Heptane, 3-methylene-
Phenol	**Ethylbenzene**
Furan, 2-propyl-	Cyclopropane, 1-ethyl-1-methyl-
Furan, 2,2'-methylenebis-	Pentadecane
Furfural	Benzene, 1-ethyl-2-methyl-
C4 Benzene	C4 Benzene
Benzene, 1,3-dimethyl-	Unknown
C4 Benzene	Cyclopentene, 1-methyl-
Heptane, 2-methyl-	Cyclohexane, 1,3-dimethyl-, trans-
Hexane, 2-methyl-	Decanal
1-Pentene, 2-methyl-	Cyclotrisiloxane, hexamethyl-
C4 Benzene	Unknown
2-Butenoic acid, methyl ester, (Z)	

Bold=HAP or criteria pollutant
Italic =POM
compounds listed in decreasing order

Six of the 65 compounds in the top 90% of the GC/MS area were also pre-selected target compounds. But most of the concentration of emissions found from GC/MS analysis was not from compounds pre-selected for collection and analysis. The poor agreement between pre-selected target and actual compounds found in emissions could explain why the calculated TGOC as Propane number is only 32% of the measured TGOC as Propane number.

Figures 3-1 to 3-4 graphically present the data from Table 3-1 for Test HV and Test GU for the five emissions indicators, selected individual HAP, target analyte, and criteria pollutant and greenhouse gas emissions as lb/tn of metal.

Figure 3-1 Comparison of Emissions Indicators of Test HV to Reference Test GU, Average Results- lb/ton metal

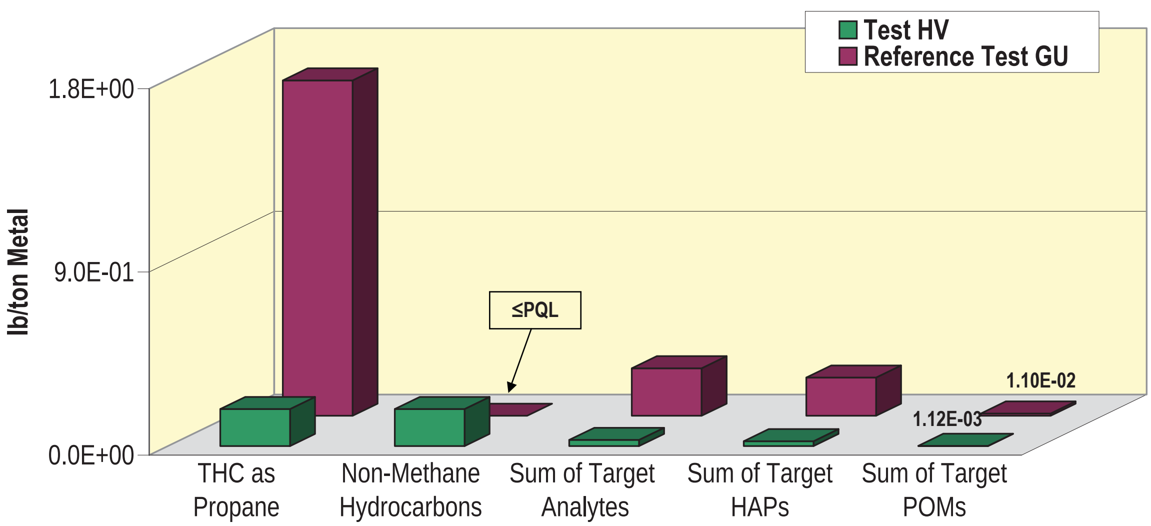


Figure 3-2 Comparison of Selected HAP and POM Emissions of Test HV to Reference Test GU, Average Results – lb/ton metal

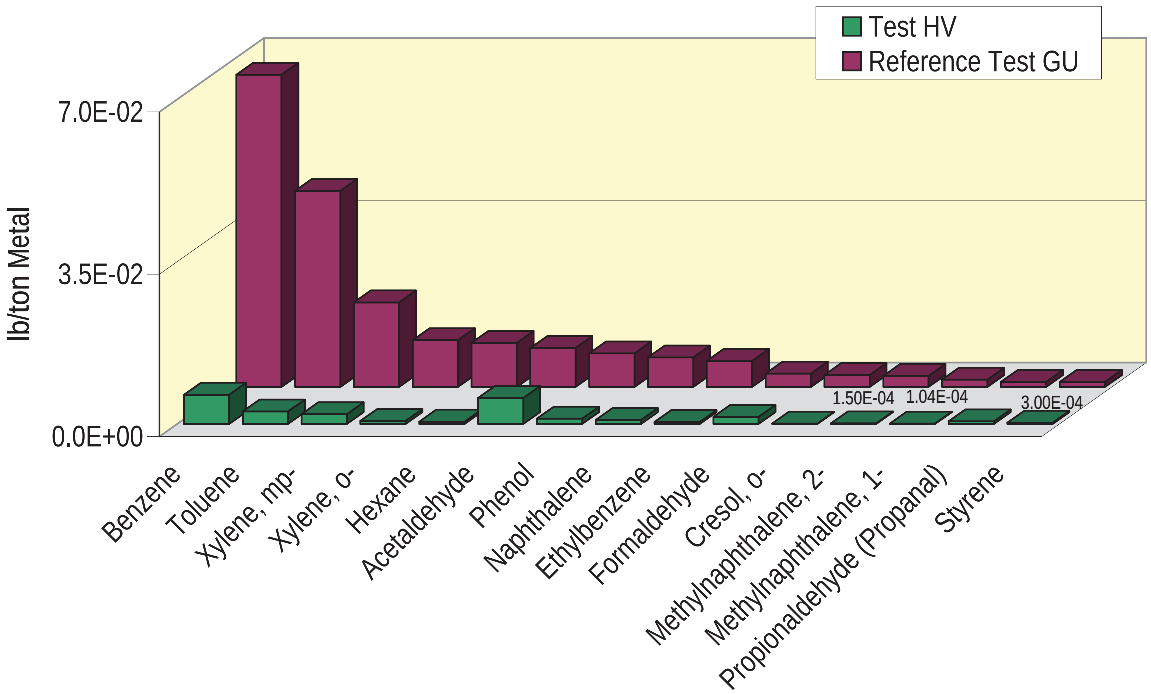


Figure 3-3 Comparison of Selected Target Analyte Emissions of Test HV to Reference Test GU, Average Results – lb/ton metal

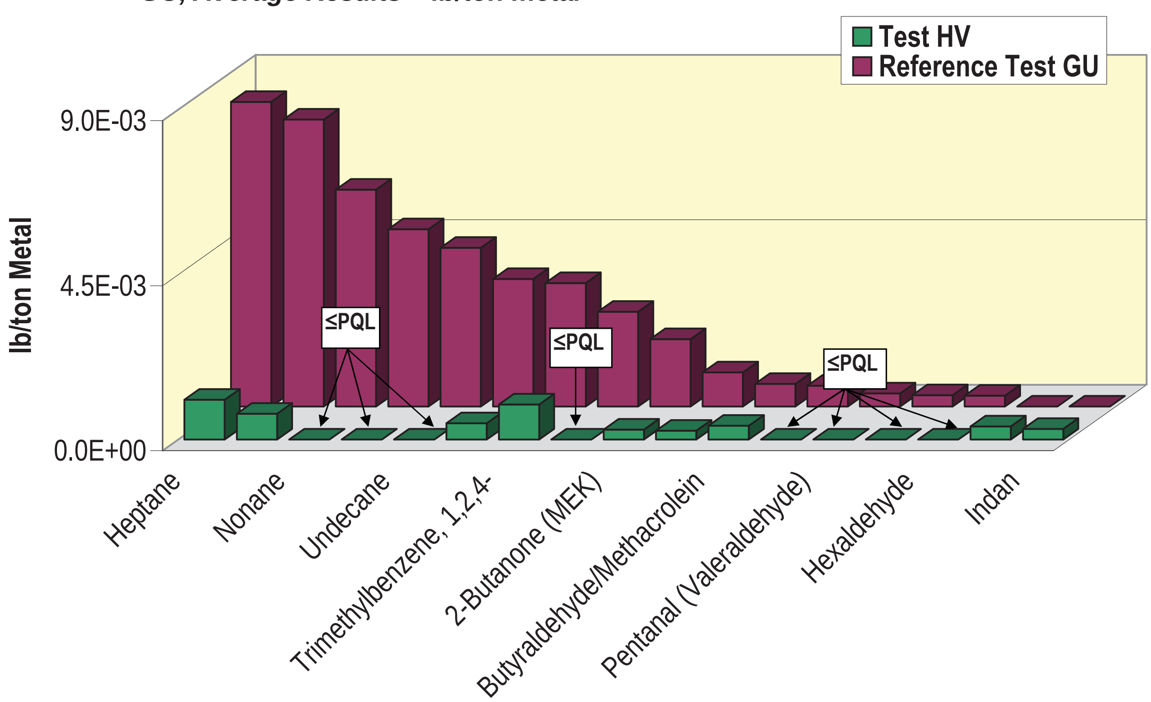
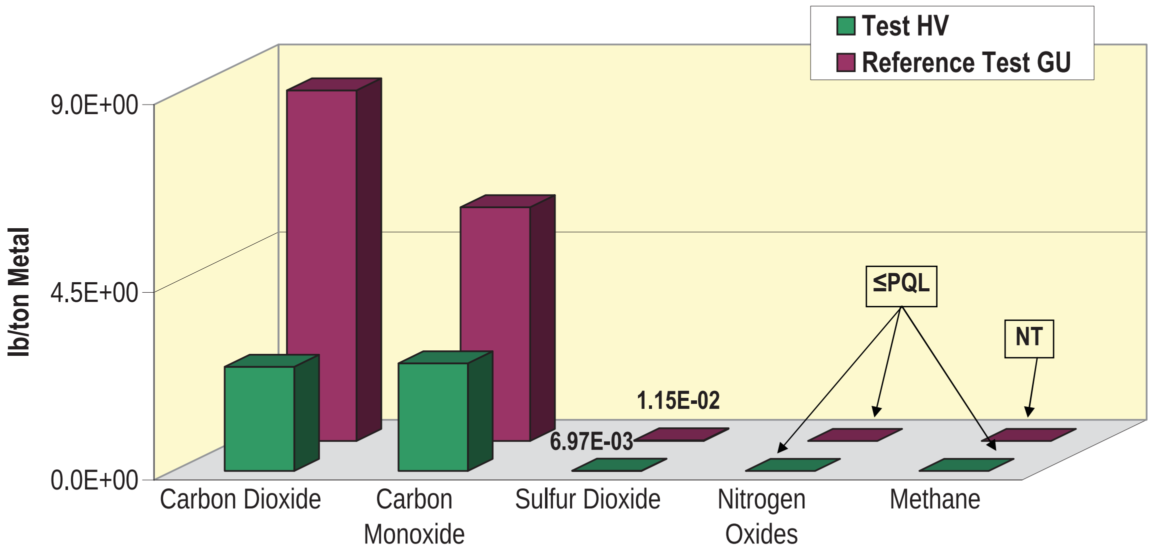


Figure 3-4 Comparison of Criteria Pollutants and Greenhouse Gases of Test HV to Reference Test GU, Average Results – lb/ton metal



With only a couple of exceptions, the speciated analytes targeted for Test HV showed decreases of 80% or greater when compared to Test GU. Emission Indicators for lb/tn metal for Test HV show statistically significant decreases on average of approximately 88 % for Test HV when compared to Test GU as lb/ton metal.

Of the 73 individual Target Analytes sampled by adsorption tube from Test HV (excluding criteria pollutants and greenhouse gases), 34 contributed to emissions above the PQL. Of the 30 HAPs targeted for analysis, 18 contributed to emissions above the PQL. Benzene, acetaldehyde, toluene, mp-xylene, formaldehyde, phenol, and naphthalene accounted for approximately 67% of the measured emissions from targeted compounds. The remaining compounds contributed 2% or less to total emissions.

The top non-HAP contributors for Test HV were heptane, 1,2,4-trimethylbenzene, and octane at 4,3, and 2%, respectively. All remaining compounds contributed less than 1% to total emissions.

3.1.2. Casting Quality Results

The influence of the mold coating on casting quality was determined by comparing the surface quality of castings from Test HV to those of step core castings made from molds containing seacoal. Castings from Test GB were used in lieu of castings from Test GU, as Test GU castings were unfortunately unavailable. Like Test GU, Test GB provided iron step core castings poured in greensand with seacoal.

Nine castings, one each from cavity 3 of each of the emissions sampling runs from both Test HV and Test GB were chosen for the comparison. The comparison consisted initially of a visual examination of minor surface defects such as penetration. Castings were first ranked according to those defects. To further differentiate surface quality among castings, the finish was tested by touch for smoothness. The smoothest casting with the fewest visual surface defects received the highest ranking. The method for grading the casting surface quality of castings from Test HV was changed slightly from the standard procedure, because the greensand mold side of the casting was graded instead of the core side.

Three benchmark visual casting quality rankings consisting of the best, the median, and the worst casting were assigned to three of the castings from the reference Test GB and current Test HV. The "best" designation means that the internal surface of a casting is the best appearing of the lot of 9, and was given an in-series rank of 1. The "median" designation, given an in-series rank of 5 means that four castings are better in appearance and four are worse. The "worst" designation is assigned to that casting which is of the poorest quality, and is assigned an in-series rank of 9.

The best, median, and worst castings were chosen for each test. Then, the best, median, and worst castings from Test GB were compared to all of the cavity 3 castings from Test HV. Comparison results are shown in Table 3-5.

Table 3-5 Rank Order of Casting Appearance – Test HV and Test GB

	Test GB	Test HV	
Overall Rank Order of Appearance	Sample Number	Sample Number	Test Rank
Rank 1	GB004		Best
Rank 2	GB005		Median
Rank 3	GB009		Worst
Rank 4		HV002	Best
Rank 5		HV005	
Rank 6		HV009	
Rank 7		HV003	
Rank 8		HV006	Median
Rank 9		HV004	
Rank 10		HV007	
Rank 11		HV008	
Rank 12		HV001	Worst

Because of the core cavity shape and depth in the molds, as well as the shape of the spraying equipment (Figure 2-4), it was difficult to evenly coat the surface of the cavity. The bottoms of the inside of the cavity therefore received more mold coating during the coating application procedure. This is most likely why the castings from Test HV showed more burn-in and a rougher surface than the castings from Test GB on the outside circumference of the castings, but the bottoms were equally smooth.

The four appendices in this report contain detailed information regarding testing, sampling, data collection and results for each sampling event. Appendix A contains test plans, instructions, and the sampling plans for Test GU and Test HV. Appendix B contains detailed lb/ton emissions data for the reference Test GU, as well as for Test HV calculated as lb/ton, lb/lb binder and lb/lb coating. Target analyte practical quantitation limits for all targeted analytes for these three concentration calculations 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.

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APPENDIX A TEST AND SAMPLE PLANS AND PROCESS INSTRUCTIONS

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TECHNIKON TEST PLAN

- **Contract Number:** 1411 **TASK NUMBER** 619 **SERIES** GU
- **Site:** Research Foundry
- **Test Type:** Green Sand Baseline Comparison
- **Metal Type:** Class 30 Gray Iron poured at 2680 F
- **Mold Type:** Reference: 4-on Star with seacoal, Comparative: 4-on Sodium Silicate Step Core with seacoal.
- **Number of Molds:** 3 star conditioning, 6 star, 6 step core all same sand, total 15 molds
- **Core Type:** Step Core at 5% (BOS) JBDeVenne Cast Clean® #1 Sodium Silicate binder.
- **Core Coating:** Cores to be uncoated
- **Sample Events:** 6 star, 6 step mold, total 12 runs
- **Test Date(s):** **START:** 12 July 2005

  FINISH: 28 July 2005

TEST OBJECTIVES:

Measure selected PCS HAP & VOC emissions, CO, CO2, NOx, & TGOC.

Use Analyte list A

VARIABLES:

Two patterns will be the 4-on star and the 4-on step core. All molds will be made with Wexford W450 Lake Sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5 % MB Clay, 5% seacoal, and tempered to 40-50% compactability, mechanically compacted. The molds will be maintained at 80-90 deg. F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2680 +/- 10 deg. 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. Cores will be made with Wedron 530 silica sand & 5% (BOS) JB DeVeene KleenKast #1 Sodium Silicate. No emission sampling will be done during core manufacture.

BRIEF OVERVIEW:

The green sand baseline test has previously been reevaluated to reflect improvements in analytic methods and foundry facilities and procedures. The first greensand baseline configuration was 6-on sodium silicate step cores in a 14 cubic foot greensand mold. The most recent was a 6.7 cubic foot 4-on coreless star greensand mold. Despite every effort to maintain the engineering ratios between the two mold configurations that drive emissions differences in the emissions measured did result. This test will attempt to resolve those differences.

The greensand molds will be produced on the mechanically assisted Osborne 716 molding machines and poured at a common pouring temperature of 2680 dsegrees F.

The measured emissions from the step core configuration will be compared to the those from the star as a reference.

SPECIAL CONDITIONS:

The step core configuration will be poured at 2680 degrees F to eliminate temperature as a factor. Historically the step core was poured at 2630 degrees F.

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

Technikon Test Plan

page 1 of 3

Fill-in and check all that apply

♦ CONTRACT NUMBER: 1413 TASK NUMBER 118 DOUBLE ALPHA HV

♦ SITE:	☒ On Site at Research Foundry ☐ Off Site at _____
♦ DATE RANGE:	From Aug. 6, 07 to Aug. 10, 07
♦ TEST OBJECTIVE:	☒ Emissions Testing ☐ Mechanical Properties ☐ Casting Quality ☒ Comparison to GU ☐ Other _____
♦ PROCESSES:	☒ Pouring ☒ Cooling ☒ Shakeout ☐ Mixing ☐ Making ☐ Storage ☐ Other _____
♦ TEST TYPE:	☐ Baseline ☒ Product ☐ Other _____
♦ METAL:	☒ Iron ☐ Aluminum ☐ Steel ☐ Other _____ Alloy _____ Pour Temp: 2630±10°F
♦ RUNS:	Number for Conditioning 3 Duration 75 minutes Number for Testing Samples 9 Duration 75 minutes
♦ PROPERTIES TO BE TESTED:	☐ Mold Strength ☒ Moisture Content ☒ 1800 °F LOI% ☒ 900 °F Volatiles ☐ Release Agent ☐ Binder ☒ Clay ☒ Sand ☐ Activator Other _____
♦ RESULTS TO BE ANALYZED AND REPORTED:	☒ Emissions*: ☒ Select HAPs ☒ Select POMs ☒ Select Criteria Pollutants ☒ Select Greenhouse Gases ☐ Other _____ ☒ Casting Quality: ☐ Coated Cores ☐ One Cavity ☐ All Cavities ☒ Other Coated Mold ☐ Mechanical Properties: ☐ Tensile Strength ☐ Weight Change ☐ Flowability ☐ Compressibility ☐ Other _____ *Select/target analyte list varies per test – the list for this test is available in the emission testing office.
♦ BRIEF OVERVIEW:	*Molds will be coated with Hill & Griffith EZ Kote™ G Plastic PM mold coating for emissions purposes. Emissions results are to be compared with the 2nd part of Test GU, which had sodium silicate cores in a greensand mold containing seacoal. The results will have to be reported in lbs of emissions per ton of metal poured.*
♦ ADDITIONAL COMMENTS:	*It is important to correctly record the weight of the coating added to the mold.*

Technikon Test Plan

page 2 of 3

Fill-in and check all that apply

♦ CONTRACT NUMBER: 1413 TASK NUMBER 118 DOUBLE ALPHA HV

	Cores	Molds	Other
♦ PATTERN:	☒ Step ☐ Other _____ Number 4 Storage Temp: 70-90°F Storage Age: 148 Dimensions: ☐ Other _____	☒ Step ☐ Star ☐ Irregular Gear ☐ Other _____ Number _____ Number Cavities 4 Storage Temp: 70-90°F Storage Age: _____ Dimensions: ☒ Standard (24x24x10/10) ☐ Other _____	☐ Dogbone ☐ Shakeout ☐ Flowability ☐ Other _____ Number _____ Number Cavities _____ Storage Temp: _____°F Storage Age: _____ Dimensions: ☐ Standard (24x24x10/10) ☐ Other _____
♦ BINDER :	☐ Cold box ☐ Warm box ☐ Hot box ☐ No-bake ☐ Shell ☐ Oil ☒ Other Dehydration Concentration 2.0% (BOS) Ratio ($\frac{P1}{P2}$) _____ Product Name(s) Cordis	☐ Cold box ☐ Warm box ☐ Hot box ☐ No-bake ☐ Shell ☐ Oil ☐ Other _____ Concentration _____ (BOS) Ratio ($\frac{P1}{P2}$) _____ Product Name(s) _____	☐ Cold box ☐ Warm box ☐ Hot box ☐ No-bake ☐ Shell ☐ Oil ☐ Other _____ Concentration _____ (BOS) Ratio ($\frac{P1}{P2}$) _____ Product Name(s) _____
♦ CHEMISTRY:	☐ Phenolic Urethane ☒ Low Emission (inc. Sodium Silicate) ☐ Epoxy-Acrylic ☐ Furfural ☐ Alkaline Phenolic Ester ☐ Other _____	☐ Phenolic Urethane ☐ Low Emission (inc. Sodium Silicate) ☐ Epoxy-Acrylic ☐ Furfural ☐ Alkaline Phenolic Ester ☐ Other _____	☐ Phenolic Urethane ☐ Low Emission (inc. Sodium Silicate) ☐ Epoxy-Acrylic ☐ Furfural ☐ Alkaline Phenolic Ester ☐ Other _____
♦ CATALYST:	☐ CO_2 Cured ☐ SO_2 Cured ☐ Acid Cured ☐ TEA Cured ☒ Hot Air Cured ☐ Methyl Formate Cured Concentration _____ BOS Concentration_____ BOR ☐ Other _____	☐ CO_2 Cured ☐ SO_2 Cured ☐ Acid Cured ☐ TEA Cured ☐ Hot Air Cured ☐ Methyl Formate Cured Concentration _____ BOS Concentration_____ BOR ☐ Other _____	☐ CO_2 Cured ☐ SO_2 Cured ☐ Acid Cured ☐ TEA Cured ☐ Hot Air Cured ☐ Methyl Formate Cured Concentration _____ BOS Concentration_____ BOR ☐ Other _____

Technikon Test Plan

Fill-in and check all that apply

♦ CONTRACT NUMBER: 1413 TASK NUMBER 118 DOUBLE ALPHA HV

	Cores	Molds	Other
♦ SAND:	[ ] Greensand [ ] No-Bake [X] Other Blown sand Additives _____ to yield _____ %LOI Product Name(s) Wedron 530	[X] Greensand [ ] No-Bake [ ] Other _____ Additives 7.0±0.5% Western and Southern Bentonite in a 5:2 Ratio to yield _____ %LOI Product Name(s) Wexford 450	[ ] Greensand [ ] No-Bake [ ] Other _____ Additives _____ to yield _____ %LOI Product Name(s) _____
♦ RELEASE AGENT:	Concentration _____ Application Method _____ Product Name(s) _____	Concentration Supplied Application Method Sprayed Product Name(s) Black Diamond	Concentration _____ Application Method _____ Product Name(s) _____
♦ COATING:	[X] None [ ] All Runs [ ] Conditioning Runs Only [ ] Test Runs Only [ ] Baumé _____ [ ] Other _____ Application Method _____ Drying Method _____ Product Name(s) _____	[ ] None [X] All Runs [ ] Conditioning Runs Only [ ] Test Runs Only [ ] Baumé _____ [ ] Other _____ Application Method Spray Drying Method None Product Name(s) H&G EZ Kote G Plastic PM	

This test plan routed to or reviewed by:

- Senior Process Engineer
- Technical Director/Foundry Manager
- Director of Measurement Technologies
- Vice President of Operations
- Applicable Steering Committee Members

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/18/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU007	X									TOTAL
M-18	GU00701		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
OSHA ID200	GU00702		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Excess
NIOSH 1500	GU00703		1						1000	7	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	8	Excess
TO11	GU00704		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: Channel 10 plugged during the run; duplicate for TO11 will be done on GU009. Do not send sample GU00808 for analysis.
7/18/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU008	X									TOTAL
M-18	GU00801		1						30	1	Carbopak charcoal
M-18	GU00802			1					30	2	Carbopak charcoal
	Excess								30	3	Excess
	Excess								30	4	Excess
OSHA ID200	GU00803		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	GU00804			1					1000	6	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	GU00805		1						1000	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GU00806			1					1000	8	100/50 mg Charcoal (SKC 226-01)
TO11	GU00807		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	GU00808			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments: Channel 1 plugged during the run; no M18 FID sample for this run. Do not send sample GU00901 for analysis.
7/18/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU009	X									TOTAL
M-18	GU00901		1						30	1	Carbopak charcoal
M-18 MS	GU00902		1						30	2	Carbopak charcoal
M-18 MS	GU00903			1					30	3	Carbopak charcoal
	Excess								30	4	Excess
OSHA ID200	GU00904		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Excess
NIOSH 1500	GU00905		1						1000	7	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	8	Excess
TO11	GU00906		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	GU00907			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/19/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU010	X									TOTAL
M-18	GU01001		1						30	1	Carbopak charcoal
M-18	GU01002					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
OSHA ID200	GU01003		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Excess
NIOSH 1500	GU01004		1						1000	7	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	8	Excess
TO11	GI01005		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/19/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU011	X									TOTAL
M-18	GU01101		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
OSHA ID200	GU01102		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Excess
NIOSH 1500	GU01103		1						1000	7	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	8	Excess
TO11	GU01104		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

GU - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
7/19/2005											
											Sodium Silicate Cores
THC, CO, CO2 & Nox	GU012	X									TOTAL
M-18	GU01201		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
OSHA ID200	GU01202		1						1000	5	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	6	Excess
NIOSH 1500	GU01203		1						1000	7	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	8	Excess
TO11	GU01204		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/6/2007											
CONDITIONING - 1											
THC, CO, CO2, NOx, CH4	HV CR-1	X									TOTAL

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/6/2007											
CONDITIONING - 2											
THC, CO, CO2, NOx, CH4	HV CR-2	X									TOTAL

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/6/2007											
CONDITIONING - 3											
THC, CO, CO2, NOx, CH4	HV CR-3	X									TOTAL

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/7/2007											
THC, CO, CO2, NOx, CH4	HV001	X									TOTAL
TO-17	HV00101		1						200	1	Carbopak charcoal
TO-17	HV00102				1				0		Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00103		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HV00104				1				0		100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00105		1						1000	8	DNPH Silica Gel (SKC 226-119)
TO-11	HV00106				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess									10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
8/7/2007											
THC, CO, CO2, NOx, CH4	HV002	X									TOTAL
TO-17	HV00201		1						200	1	Carbopak charcoal
TO-17	HV00202			1					200	2	Carbopak charcoal
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00203		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HV00204			1					1000	7	100/50 mg Carbon Bead (SKC 226-80)
TO-11	HV00205		1						1000	8	DNPH Silica Gel (SKC 226-119)
TO-11	HV00206			1					1000	9	DNPH Silica Gel (SKC 226-119)
	Excess		1							10	Blocked
	Excess			1						11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/7/2007											
THC, CO, CO2, NOx, CH4	HV003	X									TOTAL
TO-17	HV00301		1						200	1	Carbopak charcoal
TO-17MS	HV00302		1						200	2	Carbopak charcoal
TO-17MS	HV00303			1					200	3	Carbopak charcoal
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00304		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00305		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
8/8/2007											
THC, CO, CO2, NOx, CH4	HV004	X									TOTAL
TO-17	HV00401		1						200	1	Carbopak charcoal
TO-17	HV00402					1			200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00403		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00404		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/8/2007											
THC, CO, CO2, NOx, CH4	HV005	X									TOTAL
TO-17	HV00501		1						200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00502		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00503		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/8/2007											
THC, CO, CO2, NOx, CH4	HV006	X									TOTAL
TO-17	HV00601		1						200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00602		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00603		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
8/9/2007											
THC, CO, CO2, NOx, CH4	HV007	X									TOTAL
TO-17	HV00701		1						200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00702		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00703		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
8/9/2007											
THC, CO, CO2, NOx, CH4	HV008	X									TOTAL
TO-17	HV00801		1						200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00802		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00803		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HV - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
8/9/2007											
THC, CO, CO2, NOx, CH4	HV009	X									TOTAL
TO-17	HV00901		1						200	1	Carbopak charcoal
	Excess								200	2	Blocked
	Excess								200	3	Blocked
	Excess									4	Blocked
	Excess									5	Blocked
OSHA ID200	HV00902		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
TO-11	HV00903		1						1000	8	DNPH Silica Gel (SKC 226-119)
	Excess								1000	9	Blocked
	Excess		1							10	Blocked
	Excess									11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

Series 1411-6.1.9-GU

Comparison of Sodium Silicate Step Core to Coreless Star Configuration PCS Greensand Baseline Emissions Using Mechanized Molding

Process Instructions

A. Experiment:

1. Measure and compare a selected list of VOC emissions from a sodium silicate Step Core greensand mold to a coreless Star greensand mold. The greensand will contain seacoal. The same sand will be used sequentially to make the Star conditioning runs, Star reference test runs , and Step Core comparative test runs. The molds shall be tempered with potable water to 40-45% compactability and poured at constant temperature. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand.

B. Materials:

1. Mold sand: Virgin mix of Wexford W450 lake sand, western and southern bentonites in ratio of 5:2 to yield 7.0+/-0.5% Bentonite, H & G Seacoal to yield 5.0+/-0.3 % LOI, and potable water per recipe.

2. Core: Uncoated step core made with virgin Wedron 530 silica sand and 5.0% (BOS) JBDeVenne KleenCast #1 Sodium Silicate binder, CO2 activated.

3. Core coating: None

4. Metal: Class-30 gray cast iron poured at 2680 +/- 10°F.

5. Pattern release: Black Diamond, hand wiped.

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. Silicate Cores:

1. Core sand mixing.

a. Clean the core sand mixer.

b. Add 50 pounds of Lake sand to the running mixer.

c. Slowly pour 2.5 +/- .03 pounds of Sodium silicate resin into the sand. Distribute the resin as it is poured. Avoid pouring the resin on the plows or walls of the mixer or in one location or resin balling will occur preventing proper mixing.

- **d.** Mix for three minutes after the resin is all in.
- **e.** One batch will make about 6 cores.

2. Making step cores.

- **a.** Place the core box on a flat surface large open side up.
- **b.** Place about 2 inches of sand in the bottom of the step section. Firmly tamp the sand into the 1inch diameter bottom using a ½ inch diameter rod.
- **c.** Place a few more inches of sand in the core box and compact it. Take care to avoid parting planes. Repeat until the box is full.
- **d.** Scrape off the excess. Remove the unused sand away from the gassing area.
- **e.** Place a gassing plate on the open end of the core box.
- **f.** Hold the plate down and gas the core for 20 seconds on each of the two gas holes with 20 psi CO_2 gas.
- **g.** Dry the cores for two hours at 250°F and allow to cool.
- **h.** Bag the cores in moisture proof bags for storage.
- **i.** Identify each bag by batch number.
- **j.** Record the date, batch number, the batch mix time, sand batch weight, resin weight, the gassing time, the gas pressure, individual dried core weight, good core count from each batch.

E. Sand preparation

1. Start up batch: make 1, GUER1.

- **a.** Thoroughly clean the pre-production muller elevator and molding hoppers.
- **b.** Weigh and add 1230 +/-10 pounds of new Wexford W450 Lakesand, per the recipe, to the running pre-production muller to make a 1300 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 and seacoal slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipes 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 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 the 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 total coal added, the amount of water added, the total mix time, the final compactability and sand temperature at discharge into the mold.

l. The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, 1800°F loss on ignition (LOI), and 900 oF volatiles. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.

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

2. Re-mulling: GUER2

a. Add to the sand recovered from poured mold GUER1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.

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

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

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

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

3. Re-mulling: GUER3, GU001-GU0XX

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. Note: The re-mull recipe will change after GU009.

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.3.a.

F. Molding: Star and Step Core pattern.

1. Pattern preparation:

a. The Star pattern will be used for molds GUER1-GU009.

b. The Step Core pattern will be used for molds GU0010-GU015.

c. Inspect and tighten all loose pattern and gating pieces.

d. Repair any damaged pattern or gating parts.

2. Making the green sand mold.

a. For the Star pattern mount the Cope/Drag pattern on the North Osborne Whisper Ram molding machine.

b. For the Step Core pattern mount the drag pattern on one Osborne Whisper Ram molding machine and mount the cope pattern on the other Osborne machine.

c. Lightly apply parting release to the pattern and rub with an 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 of 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 x4 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. For the Step Core pattern only 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 portion 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 compactabilty 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 no 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.
7. Set the ceramic metal filter
8. Close the cope over the drag being careful not to crush anything.
9. Clamp the flask halves together.
10. Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the uncoated cores, and the sand weight by difference.
11. Measure and record the sand temperature.
12. Deliver the mold to the previously cleaned shakeout to be poured.
13. 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 on top.
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 oF.
f. Slag the furnace and add the balance of the alloys.
g. Raise the temperature of the melt to 2700 oF and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350oF.
h. Hold the furnace at 2500-2550oF until near ready to tap.
i. When ready to tap raise the temperature to 2700oF 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 at the side draft hood only 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 to 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. Cover the ladle to conserve heat.
f. Move the ladle to the pour position and wait until the metal temperature reaches 2680 +/- 10°F.
g. Commence pouring keeping the sprue full.

h. Upon completion return the extra metal to the furnace, and cover the ladle.
i. Record the pour temperature and pour time on the heat log.

Steven M. Knight
Mgr. Process Engineering

1412-1.1.8 HV

PCS Product Test: Mold Coating on Greensand & Mechanized Molding

Process Instructions

A. Experiment:

1. Product emissions measurement from a greensand mold, coated with EZ Kote mold coating, and with hot air cured low emission 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 molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand.

B. Materials:

1. Mold sand:

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

2. Core:

a) Uncoated step core made with virgin Wedron 530 silica sand and 2.0% (BOS) HA International Cordis, hot air cured.

3. Mold coating:

a) Hill & Griffith S – EZ Kote™ G Plastic PM.

4. Metal:

a) Class-30 gray iron poured at 2630 ± 10°F.

5. Pattern release:

a) Black Diamond, hand wiped.

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

C. Briefing:

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

Caution

Observe all safety precautions attendant to these operations as delineated in the Pre-

production operating and safety instruction manual.

D. HA International Cordis® Cores:
- **1.** Klein vibratory core sand mixer.
  - **a)** The binder components should be 75-85°F.
  - **b)** Calibrate the Klein mixer sand batch size.
    - **i)** Calibrate sand.
      - ♦ Turn the AUTO/MAN switch to MANUAL on main control panel.
      - ♦ Zero a container on the scale.
      - ♦ Put the same container below the mixing bowl to catch the sand.
      - ♦ Open a few bags of WEDRON 530 sand into the sand hopper and manually fill batch hopper using max. and min. proximity switches.
      - ♦ Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.
      - ♦ Repeat 3 times to determine the weight variation. The sand should be 75-85°F.
  - **c)** Stir binder for 10 minutes prior to use, and 2 minutes per hour during use.
  - **d)** Pre-weigh 2.0% (BOS) of the binder into a non-absorbing container for addition to the mixer.
  - **e)** Turn on the mixer and turn the AUTO/MAN switch to AUTO.
  - **f)** Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. As soon as the sand enters the mixer chamber pour the pre-weighed binder through the open top front half of the mixing chamber.
  - **g)** Make three (3) batches to start the Redford Carver core machine.
  - **h)** Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.
  - **i)** Clean the mixer bowl when done.

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

- **2.** Redford/Carver core machine.
  - **a)** Mount the Step-Core core box on the Carver/Redford core machine.
  - **b)** Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
  - **c)** Set up the core machine in the warm box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
    - **i)** Core process setup
      - ♦ Set the core box heaters to 300°F

- Set the blow pressure to 50+/-2 psi for 3 seconds (R/C).
- Set the gas time to 0 seconds.
- Set the purge for 180 seconds(R/C).
- Total cycle time approximately 4 minutes.

d) Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. Make five (5) additional 50 pound sand batches and run the sand out making core. A minimum of 60 cores are required.

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

3. OSI Core Drying Oven

a) Set core drying oven set point to 275°F and let the oven heat up.

b) Set the cores in and run the conveyor at 42.

c) Remove and bag the cores.

E. Sand preparation

1. Start up batch: make 1, HVER1.

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

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

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

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

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

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

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

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

i) Discharge the sand into the mold station elevator.

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

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

2. Re-mulling: HVER2

a) Add to the sand recovered from poured mold HVER1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.

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

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

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

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

3. Re-mulling: HVER3, HV001-HV009

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

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

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

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

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

F. Molding:

1. Step core pattern.

a) Pattern preparation:

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

ii) Repair any damaged pattern or gating parts.

2. Making the green sand mold.

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

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

Caution:

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

c) Use the overhead crane to place the pre-weighed drag/cope flask on the mold machine table, parting line surface down.
d) Locate a 24 x 24 x 4 inch deep wood upset on top of the flask.
e) Make the green sand mold cope or drag on the Osborn Whisper Ram Jolt-Squeeze mold machine.

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

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

f) Open the air supply to the mold machine.

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

g) On the operator's panel turn the POWER switch to ON.
h) Turn the RAM-JOLT-SQUEEZE switch to ON.
i) Turn the DRAW UP switch to AUTO.
j) Set the PRE-JOLT timer to 4-5 seconds.
k) Set the squeeze timer to 8 seconds.
l) Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
m) Manually spread one to two inches or so of sand over the pattern using a shovel. Source the sand from the overhead mold sand hopper by actuating the hopper gate valve with the lever located under the operators panel.
n) Fill the center potion of the flask.
o) Manually move sand from the center portion to the outboard areas and hand tuck the sand.
p) Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
q) Grab a sufficient sample of sand to fill a quart zip-lock bag. Label bag with the

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

r) Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.

s) The operator will grab a sand sample for the Lab. The sand technician will quickly measure the sand temperature and compactability and record the results.

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

u) Remove the upset and set it aside.

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

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

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

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

w) Screed the bottom of the drag mold flat to the bottom of the flask if required.

x) Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.

y) Use the overhead crane to lift the mold half and remove it from the machine. If the mold half is a drag, roll it parting line side up, set it on the floor, blow it out.

z) Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.

aa) Dilute the EZ Kote™ G Plastic PM to a Baumé of 40.

bb) Weigh and record the EZ Kote™ G Plastic PM spray system.

cc) Carefully spray the drag side evenly coating all the walls and avoiding spillage.

dd) Weigh and record the EZ Kote™ G Plastic PM spray system.
ee) Let the coating dry.
ff) 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.
gg) Close the cope over the drag being careful not to crush anything.
hh) Clamp the flask halves together.
ii) Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, the uncoated cores, and the sand weight by difference.
jj) Measure and record the sand temperature.
kk) Deliver the mold to the previously cleaned shakeout to be poured.
ll) Cover the mold with the emission hood.

G. 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.

H. Shakeout.

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

a) When the emission sampling is completed remove the flask, with casting, and recover the sand from the hopper and surrounding floor.

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

I. Melting:

1. Initial 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

J. Emptying the furnace.

1. Pig the extra metal only after the last emission measurement is complete to avoid contaminating the air sample.

2. Cover the empty furnace with ceramic blanket to cool.

K. 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.

L. Shot Blasting

1. All castings from emission runs HVER1-HVER3 will be shot blasted for 8 minutes at 12 amps, weighed and the weight recorded, and saved for evaluation.

2. All castings from emission runs HV001-HV009 will be shot blasted for 8 minutes at 12 amps, weighed and the weight recorded, and recycled.

M. 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 emissions runs, with coated molds only.
3. Review the general appearance of the interior of the castings and select specific casting features to compare.
4. For each cavity 3 :
   - **a)** Place each casting initially in sequential mold number order.
   - **b)** Beginning with the casting from mold HV001, compare it to castings from mold HV002.
   - **c)** Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   - **d)** Repeat this procedure with HV001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HV001 and the next casting farther down the line is inferior.
   - **e)** Repeat this comparison to next neighbors for each casting number.
   - **f)** When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
   - **g)** Repeat this comparison until all concur with the ranking order.

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

Thomas J Fennell Jr.
Process Engineer

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APPENDIX B DETAILED EMISSION RESULTS AND QUANTITATION LIMITS

Detailed Emissions Data - Test GU, lb/ton metal

TA	POM	HAP		GU007	GU008	GU009	GU010	GU011	GU012	Average	Standard Deviation
			Test Dates	**18-Jul-05**	**18-Jul-05**	**18-Jul-05**	**19-Jul-05**	**19-Jul-05**	**19-Jul-05**	**–**	**–**
Emission Indicators											
			THC as Propane	1.80E+00	1.71E+00	1.58E+00	1.71E+00	1.59E+00	1.48E+00	1.65E+00	1.15E-01
			Non-Methane Hydrocarbons	NA	NA	NA	NA	NA	NA	NA	NA
			Sum of Target Analytes	NA	2.56E-01	NA	2.32E-01	2.22E-01	2.21E-01	2.33E-01	1.61E-02
			Sum of Target HAPs	NA	2.03E-01	NA	1.89E-01	1.80E-01	1.77E-01	1.88E-01	1.17E-02
			Sum of Target POMs	NA	1.31E-02	NA	1.04E-02	1.01E-02	1.03E-02	1.10E-02	1.43E-03
Selected Target HAPs and POMs											
TA		H	Benzene	I	7.49E-02	I	6.89E-02	6.42E-02	6.12E-02	6.73E-02	6.00E-03
TA		H	Toluene	I	4.55E-02	I	4.16E-02	4.19E-02	4.02E-02	4.23E-02	2.28E-03
TA		H	Xylene, mp-	I	1.99E-02	I	1.76E-02	1.78E-02	1.78E-02	1.83E-02	1.09E-03
TA		H	Xylene, o-	I	1.09E-02	I	1.00E-02	9.90E-03	9.65E-03	1.01E-02	5.25E-04
TA		H	Hexane	I	1.01E-02	I	1.04E-02	9.44E-03	8.22E-03	9.54E-03	9.70E-04
TA		H	Acetaldehyde	7.77E-03	7.49E-03	9.27E-03	9.19E-03	8.08E-03	8.74E-03	8.42E-03	7.51E-04
TA		H	Phenol	I	7.92E-03	I	7.92E-03	6.17E-03	7.04E-03	7.26E-03	8.38E-04
TA	P	H	Naphthalene	I	7.70E-03	I	5.93E-03	6.05E-03	5.84E-03	6.38E-03	8.82E-04
TA		H	Ethylbenzene	I	6.00E-03	I	5.43E-03	5.56E-03	5.54E-03	5.63E-03	2.51E-04
TA		H	Formaldehyde	2.45E-03	2.36E-03	3.94E-03	2.52E-03	2.44E-03	3.63E-03	2.89E-03	7.05E-04
TA		H	Cresol, o-	I	2.72E-03	I	≤PQL	≤PQL	≤PQL	2.59E-03	8.72E-05
TA	P	H	Methylnaphthalene, 2-	I	2.92E-03	I	2.23E-03	2.12E-03	2.32E-03	2.40E-03	3.60E-04
TA	P	H	Methylnaphthalene, 1-	I	1.77E-03	I	1.65E-03	1.38E-03	1.52E-03	1.58E-03	1.65E-04
TA		H	Propionaldehyde (Propanal)	1.01E-03	1.04E-03	1.31E-03	1.12E-03	1.09E-03	1.20E-03	1.13E-03	1.10E-04
TA		H	Styrene	I	1.12E-03	I	1.19E-03	1.00E-03	1.08E-03	1.10E-03	7.96E-05
TA	P	H	Dimethylnaphthalene, 1,3-	I	7.53E-04	I	5.80E-04	5.70E-04	6.54E-04	6.39E-04	8.47E-05
TA	P	H	Acenaphthalene	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Cresol, mp-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Biphenyl	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA

NT= Not Tested,
NA= Not Applicable
I=Invalidated Data
≤PQL=equal to or less than the Practical Quantitation Limits

Detailed Emissions Data - Test GU, lb/ton metal *(continued)*

TA	POM	HAP		GU007	GU008	GU009	GU010	GU011	GU012	Average	Standard Deviation
			Test Dates	**18-Jul-05**	**18-Jul-05**	**18-Jul-05**	**19-Jul-05**	**19-Jul-05**	**19-Jul-05**	**–**	**–**
Additional Selected Target Analytes											
TA			Heptane	I	8.60E-03	I	8.70E-03	9.00E-03	6.94E-03	8.31E-03	9.29E-04
TA			Octane	I	8.36E-03	I	8.30E-03	7.80E-03	6.86E-03	7.83E-03	6.94E-04
TA			Nonane	I	6.32E-03	I	6.16E-03	5.92E-03	5.26E-03	5.92E-03	4.66E-04
TA			Decane	I	5.37E-03	I	5.00E-03	4.68E-03	4.31E-03	4.84E-03	4.52E-04
TA			Undecane	I	5.13E-03	I	4.11E-03	4.05E-03	4.04E-03	4.33E-03	5.35E-04
TA			Ethyltoluene, 3-	I	3.84E-03	I	3.34E-03	3.34E-03	3.41E-03	3.48E-03	2.41E-04
TA			Trimethylbenzene, 1,2,4-	I	6.56E-03	I	≤PQL	≤PQL	5.91E-03	3.37E-03	3.32E-03
TA			Cyclohexane	I	2.70E-03	I	≤PQL	≤PQL	≤PQL	2.58E-03	7.87E-05
TA			2-Butanone (MEK)	1.78E-03	1.65E-03	2.12E-03	1.74E-03	1.82E-03	1.93E-03	1.84E-03	1.67E-04
TA			Ethyltoluene, 2-	I	2.21E-03	I	≤PQL	≤PQL	≤PQL	9.34E-04	8.50E-04
TA			Butyraldehyde/Methacrolein	5.43E-04	5.64E-04	7.33E-04	5.97E-04	5.97E-04	6.68E-04	6.17E-04	7.10E-05
TA			o,m,p-Tolualdehyde	7.30E-04	5.03E-04	6.74E-04	≤PQL	4.79E-04	5.79E-04	5.72E-04	1.10E-04
TA			Pentanal (Valeraldehyde)	3.14E-04	3.24E-04	4.55E-04	3.36E-04	3.50E-04	3.93E-04	3.62E-04	5.33E-05
TA			Benzaldehyde	2.68E-04	2.85E-04	4.11E-04	3.27E-04	2.79E-04	2.92E-04	3.10E-04	5.33E-05
TA			Hexaldehyde	2.74E-04	2.94E-04	3.70E-04	2.67E-04	2.72E-04	3.14E-04	2.99E-04	3.92E-05
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Propylbenzene, n-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tetradecane	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,2,3-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylbenzene, 1,3,5-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,3-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,6-	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indan	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	I	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutals and Greenhouse Gases											
			Carbon Dioxide	7.02E+00	7.18E+00	1.06E+01	7.23E+00	8.00E+00	1.04E+01	8.40E+00	1.66E+00
			Carbon Monoxide	5.76E+00	5.77E+00	4.72E+00	6.50E+00	6.07E+00	4.78E+00	5.60E+00	7.12E-01
			Sulfur Dioxide	1.14E-02	1.11E-02	1.10E-02	1.16E-02	1.19E-02	1.21E-02	1.15E-02	4.43E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

NT= Not Tested,
NA= Not Applicable
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≤PQL=equal to or less than the Practical Quantitation Limits

Practical Reporting Limits, Test GU Step Core, lb/ton metal

Analyte	lb/tnmetal	Analyte	lb/tnmetal
2-Butanone (MEK)	1.74E-04	Formaldehyde	1.74E-04
Acenaphthalene	2.54E-03	Heptane	2.54E-03
Acetaldehyde	1.74E-04	Hexaldehyde	1.74E-04
Acrolein	1.74E-04	Hexane	5.09E-04
Benzaldehyde	1.74E-04	Indan	2.54E-03
Benzene	5.09E-04	Indene	2.54E-03
Biphenyl	2.54E-03	Methylnaphthalene, 1-	5.09E-04
Butyraldehyde/Methacrolein	2.90E-04	Methylnaphthalene, 2-	5.09E-04
Carbon Dioxide	7.17E-02	Naphthalene	5.09E-04
Carbon Monoxide	4.56E-02	Nitrogen Oxides	4.89E-02
Cresol, mp-	2.54E-03	Nonane	2.54E-03
Cresol, o-	2.54E-03	o,m,p-Tolualdehyde	4.65E-04
Crotonaldehyde	1.74E-04	Octane	2.54E-03
Cyclohexane	2.54E-03	Pentanal (Valeraldehyde)	1.74E-04
Decane	2.54E-03	Phenol	2.54E-03
Diethylbenzene, 1,3-	2.54E-03	Propionaldehyde (Propanal)	1.74E-04
Dimethylnaphthalene, 1,2-	2.54E-03	Propylbenzene, n-	2.54E-03
Dimethylnaphthalene, 1,3-	5.09E-04	Styrene	5.09E-04
Dimethylnaphthalene, 1,5-	2.54E-03	Sulfur Dioxide	2.23E-03
Dimethylnaphthalene, 1,6-	2.54E-03	Tetradecane	2.54E-03
Dimethylnaphthalene, 1,8-	2.54E-03	THC as Propane	7.17E-02
Dimethylnaphthalene, 2,3-	2.54E-03	Toluene	5.09E-04
Dimethylnaphthalene, 2,6-	2.54E-03	Trimethylbenzene, 1,2,3-	5.09E-04
Dimethylnaphthalene, 2,7-	2.54E-03	Trimethylbenzene, 1,2,4-	5.09E-04
Dimethylphenol, 2,4-	2.54E-03	Trimethylbenzene, 1,3,5-	5.09E-04
Dimethylphenol, 2,6-	2.54E-03	Trimethylnaphthalene, 2,3,5-	2.54E-03
Dodecane	2.54E-03	Undecane	5.09E-04
Ethylbenzene	5.09E-04	Xylene, mp-	5.09E-04
Ethyltoluene, 2-	5.09E-04	Xylene, o-	5.09E-04
Ethyltoluene, 3-	2.54E-03		

Detailed Emissions Data - Test HV, lb/ton metal

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
Emission Indicators														
			THC as Propane	1.90E-01	1.79E-01	1.92E-01	1.65E-01	1.96E-01	I	1.64E-01	1.79E-01	1.89E-01	1.82E-01	1.22E-02
			Non-Methane Hydrocarbons	1.90E-01	1.79E-01	1.92E-01	1.65E-01	1.96E-01	I	1.64E-01	1.79E-01	1.89E-01	1.82E-01	1.22E-02
			Sum of Target Analytes	2.51E-02	2.95E-02	3.23E-02	2.76E-02	3.10E-02	3.07E-02	2.92E-02	3.12E-02	3.17E-02	3.02E-02	2.27E-03
			Sum of Target HAPs	2.09E-02	2.30E-02	2.55E-02	2.14E-02	2.47E-02	2.49E-02	2.35E-02	2.50E-02	2.54E-02	2.39E-02	1.72E-03
			Sum of Target POMs	1.85E-03	1.51E-03	1.47E-03	1.11E-03	1.02E-03	8.76E-04	7.17E-04	6.83E-04	8.52E-04	1.12E-03	4.05E-04
Selected Target HAPs and POMs														
TA		H	Benzene	4.47E-03	5.87E-03	7.48E-03	5.67E-03	6.65E-03	6.57E-03	6.56E-03	6.77E-03	6.81E-03	6.32E-03	8.72E-04
TA		H	Acetaldehyde	5.13E-03	5.20E-03	5.55E-03	5.21E-03	5.70E-03	5.79E-03	5.80E-03	6.22E-03	5.94E-03	5.62E-03	3.73E-04
TA		H	Toluene	1.94E-03	2.44E-03	2.75E-03	2.51E-03	3.07E-03	2.87E-03	2.97E-03	3.01E-03	2.92E-03	2.72E-03	3.65E-04
TA		H	Xylene, mp-	1.52E-03	1.98E-03	2.06E-03	1.85E-03	2.65E-03	2.21E-03	2.23E-03	2.39E-03	2.31E-03	2.13E-03	3.27E-04
TA		H	Formaldehyde	1.66E-03	1.51E-03	1.72E-03	1.40E-03	1.37E-03	1.58E-03	1.32E-03	1.39E-03	2.05E-03	1.56E-03	2.30E-04
TA		H	Phenol	1.91E-03	1.45E-03	1.21E-03	9.84E-04	8.29E-04	1.60E-03	6.95E-04	7.56E-04	1.03E-03	1.16E-03	4.14E-04
TA	P	H	Naphthalene	1.65E-03	1.18E-03	1.16E-03	9.41E-04	7.67E-04	6.36E-04	4.68E-04	4.44E-04	5.65E-04	8.68E-04	4.03E-04
TA		H	Xylene, o-	4.96E-04	6.23E-04	6.67E-04	5.97E-04	8.64E-04	7.25E-04	7.33E-04	7.71E-04	7.59E-04	6.93E-04	1.10E-04
TA		H	Propionaldehyde (Propanal)	4.95E-04	5.25E-04	5.67E-04	5.22E-04	5.70E-04	6.30E-04	5.98E-04	6.27E-04	6.41E-04	5.75E-04	5.28E-05
TA		H	Hexane	5.37E-04	5.26E-04	5.80E-04	3.48E-04	4.56E-04	6.32E-04	4.48E-04	6.68E-04	4.06E-04	5.11E-04	1.06E-04
TA		H	Ethylbenzene	3.46E-04	4.22E-04	4.42E-04	4.08E-04	5.39E-04	4.50E-04	4.64E-04	5.38E-04	4.75E-04	4.54E-04	6.11E-05
TA		H	Cresol, mp-	I	2.70E-04	2.67E-04	2.51E-04	2.82E-04	3.30E-04	3.09E-04	4.44E-04	4.48E-04	3.25E-04	7.87E-05
TA		H	Styrene	3.12E-04	3.32E-04	3.83E-04	2.73E-04	3.03E-04	2.46E-04	2.31E-04	2.71E-04	3.47E-04	3.00E-04	4.94E-05
TA		H	Isopropylbenzene	I	1.55E-04	1.76E-04	1.79E-04	1.97E-04	1.71E-04	1.69E-04	1.80E-04	1.69E-04	1.75E-04	1.21E-05
TA	P	H	Methylnaphthalene, 2-	9.87E-05	1.89E-04	1.85E-04	8.65E-05	1.65E-04	1.44E-04	1.48E-04	1.58E-04	1.71E-04	1.50E-04	3.57E-05
TA		H	Cresol, o-	1.30E-04	≤PQL	≤PQL	≤PQL	1.42E-04	1.11E-04	1.33E-04	1.38E-04	1.44E-04	1.10E-04	3.55E-05
TA	P	H	Methylnaphthalene, 1-	1.04E-04	1.42E-04	1.25E-04	8.22E-05	8.61E-05	9.63E-05	1.01E-04	8.06E-05	1.17E-04	1.04E-04	2.08E-05
TA		H	Biphenyl	8.26E-05	1.23E-04	1.18E-04	≤PQL	1.05E-04	8.30E-05	8.45E-05	9.98E-05	1.20E-04	9.79E-05	2.05E-05
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Anthracene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/ton metal *(continued)*

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes														
TA			Heptane	8.03E-04	9.50E-04	1.08E-03	7.52E-04	1.41E-03	1.05E-03	1.25E-03	1.36E-03	1.11E-03	1.08E-03	2.29E-04
TA			Trimethylbenzene, 1,2,4-	I	1.03E-03	9.50E-04	9.35E-04	I	9.41E-04	8.77E-04	9.67E-04	9.68E-04	9.53E-04	4.67E-05
TA			Octane	6.46E-04	7.63E-04	6.67E-04	6.26E-04	7.77E-04	8.18E-04	6.66E-04	6.96E-04	6.72E-04	7.03E-04	6.62E-05
TA			Trimethylbenzene, 1,2,3-	I	7.20E-04	4.92E-04	7.06E-04	5.52E-04	3.30E-04	2.48E-04	2.65E-04	2.77E-04	4.49E-04	1.96E-04
TA			Ethyltoluene, 3-	3.98E-04	I	4.27E-04	3.78E-04	5.11E-04	4.44E-04	4.36E-04	4.79E-04	4.60E-04	4.41E-04	4.26E-05
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	3.85E-04	≤PQL	3.65E-04	3.90E-04	3.76E-04	3.91E-04	4.19E-04	3.72E-04	2.71E-05
TA			Diethylbenzene, 1,3-	I	5.40E-04	4.11E-04	5.14E-04	4.30E-04	2.84E-04	2.03E-04	2.18E-04	2.37E-04	3.55E-04	1.36E-04
TA			Tetradecane	3.05E-04	3.49E-04	3.46E-04	2.31E-04	3.08E-04	2.36E-04	2.69E-04	3.06E-04	3.29E-04	2.98E-04	4.36E-05
TA			Indan	6.91E-04	4.14E-04	3.24E-04	4.04E-04	2.81E-04	1.74E-04	9.99E-05	1.06E-04	1.16E-04	2.90E-04	1.95E-04
TA			Ethyltoluene, 4-	2.41E-04	3.23E-04	2.89E-04	2.15E-04	3.31E-04	2.71E-04	2.61E-04	2.90E-04	2.59E-04	2.76E-04	3.71E-05
TA			2-Butanone (MEK)	2.55E-04	2.66E-04	2.67E-04	2.13E-04	2.47E-04	2.95E-04	2.44E-04	3.13E-04	3.53E-04	2.73E-04	4.17E-05
TA			Ethyltoluene, 2-	2.39E-04	2.49E-04	2.36E-04	2.29E-04	2.65E-04	2.24E-04	2.19E-04	2.36E-04	2.35E-04	2.37E-04	1.36E-05
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	3.21E-04	2.69E-04	3.69E-04	≤PQL	2.98E-04	3.34E-04	3.17E-04	2.34E-04	1.30E-04
TA			Propylbenzene, n-	1.25E-04	2.86E-04	4.18E-04	1.43E-04	1.55E-04	1.93E-04	1.25E-04	1.51E-04	4.03E-04	2.22E-04	1.18E-04
TA			Diethylbenzene, 1,2-	I	1.36E-04	1.06E-04	1.23E-04	1.22E-04	8.11E-05	≤PQL	≤PQL	≤PQL	9.51E-05	2.99E-05
TA			Isobutylbenzene	1.43E-04	9.46E-05	8.44E-05	8.68E-05	9.51E-05	7.34E-05	1.03E-04	1.06E-04	6.51E-05	9.46E-05	2.23E-05
TA			Butylbenzene, tert-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cymene, p-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			alpha-Methylstyrene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/ton metal *(continued)*

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, sec-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diisopropylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tridecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,4,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Monoxide	2.73E+00	2.28E+00	2.67E+00	2.48E+00	2.49E+00	I	2.56E+00	2.58E+00	2.88E+00	2.58E+00	1.81E-01
			Carbon Dioxide	2.81E+00	2.22E+00	2.59E+00	2.12E+00	2.78E+00	I	1.93E+00	2.23E+00	3.30E+00	2.50E+00	4.52E-01
			Sulfur Dioxide	8.73E-03	5.93E-03	7.26E-03	6.98E-03	6.27E-03	7.82E-03	6.34E-03	6.42E-03	I	6.97E-03	9.40E-04
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA
			Methane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/lb binder

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
Emission Indicators														
			THC as Propane	1.82E-02	2.01E-02	2.16E-02	1.84E-02	2.19E-02	I	1.82E-02	2.03E-02	2.12E-02	2.00E-02	1.53E-03
			Non-Methane Hydrocarbons	1.63E-02	1.72E-02	1.82E-02	1.61E-02	1.87E-02	I	1.53E-02	1.72E-02	1.80E-02	1.71E-02	1.16E-03
			Sum of Target Analytes	2.38E-03	3.27E-03	3.62E-03	3.03E-03	3.46E-03	3.52E-03	3.24E-03	3.54E-03	3.56E-03	3.34E-03	3.90E-04
			Sum of Target HAPs	2.01E-03	2.58E-03	2.86E-03	2.38E-03	2.76E-03	2.86E-03	2.61E-03	2.83E-03	2.86E-03	2.64E-03	2.88E-04
			Sum of Target POMs	1.79E-04	1.70E-04	1.65E-04	1.24E-04	1.14E-04	1.01E-04	7.98E-05	7.74E-05	9.58E-05	1.23E-04	3.93E-05
Selected Target HAPs and POMs														
TA		H	Benzene	4.30E-04	6.59E-04	8.41E-04	6.32E-04	7.42E-04	7.55E-04	7.31E-04	7.68E-04	7.65E-04	7.03E-04	1.19E-04
TA		H	Acetaldehyde	4.94E-04	5.84E-04	6.24E-04	5.81E-04	6.36E-04	6.65E-04	6.46E-04	7.05E-04	6.67E-04	6.22E-04	6.24E-05
TA		H	Toluene	1.87E-04	2.74E-04	3.09E-04	2.80E-04	3.43E-04	3.29E-04	3.30E-04	3.41E-04	3.28E-04	3.03E-04	5.02E-05
TA		H	Xylene, mp-	1.47E-04	2.22E-04	2.32E-04	2.07E-04	2.96E-04	2.54E-04	2.48E-04	2.71E-04	2.59E-04	2.37E-04	4.31E-05
TA		H	Formaldehyde	1.60E-04	1.69E-04	1.93E-04	1.56E-04	1.53E-04	1.82E-04	1.47E-04	1.58E-04	2.30E-04	1.72E-04	2.63E-05
TA		H	Phenol	1.84E-04	1.63E-04	1.36E-04	1.10E-04	9.25E-05	1.83E-04	7.74E-05	8.57E-05	1.16E-04	1.27E-04	4.11E-05
TA	P	H	Naphthalene	1.59E-04	1.33E-04	1.30E-04	1.05E-04	8.57E-05	7.30E-05	5.20E-05	5.04E-05	6.35E-05	9.46E-05	3.92E-05
TA		H	Xylene, o-	4.77E-05	6.99E-05	7.50E-05	6.65E-05	9.65E-05	8.32E-05	8.16E-05	8.75E-05	8.53E-05	7.70E-05	1.43E-05
TA		H	Propionaldehyde (Propanal)	4.77E-05	5.90E-05	6.38E-05	5.82E-05	6.36E-05	7.23E-05	6.65E-05	7.11E-05	7.20E-05	6.38E-05	8.03E-06
TA		H	Hexane	5.17E-05	5.91E-05	6.51E-05	3.88E-05	5.09E-05	7.26E-05	4.99E-05	7.57E-05	4.57E-05	5.66E-05	1.24E-05
TA		H	Ethylbenzene	3.33E-05	4.74E-05	4.97E-05	4.55E-05	6.02E-05	5.17E-05	5.17E-05	6.11E-05	5.34E-05	5.05E-05	8.28E-06
TA		H	Cresol, mp-	I	3.03E-05	3.00E-05	2.80E-05	3.15E-05	3.79E-05	3.44E-05	5.04E-05	5.04E-05	3.66E-05	9.01E-06
TA		H	Styrene	3.01E-05	3.73E-05	4.31E-05	3.05E-05	3.39E-05	2.83E-05	2.57E-05	3.08E-05	3.89E-05	3.32E-05	5.61E-06
TA		H	Isopropylbenzene	I	1.74E-05	1.98E-05	2.00E-05	2.21E-05	1.96E-05	1.88E-05	2.04E-05	1.90E-05	1.96E-05	1.34E-06
TA	P	H	Methylnaphthalene, 2-	9.50E-06	2.12E-05	2.08E-05	9.65E-06	1.84E-05	1.66E-05	1.65E-05	1.79E-05	1.92E-05	1.66E-05	4.33E-06
TA	P	H	Methylnaphthalene, 1-	1.00E-05	1.59E-05	1.40E-05	9.17E-06	9.61E-06	1.11E-05	1.12E-05	9.14E-06	1.31E-05	1.15E-05	2.39E-06
TA		H	Biphenyl	7.95E-06	1.38E-05	1.33E-05	≤PQL	1.17E-05	9.53E-06	9.41E-06	1.13E-05	1.35E-05	1.01E-05	4.12E-06
TA		H	Cresol, o-	1.25E-05	≤PQL	≤PQL	≤PQL	1.59E-05	1.28E-05	1.48E-05	1.57E-05	1.61E-05	9.94E-06	7.13E-06
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Anthracene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

NT= Not Tested,
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Detailed Emissions Data - Test HV, lb/lb binder *(continued)*

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes														
TA			Heptane	7.73E-05	1.07E-04	1.22E-04	8.39E-05	1.57E-04	1.20E-04	1.39E-04	1.55E-04	1.24E-04	1.21E-04	2.80E-05
TA			Trimethylbenzene, 1,2,4-	I	1.16E-04	1.07E-04	1.04E-04	I	1.08E-04	9.77E-05	1.10E-04	1.09E-04	1.07E-04	5.58E-06
TA			Octane	6.21E-05	8.57E-05	7.50E-05	6.99E-05	8.68E-05	9.39E-05	7.41E-05	7.89E-05	7.55E-05	7.80E-05	9.60E-06
TA			Trimethylbenzene, 1,2,3-	I	8.08E-05	5.53E-05	7.87E-05	6.17E-05	3.79E-05	2.76E-05	3.01E-05	3.11E-05	5.04E-05	2.18E-05
TA			Ethyltoluene, 3-	3.83E-05	I	4.80E-05	4.21E-05	5.70E-05	5.10E-05	4.85E-05	5.43E-05	5.17E-05	4.89E-05	6.17E-06
TA			Diethylbenzene, 1,3-	I	6.06E-05	4.62E-05	5.73E-05	4.81E-05	3.26E-05	2.26E-05	2.47E-05	2.66E-05	3.99E-05	1.51E-05
TA			Tetradecane	2.93E-05	3.92E-05	3.89E-05	2.58E-05	3.44E-05	2.71E-05	2.99E-05	3.47E-05	3.69E-05	3.29E-05	5.04E-06
TA			Indan	6.65E-05	4.65E-05	3.64E-05	4.51E-05	3.14E-05	1.99E-05	1.11E-05	1.20E-05	1.31E-05	3.13E-05	1.91E-05
TA			Ethyltoluene, 4-	2.32E-05	3.63E-05	3.25E-05	2.40E-05	3.69E-05	3.11E-05	2.90E-05	3.29E-05	2.91E-05	3.06E-05	4.80E-06
TA			2-Butanone (MEK)	2.45E-05	2.99E-05	3.00E-05	2.38E-05	2.76E-05	3.39E-05	2.72E-05	3.55E-05	3.96E-05	3.02E-05	5.24E-06
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	4.32E-05	≤PQL	4.08E-05	4.48E-05	4.18E-05	4.43E-05	4.70E-05	3.02E-05	2.03E-05
TA			Ethyltoluene, 2-	2.30E-05	2.80E-05	2.65E-05	2.56E-05	2.96E-05	2.57E-05	2.43E-05	2.68E-05	2.64E-05	2.62E-05	1.92E-06
TA			Propylbenzene, n-	1.20E-05	3.21E-05	4.69E-05	1.60E-05	1.73E-05	2.21E-05	1.39E-05	1.71E-05	4.53E-05	2.47E-05	1.35E-05
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	3.61E-05	3.00E-05	4.12E-05	≤PQL	3.32E-05	3.79E-05	3.56E-05	2.40E-05	1.78E-05
TA			Isobutylbenzene	1.37E-05	1.06E-05	9.49E-06	9.68E-06	1.06E-05	8.43E-06	1.14E-05	1.20E-05	7.32E-06	1.04E-05	1.93E-06
TA			Diethylbenzene, 1,2-	I	1.52E-05	1.19E-05	1.37E-05	1.36E-05	9.32E-06	≤PQL	≤PQL	≤PQL	8.19E-06	6.52E-06
TA			Butylbenzene, tert-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cymene, p-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			alpha-Methylstyrene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, sec-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/lb binder

(continued)

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diisopropylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tridecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,4,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Monoxide	2.62E-01	2.56E-01	3.00E-01	2.77E-01	2.78E-01	I	2.85E-01	2.93E-01	3.24E-01	2.84E-01	2.16E-02
			Carbon Dioxide	2.70E-01	2.49E-01	2.92E-01	2.37E-01	3.10E-01	I	2.15E-01	2.53E-01	3.70E-01	2.75E-01	4.91E-02
			Methane	1.91E-03	2.92E-03	3.35E-03	2.28E-03	3.24E-03	I	2.96E-03	3.17E-03	3.21E-03	2.88E-03	5.15E-04
			Sulfur Dioxide	8.40E-04	6.66E-04	8.16E-04	7.78E-04	7.00E-04	8.98E-04	7.06E-04	7.28E-04	I	7.67E-04	8.03E-05
			Nitrogen Oxides	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/lb Coating

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
Emission Indicators														
			THC as Propane	3.23E-02	5.24E-02	5.69E-02	4.89E-02	4.66E-02	I	3.87E-02	4.24E-02	4.53E-02	4.54E-02	7.74E-03
			Non-Methane Hydrocarbons	2.90E-02	4.47E-02	4.81E-02	4.29E-02	3.97E-02	NA	3.24E-02	3.58E-02	3.85E-02	3.89E-02	6.39E-03
			Sum of Target Analytes	4.22E-03	8.51E-03	9.57E-03	8.06E-03	7.34E-03	7.44E-03	6.88E-03	7.37E-03	7.59E-03	7.55E-03	1.45E-03
			Sum of Target HAPs	3.56E-03	6.71E-03	7.55E-03	6.32E-03	5.87E-03	6.03E-03	5.54E-03	5.90E-03	6.10E-03	5.97E-03	1.07E-03
			Sum of Target POMs	3.17E-04	4.43E-04	4.36E-04	3.29E-04	2.42E-04	2.12E-04	1.69E-04	1.61E-04	2.05E-04	2.79E-04	1.08E-04
Selected Target HAPs and POMs														
TA		H	Benzene	7.62E-04	1.72E-03	2.22E-03	1.68E-03	1.58E-03	1.59E-03	1.55E-03	1.60E-03	1.64E-03	1.59E-03	3.72E-04
TA		H	Acetaldehyde	8.75E-04	1.52E-03	1.65E-03	1.55E-03	1.35E-03	1.40E-03	1.37E-03	1.47E-03	1.43E-03	1.40E-03	2.18E-04
TA		H	Toluene	3.31E-04	7.13E-04	8.16E-04	7.44E-04	7.29E-04	6.96E-04	7.01E-04	7.12E-04	7.01E-04	6.83E-04	1.37E-04
TA		H	Xylene, mp-	2.60E-04	5.79E-04	6.11E-04	5.50E-04	6.28E-04	5.36E-04	5.26E-04	5.65E-04	5.54E-04	5.34E-04	1.08E-04
TA		H	Formaldehyde	2.83E-04	4.41E-04	5.11E-04	4.15E-04	3.24E-04	3.84E-04	3.11E-04	3.30E-04	4.91E-04	3.88E-04	8.19E-05
TA		H	Phenol	3.25E-04	4.25E-04	3.58E-04	2.92E-04	1.97E-04	3.87E-04	1.64E-04	1.79E-04	2.48E-04	2.86E-04	9.49E-05
TA	P	H	Naphthalene	2.82E-04	3.46E-04	3.44E-04	2.79E-04	1.82E-04	1.54E-04	1.10E-04	1.05E-04	1.36E-04	2.15E-04	9.79E-05
TA		H	Xylene, o-	8.46E-05	1.82E-04	1.98E-04	1.77E-04	2.05E-04	1.76E-04	1.73E-04	1.82E-04	1.82E-04	1.73E-04	3.49E-05
TA		H	Propionaldehyde (Propanal)	8.45E-05	1.54E-04	1.68E-04	1.55E-04	1.35E-04	1.53E-04	1.41E-04	1.48E-04	1.54E-04	1.44E-04	2.40E-05
TA		H	Hexane	9.16E-05	1.54E-04	1.72E-04	1.03E-04	1.08E-04	1.53E-04	1.06E-04	1.58E-04	9.75E-05	1.27E-04	3.14E-05
TA		H	Ethylbenzene	5.91E-05	1.23E-04	1.31E-04	1.21E-04	1.28E-04	1.09E-04	1.10E-04	1.27E-04	1.14E-04	1.14E-04	2.20E-05
TA		H	Cresol, mp-	I	7.90E-05	7.91E-05	7.44E-05	6.69E-05	8.01E-05	7.30E-05	1.05E-04	1.08E-04	8.31E-05	1.49E-05
TA		H	Styrene	5.33E-05	9.73E-05	1.14E-04	8.10E-05	7.19E-05	5.97E-05	5.45E-05	6.41E-05	8.32E-05	7.54E-05	2.05E-05
TA		H	Isopropylbenzene	I	4.55E-05	5.21E-05	5.32E-05	4.68E-05	4.14E-05	3.98E-05	4.25E-05	4.05E-05	4.52E-05	5.17E-06
TA	P	H	Methylnaphthalene, 2-	1.68E-05	5.53E-05	5.50E-05	2.57E-05	3.92E-05	3.50E-05	3.50E-05	3.74E-05	4.09E-05	3.78E-05	1.23E-05
TA	P	H	Methylnaphthalene, 1-	1.78E-05	4.15E-05	3.71E-05	2.44E-05	2.04E-05	2.33E-05	2.38E-05	1.91E-05	2.80E-05	2.62E-05	8.13E-06
TA		H	Biphenyl	1.41E-05	3.59E-05	3.50E-05	≤PQL	2.49E-05	2.01E-05	2.00E-05	2.36E-05	2.89E-05	2.26E-05	1.09E-05
TA		H	Cresol, o-	2.21E-05	≤PQL	≤PQL	≤PQL	3.37E-05	2.70E-05	3.14E-05	3.27E-05	3.45E-05	2.04E-05	1.53E-05
TA	P	H	Acenaphthalene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Anthracene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,2-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 1,8-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA	P	H	Dimethylnaphthalene, 2,7-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/lb Coating *(continued)*

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA	P	H	Trimethylnaphthalene, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA		H	Acrolein	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Additional Selected Target Analytes														
TA			Heptane	1.37E-04	2.78E-04	3.21E-04	2.23E-04	3.34E-04	2.54E-04	2.95E-04	3.22E-04	2.65E-04	2.70E-04	6.14E-05
TA			Trimethylbenzene, 1,2,4-	I	3.02E-04	2.82E-04	2.77E-04	I	2.28E-04	2.07E-04	2.29E-04	2.32E-04	2.51E-04	3.55E-05
TA			Octane	1.10E-04	2.23E-04	1.98E-04	1.86E-04	1.84E-04	1.98E-04	1.57E-04	1.65E-04	1.61E-04	1.76E-04	3.24E-05
TA			Trimethylbenzene, 1,2,3-	I	2.10E-04	1.46E-04	2.09E-04	1.31E-04	8.01E-05	5.84E-05	6.27E-05	6.65E-05	1.21E-04	6.38E-05
TA			Ethyltoluene, 3-	6.79E-05	I	1.27E-04	1.12E-04	1.21E-04	1.08E-04	1.03E-04	1.13E-04	1.10E-04	1.08E-04	1.77E-05
TA			Diethylbenzene, 1,3-	I	1.58E-04	1.22E-04	1.52E-04	1.02E-04	6.89E-05	4.80E-05	5.15E-05	5.69E-05	9.50E-05	4.52E-05
TA			Tetradecane	5.20E-05	1.02E-04	1.03E-04	6.86E-05	7.30E-05	5.72E-05	6.34E-05	7.23E-05	7.89E-05	7.45E-05	1.78E-05
TA			Indan	1.18E-04	1.21E-04	9.62E-05	1.20E-04	6.67E-05	4.21E-05	2.36E-05	2.50E-05	2.79E-05	7.12E-05	4.30E-05
TA			Ethyltoluene, 4-	4.12E-05	9.46E-05	8.57E-05	6.39E-05	7.85E-05	6.57E-05	6.15E-05	6.86E-05	6.22E-05	6.91E-05	1.56E-05
TA			2-Butanone (MEK)	4.35E-05	7.79E-05	7.92E-05	6.33E-05	5.87E-05	7.15E-05	5.76E-05	7.41E-05	8.46E-05	6.78E-05	1.31E-05
TA			Butyraldehyde/Methacrolein	≤PQL	≤PQL	1.14E-04	≤PQL	8.66E-05	9.47E-05	8.86E-05	9.24E-05	1.00E-04	6.52E-05	4.71E-05
TA			Ethyltoluene, 2-	4.07E-05	7.30E-05	7.00E-05	6.80E-05	6.28E-05	5.43E-05	5.16E-05	5.58E-05	5.64E-05	5.92E-05	1.02E-05
TA			Propylbenzene, n-	2.13E-05	8.37E-05	1.24E-04	4.25E-05	3.67E-05	4.67E-05	2.95E-05	3.56E-05	9.68E-05	5.74E-05	3.53E-05
TA			Trimethylbenzene, 1,3,5-	≤PQL	≤PQL	9.52E-05	7.99E-05	8.76E-05	≤PQL	7.04E-05	7.89E-05	7.60E-05	5.44E-05	4.10E-05
TA			Isobutylbenzene	2.43E-05	2.77E-05	2.51E-05	2.58E-05	2.25E-05	1.78E-05	2.43E-05	2.51E-05	1.56E-05	2.31E-05	3.92E-06
TA			Diethylbenzene, 1,2-	I	3.97E-05	3.14E-05	3.65E-05	2.89E-05	1.97E-05	≤PQL	≤PQL	≤PQL	1.97E-05	1.69E-05
TA			Butylbenzene, tert-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Crotonaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cymene, p-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Hexaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Nonane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			o,m,p-Tolualdehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Pentanal (Valeraldehyde)	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Undecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			alpha-Methylstyrene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Benzaldehyde	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, n-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Butylbenzene, sec-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Cyclohexane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA

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Detailed Emissions Data - Test HV, lb/lb Coating *(continued)*

TA	POM	HAP		HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	Average	Standard Deviation
			Test Dates	07-Aug-07	07-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	09-Aug-07	09-Aug-07	09-Aug-07	–	–
TA			Decane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diethylbenzene, 1,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Diisopropylbenzene, 1,3-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 2,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dimethylphenol, 3,4-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Dodecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Indene	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Tridecane	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,3,5-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
TA			Trimethylphenol, 2,4,6-	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	≤PQL	NA
Selected Criteria Pollutants and Greenhouse Gases														
			Carbon Monoxide	4.65E-01	6.66E-01	7.93E-01	7.36E-01	5.91E-01	I	6.04E-01	6.10E-01	6.92E-01	6.45E-01	1.01E-01
			Carbon Dioxide	4.79E-01	6.49E-01	7.70E-01	6.30E-01	6.59E-01	I	4.56E-01	5.27E-01	7.91E-01	6.20E-01	1.25E-01
			Methane	3.39E-03	7.61E-03	8.83E-03	6.05E-03	6.89E-03	I	6.27E-03	6.60E-03	6.86E-03	6.56E-03	1.55E-03
			Sulfur Dioxide	1.49E-03	1.74E-03	2.16E-03	2.07E-03	1.49E-03	1.90E-03	1.50E-03	1.52E-03	I	1.73E-03	2.78E-04
			Nitrogen Oxides	≤PQL	8.50E-04	≤PQL	≤PQL	≤PQL	I	≤PQL	≤PQL	7.79E-04	6.16E-04	1.24E-04

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Practical Reporting Limits, Test HV, lb/ton metal

Analyte	lb/tnmetal	Analyte	lb/tnmetal
2-Butanone (MEK)	2.05E-04	Ethyltoluene, 2-	6.44E-05
Acenaphthalene	6.44E-05	Ethyltoluene, 3-	6.44E-05
Acetaldehyde	2.05E-04	Ethyltoluene, 4-	6.44E-05
Acrolein	2.05E-04	Formaldehyde	2.05E-04
alpha-Methylstyrene	6.44E-05	Heptane	6.44E-05
Anthracene	6.44E-05	Hexaldehyde	2.05E-04
Benzaldehyde	2.05E-04	Hexane	6.44E-05
Benzene	6.44E-05	Indan	6.44E-05
Biphenyl	6.44E-05	Indene	6.44E-05
Butylbenzene, n-	6.44E-05	Isobutylbenzene	6.44E-05
Butylbenzene, sec-	6.44E-05	Isopropylbenzene	6.44E-05
Butylbenzene, tert-	6.44E-05	Methylnaphthalene, 1-	6.44E-05
Butyraldehyde/Methacrole	3.42E-04	Methylnaphthalene, 2-	6.44E-05
Cresol, mp-	6.44E-05	Naphthalene	6.44E-05
Cresol, o-	6.44E-05	Nonane	6.44E-05
Crotonaldehyde	2.05E-04	o,m,p-Tolualdehyde	5.46E-04
Cyclohexane	6.44E-05	Octane	6.44E-05
Cymene, p-	6.44E-05	Pentanal (Valeraldehyde)	2.05E-04
Decane	6.44E-05	Phenol	6.44E-05
Diethylbenzene, 1,2-	6.44E-05	Propionaldehyde (Propan	2.05E-04
Diethylbenzene, 1,3-	6.44E-05	Propylbenzene, n-	6.44E-05
Diethylbenzene, 1,4-	6.44E-05	Styrene	6.44E-05
Diisopropylbenzene, 1,3-	6.44E-05	Tetradecane	6.44E-05
Dimethylnaphthalene, 1,2	6.44E-05	Toluene	6.44E-05
Dimethylnaphthalene, 1,3	6.44E-05	Tridecane	6.44E-05
Dimethylnaphthalene, 1,5	6.44E-05	Trimethylbenzene, 1,2,3-	6.44E-05
Dimethylnaphthalene, 1,6	6.44E-05	Trimethylbenzene, 1,2,4-	6.44E-05
Dimethylnaphthalene, 1,8	6.44E-05	Trimethylbenzene, 1,3,5-	6.44E-05
Dimethylnaphthalene, 2,3	6.44E-05	Trimethylnaphthalene, 2,3	6.44E-05
Dimethylnaphthalene, 2,6	6.44E-05	Trimethylphenol, 2,3,5-	6.44E-05
Dimethylnaphthalene, 2,7	6.44E-05	Trimethylphenol, 2,4,6-	6.44E-05
Dimethylphenol, 2,3-	6.44E-05	Undecane	6.44E-05
Dimethylphenol, 2,4-	6.44E-05	Xylene, mp-	6.44E-05
Dimethylphenol, 2,5-	6.44E-05	Xylene, o-	6.44E-05
Dimethylphenol, 2,6-	6.44E-05	THC as Propane	8.50E-02
Dimethylphenol, 3,4-	6.44E-05	Carbon Monoxide	5.41E-02
Dimethylphenol, 3,5-	6.44E-05	Carbon Dioxide	8.50E-02
Dodecane	6.44E-05	Nitrogen Oxides	5.79E-02
Ethylbenzene	6.44E-05	Methane	3.09E-02
		Sulfur Dioxide	2.71E-03

Practical Reporting Limits, Test HV, lb/lb binder

Analyte	lb/tn core	Analyte	lb/tn core
2-Butanone (MEK)	1.88E-06	Dodecane	5.90E-07
Acenaphthalene	5.90E-07	Ethylbenzene	5.90E-07
Acetaldehyde	1.88E-06	Ethyltoluene, 2-	5.90E-07
Acrolein	1.88E-06	Ethyltoluene, 3-	5.90E-07
alpha-Methylstyrene	5.90E-07	Ethyltoluene, 4-	5.90E-07
Anthracene	5.90E-07	Formaldehyde	1.88E-06
Benzaldehyde	1.88E-06	Heptane	5.90E-07
Benzene	5.90E-07	Hexaldehyde	1.88E-06
Biphenyl	5.90E-07	Hexane	5.90E-07
Butylbenzene, n-	5.90E-07	Indan	5.90E-07
Butylbenzene, sec-	5.90E-07	Indene	5.90E-07
Butylbenzene, tert-	5.90E-07	Isobutylbenzene	5.90E-07
Butyraldehyde/Methacrolein	3.13E-06	Isopropylbenzene	5.90E-07
Carbon Dioxide	7.78E-04	Methane	2.83E-04
Carbon Monoxide	4.95E-04	Methylnaphthalene, 1-	5.90E-07
Cresol, mp-	5.90E-07	Methylnaphthalene, 2-	5.90E-07
Cresol, o-	5.90E-07	Naphthalene	5.90E-07
Crotonaldehyde	1.88E-06	Nitrogen Oxides	5.31E-04
Cyclohexane	5.90E-07	Nonane	5.90E-07
Cymene, p-	5.90E-07	o,m,p-Tolualdehyde	5.00E-06
Decane	5.90E-07	Octane	5.90E-07
Diethylbenzene, 1,2-	5.90E-07	Pentanal (Valeraldehyde)	1.88E-06
Diethylbenzene, 1,3-	5.90E-07	Phenol	5.90E-07
Diethylbenzene, 1,4-	5.90E-07	Propionaldehyde (Propanal)	1.88E-06
Diisopropylbenzene, 1,3-	5.90E-07	Propylbenzene, n-	5.90E-07
Dimethylnaphthalene, 1,2-	5.90E-07	Styrene	5.90E-07
Dimethylnaphthalene, 1,3-	5.90E-07	Sulfur Dioxide	2.48E-05
Dimethylnaphthalene, 1,5-	5.90E-07	Tetradecane	5.90E-07
Dimethylnaphthalene, 1,6-	5.90E-07	THC as Propane	7.78E-04
Dimethylnaphthalene, 1,8-	5.90E-07	Toluene	5.90E-07
Dimethylnaphthalene, 2,3-	5.90E-07	Tridecane	5.90E-07
Dimethylnaphthalene, 2,6-	5.90E-07	Trimethylbenzene, 1,2,3-	5.90E-07
Dimethylnaphthalene, 2,7-	5.90E-07	Trimethylbenzene, 1,2,4-	5.90E-07
Dimethylphenol, 2,3-	5.90E-07	Trimethylbenzene, 1,3,5-	5.90E-07
Dimethylphenol, 2,4-	5.90E-07	Trimethylnaphthalene, 2,3,5-	5.90E-07
Dimethylphenol, 2,5-	5.90E-07	Trimethylphenol, 2,3,5-	5.90E-07
Dimethylphenol, 2,6-	5.90E-07	Trimethylphenol, 2,4,6-	5.90E-07
Dimethylphenol, 3,4-	5.90E-07	Undecane	5.90E-07
Dimethylphenol, 3,5-	5.90E-07	Xylene, mp-	5.90E-07
		Xylene, o-	5.90E-07

Practical Reporting Limits, Test HV, lb/lb Coating

Analyte	lb/tn core	Analyte	lb/tn core
2-Butanone (MEK)	1.95E-06	Ethylbenzene	6.11E-07
Acenaphthalene	6.11E-07	Ethyltoluene, 2-	6.11E-07
Acetaldehyde	1.95E-06	Ethyltoluene, 3-	6.11E-07
Acrolein	1.95E-06	Ethyltoluene, 4-	6.11E-07
alpha-Methylstyrene	6.11E-07	Formaldehyde	1.95E-06
Anthracene	6.11E-07	Heptane	6.11E-07
Benzaldehyde	1.95E-06	Hexaldehyde	1.95E-06
Benzene	6.11E-07	Hexane	6.11E-07
Biphenyl	6.11E-07	Indan	6.11E-07
Butylbenzene, n-	6.11E-07	Indene	6.11E-07
Butylbenzene, sec-	6.11E-07	Isobutylbenzene	6.11E-07
Butylbenzene, tert-	6.11E-07	Isopropylbenzene	6.11E-07
Butyraldehyde/Methacrolein	3.24E-06	Methane	2.93E-04
Carbon Dioxide	8.07E-04	Methylnaphthalene, 1-	6.11E-07
Carbon Monoxide	5.13E-04	Methylnaphthalene, 2-	6.11E-07
Cresol, mp-	6.11E-07	Naphthalene	6.11E-07
Cresol, o-	6.11E-07	Nitrogen Oxides	5.50E-04
Crotonaldehyde	1.95E-06	Nonane	6.11E-07
Cyclohexane	6.11E-07	o,m,p-Tolualdehyde	5.19E-06
Cymene, p-	6.11E-07	Octane	6.11E-07
Decane	6.11E-07	Pentanal (Valeraldehyde)	1.95E-06
Diethylbenzene, 1,2-	6.11E-07	Phenol	6.11E-07
Diethylbenzene, 1,3-	6.11E-07	Propionaldehyde (Propanal)	1.95E-06
Diethylbenzene, 1,4-	6.11E-07	Propylbenzene, n-	6.11E-07
Diisopropylbenzene, 1,3-	6.11E-07	Styrene	6.11E-07
Dimethylnaphthalene, 1,2-	6.11E-07	Sulfur Dioxide	2.57E-05
Dimethylnaphthalene, 1,3-	6.11E-07	Tetradecane	6.11E-07
Dimethylnaphthalene, 1,5-	6.11E-07	THC as Propane	8.07E-04
Dimethylnaphthalene, 1,6-	6.11E-07	Toluene	6.11E-07
Dimethylnaphthalene, 1,8-	6.11E-07	Tridecane	6.11E-07
Dimethylnaphthalene, 2,3-	6.11E-07	Trimethylbenzene, 1,2,3-	6.11E-07
Dimethylnaphthalene, 2,6-	6.11E-07	Trimethylbenzene, 1,2,4-	6.11E-07
Dimethylnaphthalene, 2,7-	6.11E-07	Trimethylbenzene, 1,3,5-	6.11E-07
Dimethylphenol, 2,3-	6.11E-07	Trimethylnaphthalene, 2,3,5-	6.11E-07
Dimethylphenol, 2,4-	6.11E-07	Trimethylphenol, 2,3,5-	6.11E-07
Dimethylphenol, 2,5-	6.11E-07	Trimethylphenol, 2,4,6-	6.11E-07
Dimethylphenol, 2,6-	6.11E-07	Undecane	6.11E-07
Dimethylphenol, 3,4-	6.11E-07	Xylene, mp-	6.11E-07
Dimethylphenol, 3,5-	6.11E-07	Xylene, o-	6.11E-07
Dodecane	6.11E-07		

APPENDIX C DETAILED PROCESS DATA AND CASTING QUALITY PHOTOS

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Detailed Process Data

Test Dates	08/06/07	08/06/07	08/06/07	08/07/07	08/07/07	08/07/07	08/08/07	08/08/07	08/08/07	08/09/07	08/09/07	08/09/07	Averages
Emissions Sample #	HVCR1	HVCR2	HVCR3	HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	
Production Sample #	HV001	HV002	HV003	HV004	HV005	HV006	HV007	HV008	HV009	HV010	HV011	HV012	
Cast weight, lbs.	118.70	117.05	108.85	102.40	117.00	118.70	118.65	118.60	121.25	118.00	118.20	120.00	117.0
Pouring time, sec.	13	14	11	10	18	10	12	13	13	12	13	12	13
Pouring temp ,°F	2627	2641	2589	2623	2626	2629	2628	2641	2633	2630	2638	2631	2631
Pour hood process air temp at start of pour, °F	87	89	86	86	86	87	86	87	88	87	87	86	87
Mixer auto dispensed sand weight, Lbs	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87	49.87
Core Binder Weight (Part 1), g	453.1	450.4	454.5	454.9	453.5	451.5	452.3	453.1	451.0	457.1	450.1	454.8	453.1
% core binder (BOS)	2.00	1.99	2.01	2.01	2.00	2.00	2.00	2.00	1.99	2.02	1.99	2.01	2.00
% core binder, actual	1.96	1.95	1.97	1.97	1.97	1.96	1.96	1.96	1.95	1.98	1.95	1.97	1.96
Total core weight in mold, Lbs.	27.02	26.71	27.06	26.98	26.50	27.01	27.14	27.03	27.03	26.77	26.69	27.10	26.92
Total binder weight in mold, Lbs.	0.53	0.52	0.53	0.53	0.52	0.53	0.53	0.53	0.53	0.53	0.52	0.53	0.53
Sprayed Coating Sprayed, lbs	0.45	0.30	0.85	0.30	0.20	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.24
Core LOI, %	0.1617	0.1699	0.1625	0.1639	0.1639	0.1625	0.1675	0.1699	0.1670	0.1625	0.1625	0.1625	0.16
2 hour Core dogbone tensile, psi	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Core age when poured, hrs.	309.12	312.79	313.19	332.64	334.35	335.91	354.45	358.61	359.90	377.59	378.97	383.35	357.31
Muller batch weight, lbs.	1300	902	899	900	900	900	900	894	900	900	900	900	899
GS mold sand weight, lbs.	629.0	612.8	613.4	609.0	591.5	613.0	628.9	619.7	611.5	608.7	592.3	591.4	607.3
Mold temperature, °F	77	82	82	80	78	80	78	81	84	79	82.4	87	81
Average green compression , psi	19.27	20.79	19.80	22.66	22.81	22.61	23.01	24.43	26.13	27.68	26.82	26.13	24.70
GS compactability, %	35	45	43	37	41	41	35	35	36	44	41	46	40
GS moisture content, %	1.92	2.36	2.16	1.88	1.84	1.88	2.22	2.22	2.00	2.85	2.62	2.64	2.24
GS MB clay content, %	6.5	6.9	7.3	7.8	7.8	7.8	7.5	7.3	8.6	8.2	8.2	7.8	7.9
MB clay reagent, ml	33.0	35.0	37.0	40.0	40.0	40.0	38.0	37.0	44.0	42.0	42.0	40.0	40.3
1800°F LOI - mold sand, %	0.9974	0.9411	0.9224	0.9782	0.9193	0.8745	0.9132	1.0452	0.9500	0.8534	0.9227	0.9300	0.93
900°F volatiles , %	0.52	0.46	0.44	0.38	0.44	0.44	0.50	0.58	0.46	0.46	0.44	0.44	0.46
Permeability index	230	245	250	250	250	249	230	245	250	250	249	240	246
Sand temperature, °F	81	83	85	86	84	88	83	86	86	82	85	86	85

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

Casting Quality Photos

Test GB | Test HV

Best


GB004 Cavity 3


HV002 Cavity 3

Median


GB005 Cavity 3


HV006 Cavity 3

Worst


GB009 Cavity 3


HV001 Cavity 3

APPENDIX D CONTINUOUS EMISSION CHARTS

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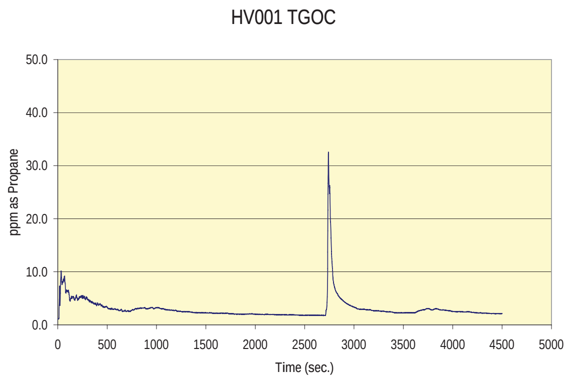
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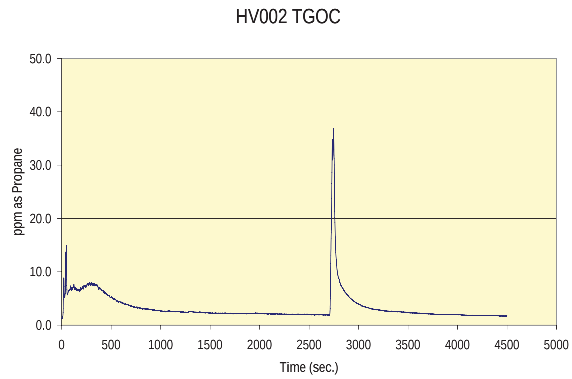
Time (sec.)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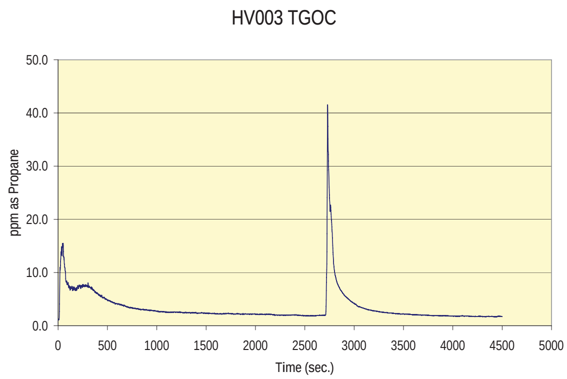
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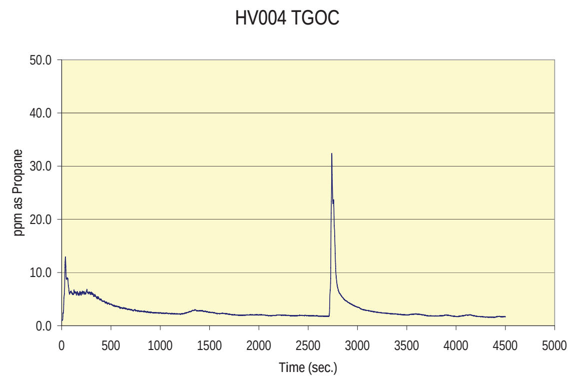
Time (sec.)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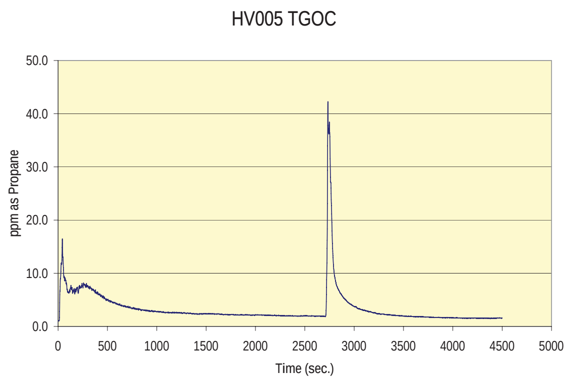
Time (sec.)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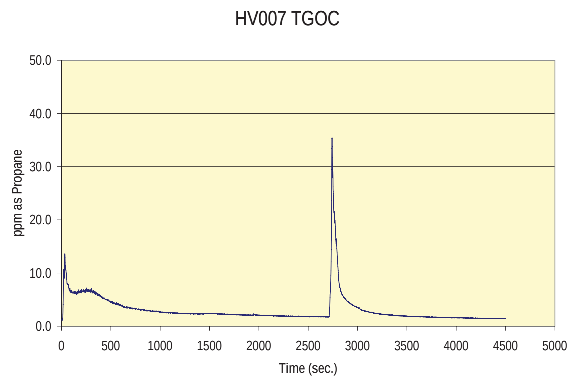
Time (sec.)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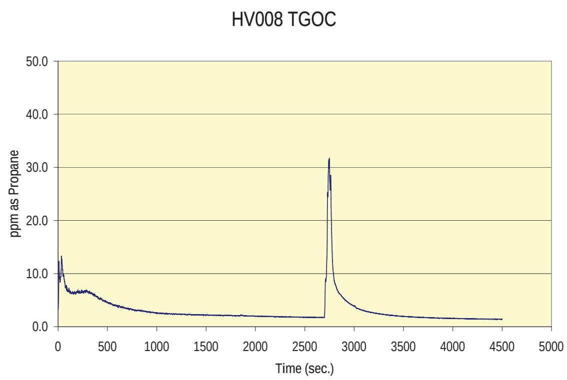
Time (sec.)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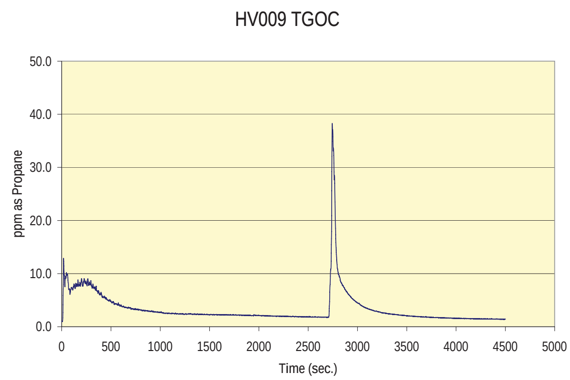
Time (sec.)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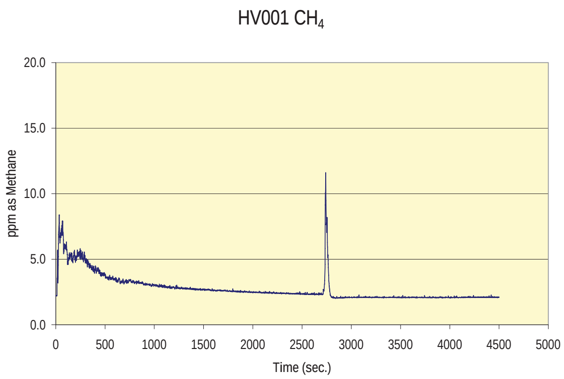
Time (sec.)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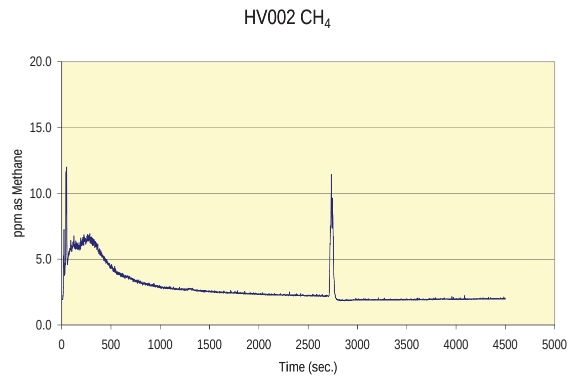
Time (sec.)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1500
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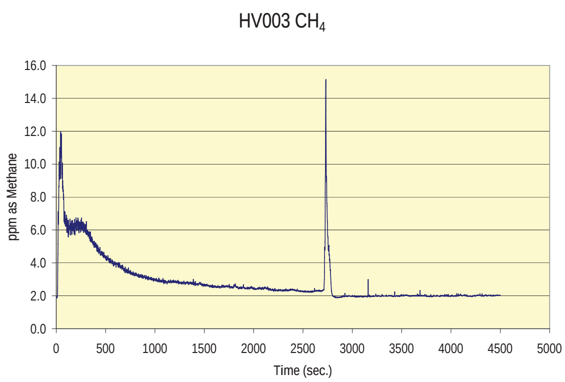
Time (sec.)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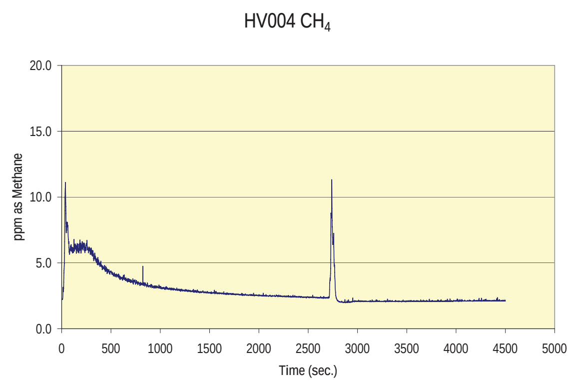
Time (sec.)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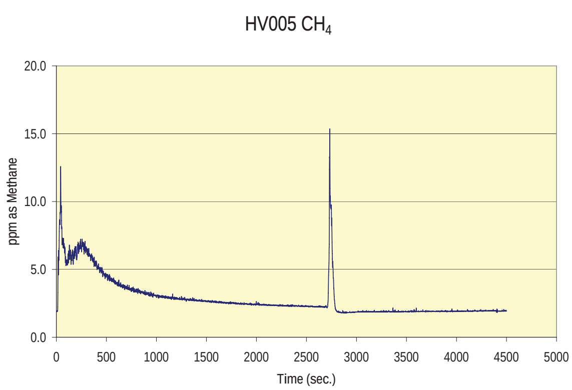
Time (sec.)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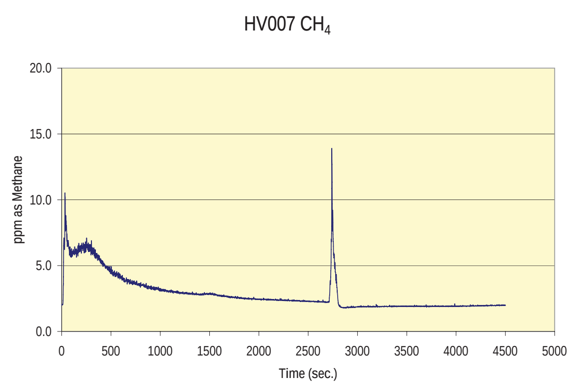
Time (sec.)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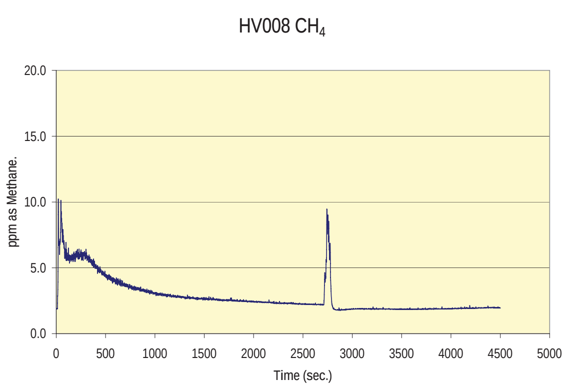
Time (sec.)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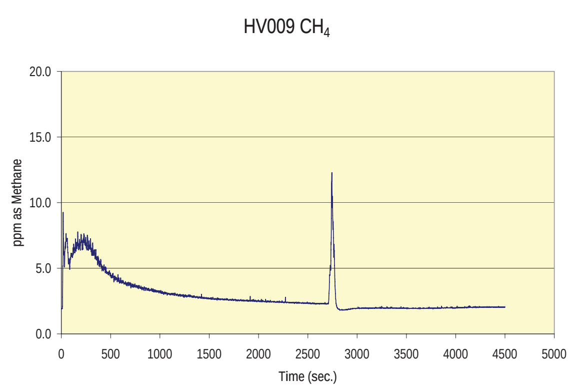
Time (sec.)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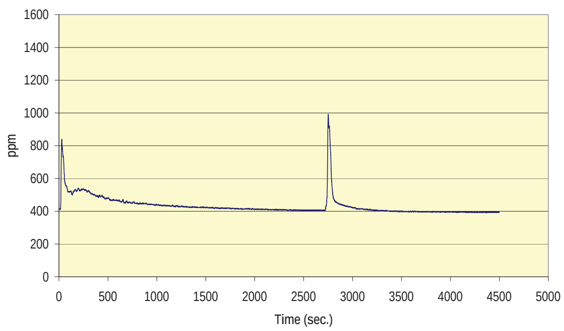
Time (sec.)

HV001 CO_2



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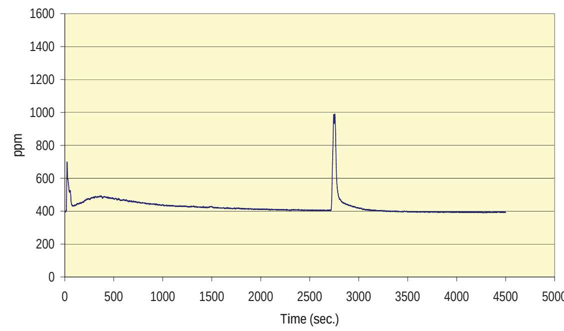

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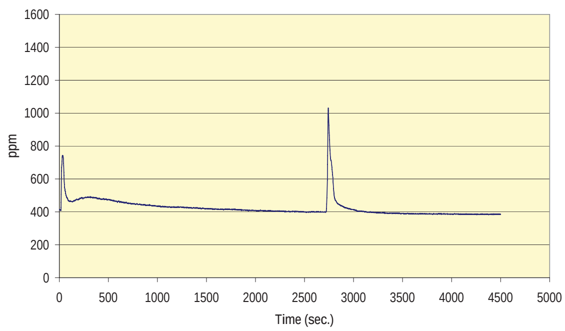

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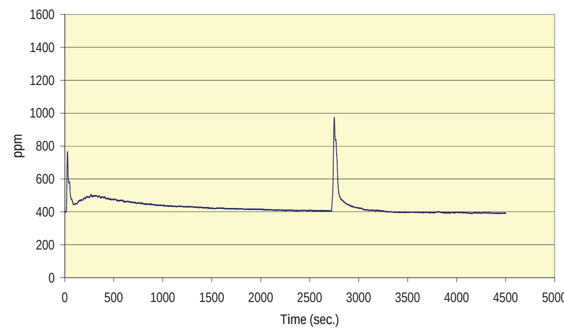

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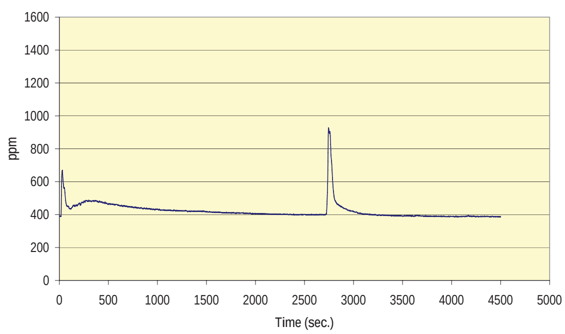

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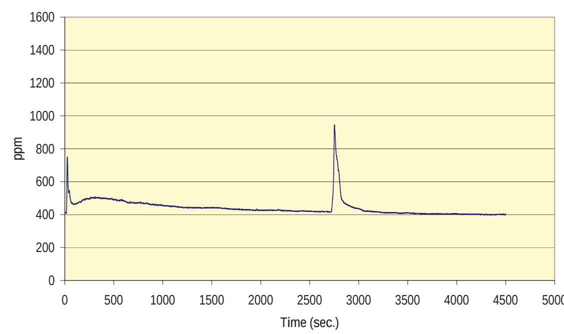

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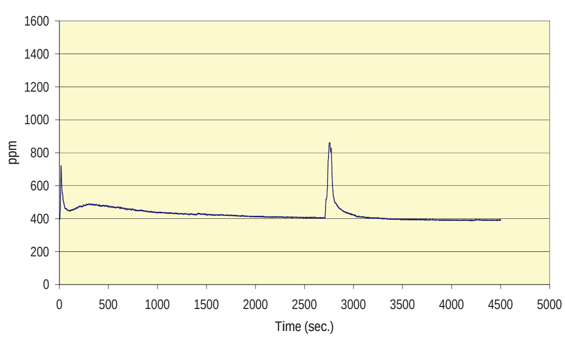

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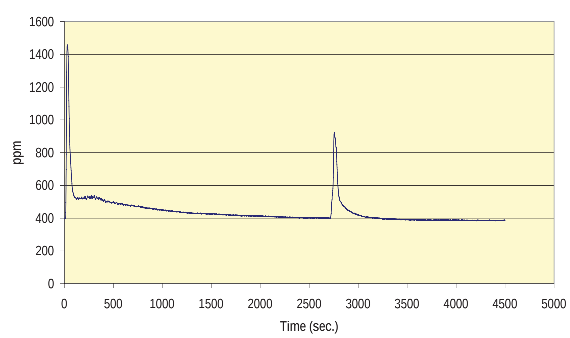

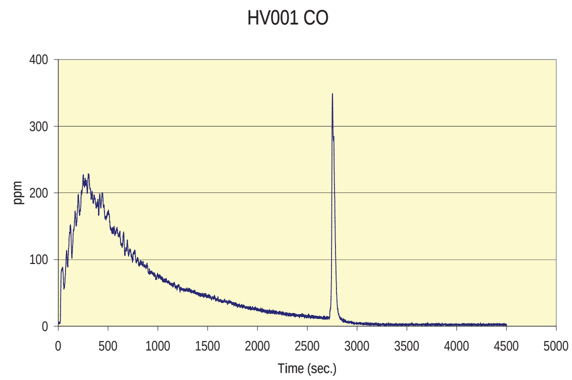
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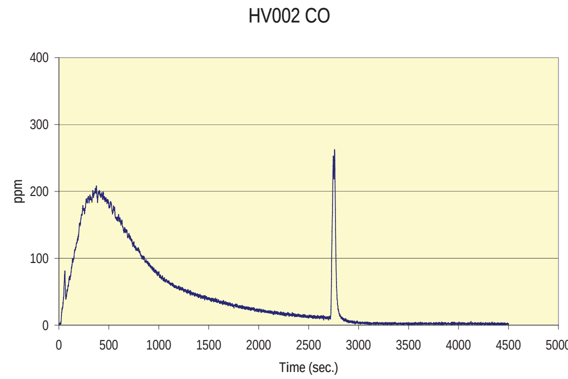
Time (sec.)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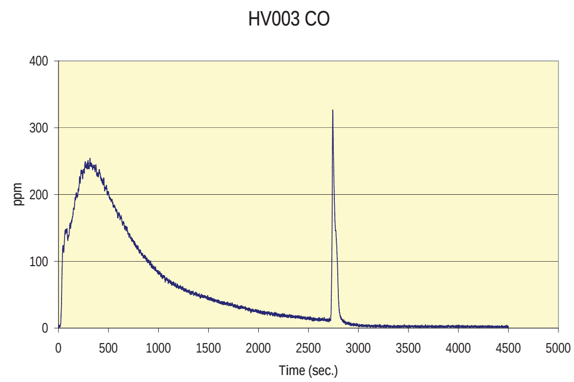
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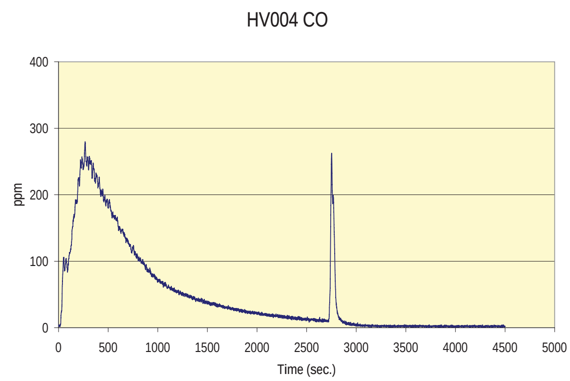
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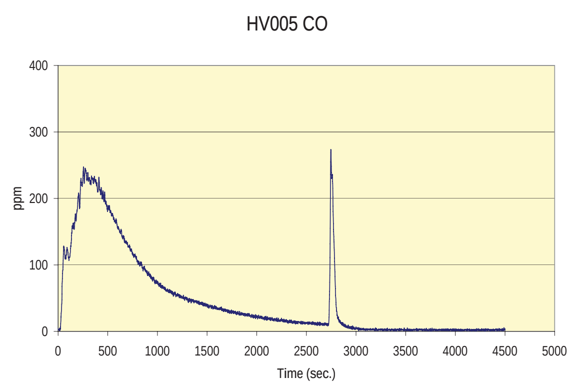
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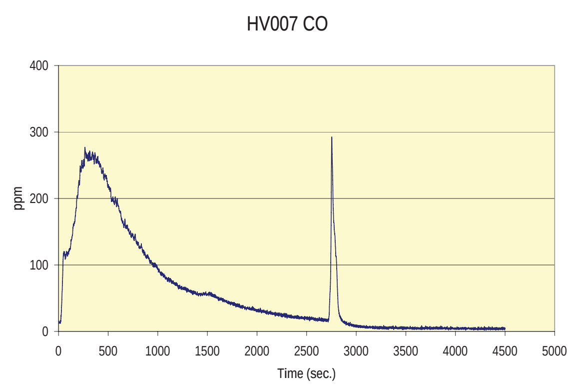
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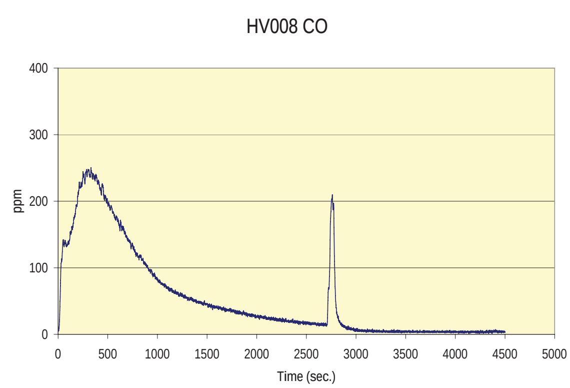
Time (sec.)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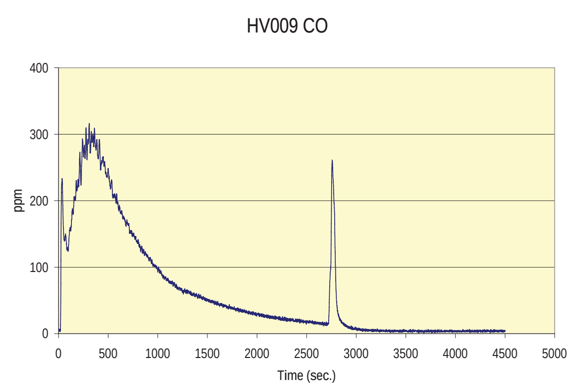
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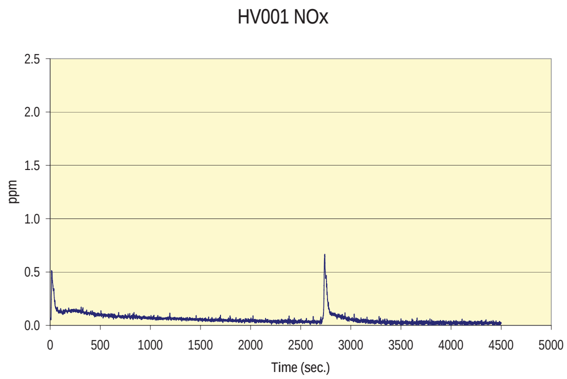
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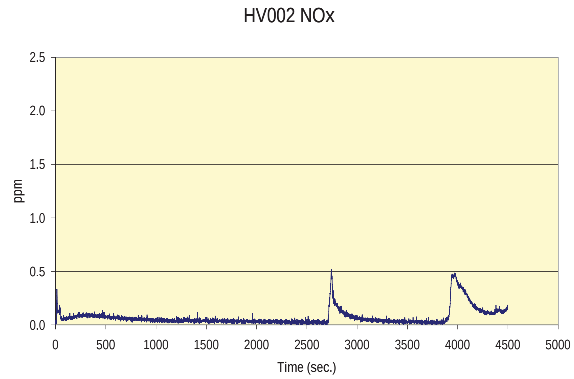
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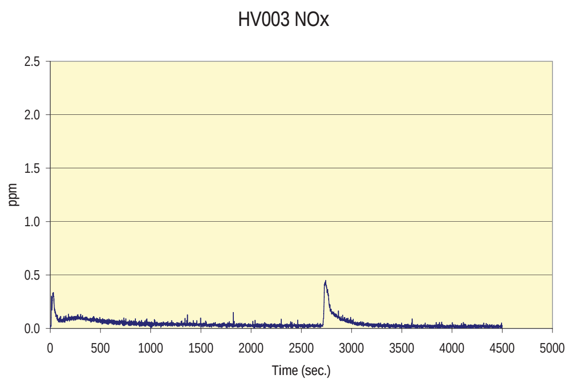
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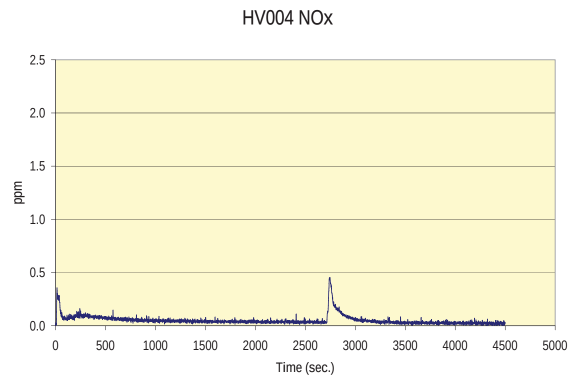
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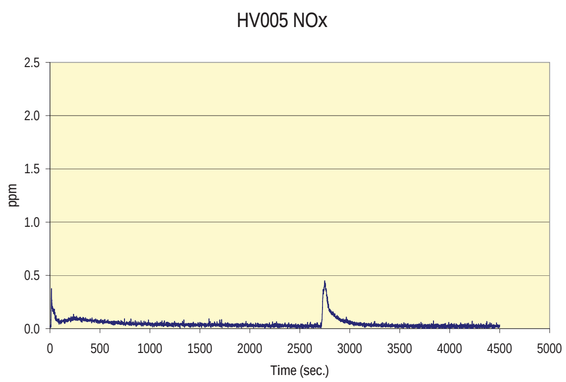
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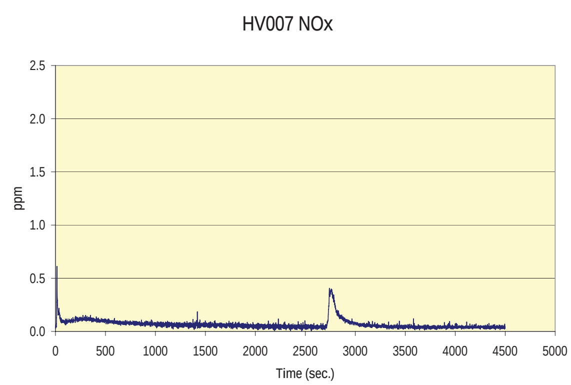
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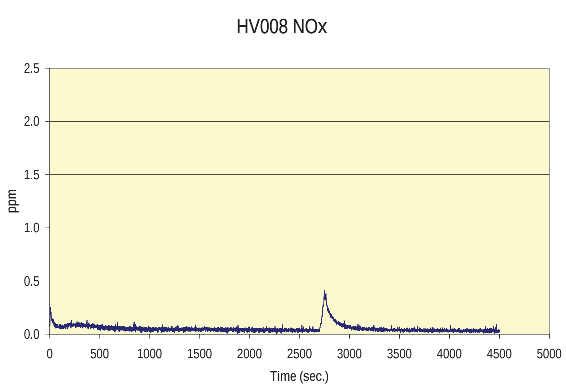
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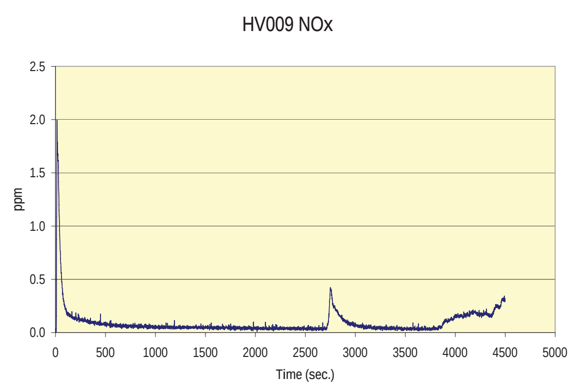
HV009 NOx
ppm
Time (sec.)

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APPENDIX E ACRONYMS AND ABBREVIATIONS

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ACRONYMS & ABBREVIATIONS

AFS	American Foundry Society
ARDEC	(US) Army Armament Research, Development and Engineering Center
BO	Based on ( ).
BOS	Based on Sand.
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CERP	Casting Emission Reduction Program
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
FID	Flame Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GS	Greensand
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
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
ND	Non-Detect; Not detected below the practical quantitation limit
NOx	Oxides of Nitrogen
NMHC	Non-Methane Hydrocarbons
NT	Not Tested
PCS	Pouring, Cooling, Shakeout

POM	Polycyclic Organic Matter
QA/QC	Quality Assurance/Quality Control
SO_2	Sulfur Dioxide
TA	Target Analyte
TGOC	Total Gaseous Organic Concentration
USCAR	United States Council for Automotive Research
VOST	Volatile Organic Sampling Train
WBS	Work Breakdown Structure