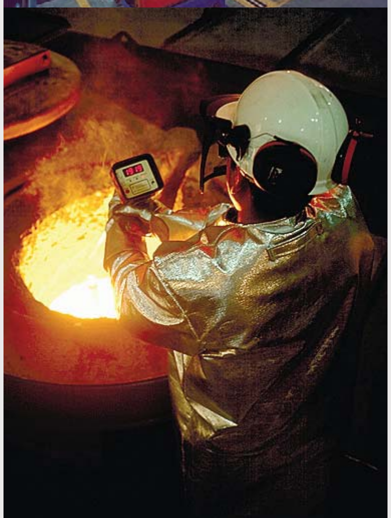
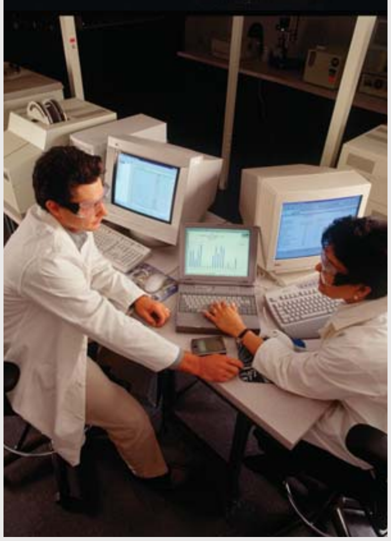
CERP

Casting Emission Reduction Program

www.cerp-us.org





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PCS Iron Coreless Star Seacoal Replacement

1412-113 HE

July 2006
(Revised for public distribution, October 2006)

CISA Casting Industry Suppliers Association

AFS American Foundry Society

Armament Research, Development & Engineering Center Picatinny, NJ

USCAR United States Council for Automotive Research

DaimlerChrysler Ford GM General Motors

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PCS Iron Coreless Star Seacoal Replacement

1412-113 HE

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

Senior Scientist	*//Original Signed//* Sue Anne Sheya, PhD	Date
V.P. 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 cost or producability.

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EXECUTIVE SUMMARY

This report contains the results of Test HE, a test for the evaluation of pouring, cooling, and shakeout airborne emissions from greensand molds containing a S & B low emission seacoal replacement premix. The results of this test will be compared to Test FK, a greensand baseline containing seacoal.

The testing performed involved the continuous collection of air samples over a seventy-five minute period, encompassing the mold pouring, cooling, shakeout, and post shakeout for nine molds poured with iron using the high surface area star pattern containing no cores. Emission Indicator results are presented in Table 1. This product reduced air emission 67% to 93% depending on the emission indicator. It must be noted in these results that the TGOC as Propane includes the exempted compound methane. At present, the methane contribution has not been determined or removed. All emissions results are reported in pounds of analyte per ton of metal poured (lb/ton). In data validation, verification and reporting of results from this test, an analyte is defined as non-detect if its concentration is below the practical quantitation limit.

Table 1 Average Emissions Indicators Summary Table - Lb/Tn Metal

Analyte Name	Reference Test FK Average	HE Average	Percent Change from Test FK
Emission Indicators			
TGOC as Propane	3.3541	0.7720	**-77**
HC as Hexane	0.4015	0.1335	**-67**
Sum of Target Organic Analytes	0.4271	0.0767	**-82**
Sum of Target Organic HAPs	0.3390	0.0642	**-81**
Sum of Target POMs	0.0197	0.0014	**-93**

Commencing with this test, name changes have been implemented in the text and tables to clarify the definition and use of emission related terms. A full description of the changes can be found in Section 3.0.

A photographic casting record was made of the twelve castings made with coated cores

produced from the three molds poured during the sand conditioning runs prior to those used for the emission test. The surface quality for each of the conditioning run castings was assessed relative to each other. Pictures of best, median and worst casting quality are shown in Appendix C. The casting quality as measured by surface finish comparison were not quite as good as the baseline castings, but acceptable for many applications.

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

1.0 INTRODUCTION

1.1. BACKGROUND

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

1.2. CERP/TECHNIKON OBJECTIVES

The primary objective of CERP is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate 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 emissions from greensand molds containing S&B IKOQuick Bond® as a seacoal replacement and poured with iron. Emission results are then compared to Test FK, an iron baseline test which used greensand molds containing an H&G® 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 of this report, with detailed data included in the appendices of this report. Section 4 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

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

Table 1-1 Test Plan Summary

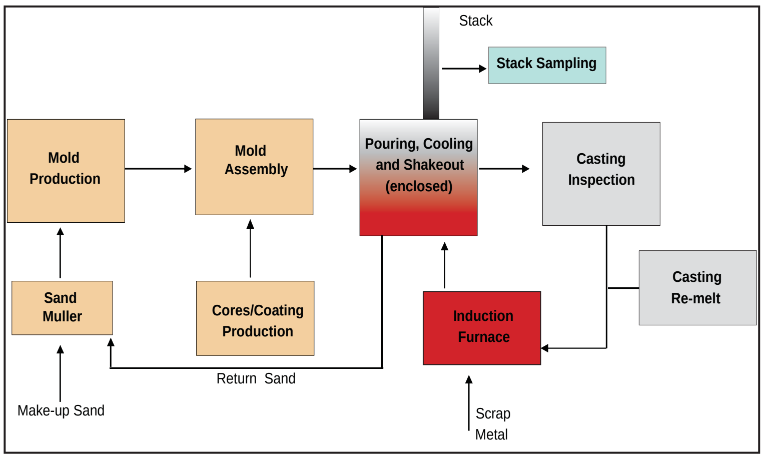
Type of Process Tested	Seacoal replacement in greensand, iron, PCS
Test Plan Number	1412-113 HE
Metal Poured	Iron
Casting Type	4-on star
Greensand System	Wexford 450 sand, S&B IKOQuickBond to yield 7.0 +/- 0.5 % MB clay, no additional seacoal
Number of Molds Poured	3 conditioning, 9 sampling
Test Dates	January 9, 2006 through January 13, 2006
Emissions Measured	55 target analytes and TGOC as propane, CO, CO_2, NOx, SO_2
Process Parameters Measured	Total casting, mold, and binder weights; metallurgical data, % LOI, sand temperature; stack temperature, moisture content, pressure, and volumetric flow rate

2.0 TEST METHODOLOGY

2.1. DESCRIPTION OF PROCESS AND TESTING EQUIPMENT

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

Figure 2-1 Research Foundry Layout Diagram



2.2. DESCRIPTION OF TESTING PROGRAM

Both process and stack parameters were monitored and recorded. Process measurements included the weights of the casting and mold sand, loss on ignition (LOI) values for the mold prior to the test, and relevant metallurgical data. Measured stack gas parameters included stack temperature, pressure, volumetric flow rate, and moisture content. All parameters were maintained within prescribed ranges to ensure the reproducibility of the test runs.

Adsorption tube samples were collected and analyzed for sixty target compounds using procedures based on approved state and/or federal regulatory methods, including those of the US Environmental Protection Agency (EPA). Continuous on-line monitoring of Total Gaseous Organic concentration (TGOC), carbon dioxide (CO_2), carbon monoxide (CO), and nitrogen oxide (NOx) concentrations was conducted according to US EPA Methods 25A, 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, Hydrocarbons (HC) as Hexane, Sum of Target Organic Analytes, Sum of Target Organic 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.

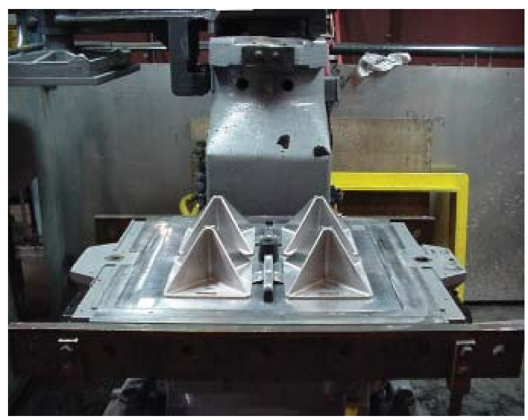
2.2.1. Test Plan Review and Approval

The proposed test plan was reviewed and approved by the Technikon staff.

2.2.2. Mold, and Metal Preparation

The molds (Figure 2-2) were prepared to a standard composition by the Technikon production team. Relevant process data were collected and recorded. The amount of metal melted was determined from the expected poured weight of the casting and the number of molds to be poured. The weight of metal poured into each mold was recorded on the process data summary sheet.

Figure 2-2 Four Cavity Star Pattern

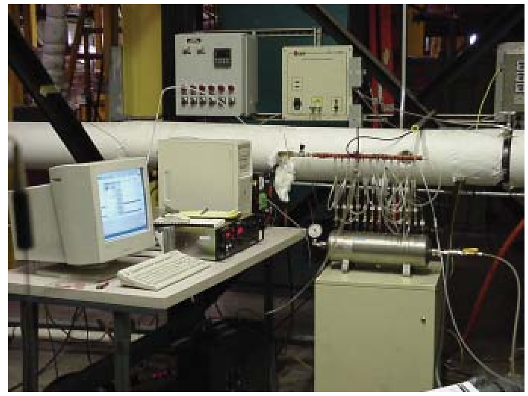


2.2.3. Individual Sampling Events

Replicate runs were performed on nine (9) mold packages after the conclusion of three (3) conditioning cycles. Prior to pouring for each run, each mold package was placed into an enclosed test stand heated to approximately 85°F. The flow rate of the emission capture air was nominally 300 scfm. Iron was poured through an opening in the top of the emission enclosure, after which the opening was closed (Figure 2-3).

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

Figure 2-4 Method 25A (TGOC) and Method 18 Sampling Train



Continuous air samples were collected during the forty-five minute pouring and cooling process, during the five minute shakeout of the mold, and for an additional twenty five minute cooling period following shakeout. Figure 2-4 shows the sampling equipment used during collection of emissions. The total sampling time was seventy-five minutes.

2.2.4. Process Parameter Measurements

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

Table 2-1 Process Equipment and Methods

Process Parameter	Equipment and Method(s)
Mold Weight	Cardinal 748E platform scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
Muller water weight	Ohaus MP2 Scale
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold	Denver Instruments XE-100 Analytical Scale (AFS procedure 5100-00-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C Immersion Pyrometer)
Carbon/Silicon Fusion Temperature	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale
Mold Compactability	Dietert 319A Sand Squeezer (AFS Procedure 2221-00-S)
Carbon/Silicon	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 regulatory reference methods shown in Table 2-2. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Standard Operating Procedures.

Table 2-2 Emission Sampling and Analytical Methods

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

*These methods modified to meet specific CERP test objectives.

2.2.6. Data Reduction, Tabulation and Preliminary Report Preparation

The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample 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 results for each analyte for all sampling events are included in Appendix B of this report. Average results for each event 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 the prescribed 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. The Manager of 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

Commencing with this test, changes have been implemented in the text and tables to clarify emission related terminology. The regulatory codified term "VOC" has been changed to the word "Organic" to ease interpretation of results. "Organic" is a more generic term, and is defined by the EPA as referring to any compound containing carbon. In the context of Technikon's emissions results, "organic" currently and henceforth will refer to carbon containing compounds. As far as is feasible, Technikon will follow EPA definitions and requirements for all emissions related testing and reporting. An additional change implemented in this report is an update of the compounds contained in the "Sum of HAPs" Emission Indicator. Methyl ethyl ketone (2-butanone or MEK) has been removed from the summation of HAPs because it is no longer regulated as such by the EPA, having been delisted in December 2005. It is still reported as a HAP in the tables and appendices of this report as a single analyte. This compound has been well documented as a HAP in the "Sum of HAPs" Emission Indicator results in all prior emissions tests where it was present.

Commensurate with the above, terminology has been changed and results have been recalculated for the reference baseline Test FK to enable a direct comparison to Test HE.

The average emission results in pounds per ton (lbs/ton) of metal for individual target analytes and emission indicators for Test HE are presented in Table 3-1. Individual target compounds or isomer classes are included which comprise at least 95% of the total targeted organic analytes measured, as well as the "Sum of Target Organic Analytes", the "Sum of Target Organic HAPs", and the "Sum of Target POMs". These three analyte sums are part of a group termed "Emission Indicators." Also included in this group and reported on the table are TGOC as propane and HC as hexane. The table additionally reports average values for selected criteria and greenhouse gases such as carbon monoxide, carbon dioxide, sulfur dioxide and nitrogen oxides. The average reported values for those analytes measured continuously on-line in real time at Technikon during Test HE have been background corrected. These include CO, CO_2, NOx and TGOC as propane. Integrated adsorption tube samples have not been background corrected with the exception of HC as hexane. In addition, this table also includes the percent change in emissions from Test FK (the reference test) to Test HE. The percent change in this case is defined as the difference

Table 3-1 Summary of Top 95% of Emission Averages - Lb/Tn Metal

Analyte Name	Reference Test FK Average	HE Average	Percent Change from Test
Emission Indicators			
TGOC as Propane	3.3541	0.7720	**-77**
HC as Hexane	0.4015	0.1335	**-67**
Sum of Target Organic Analytes	0.4271	0.0767	**-82**
Sum of Target Organic HAPs	0.3390	0.0642	**-81**
Sum of Target POMs	0.0197	0.0014	**-93**
Selected Target Organic HAPs and POMs			
Benzene	0.1450	0.0248	**-83**
Toluene	0.0744	0.0138	**-81**
Xylenes	0.0506	0.0084	**-84**
Hexane	0.0128	0.0027	**-79**
Naphthalene	0.0127	0.0008	**-94**
Cresols	0.0109	ND	NA
Ethylbenzene	0.0084	0.0013	**-84**
Phenol	0.0066	0.0016	**-75**
Methylnaphthalenes	0.0060	0.0006	NA
Acetaldehyde	0.0035	0.0063	**78**
Formaldehyde	0.0028	0.0027	-3
Additional Selected Target Organic Analytes			
Trimethylbenzenes	0.0190	0.0028	**-85**
Heptane	0.0122	0.0022	**-82**
Octane	0.0112	0.0021	**-81**
Nonane	0.0079	0.0015	**-81**
Ethyltoluenes	0.0068	0.0008	**-88**
Decane	0.0063	0.0010	**-83**
Indene	0.0062	ND	NA
Undecane	0.0051	ND	NA
Cyclohexane	0.0040	ND	NA
2-Butanone (MEK)	0.0014	0.0012	**-13**
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	I	14.3982	NA
Carbon Monoxide	I	4.5661	NA
Nitrogen Oxides	NT	0.0053	NA
Sulfur Dioxide	NT	0.0137	NA

Selected Results constitute >95% of mass of all detected target VOCs for GY and/or GW
Names in italics not included in top 95% of target organic analyte mass for Reference Test FK.
Bold numbers indicate compounds whose calculated t-statistic is significant at alpha=0.05
NT= Not Tested
ND= Not Detected
<0.0001= less than reporting limit of 0.0001 lb/ton metal

in concentrations between the current test and reference test, divided by the reference test concentration and expressed as a percentage.

Compounds that are structural isomers have been grouped together and are reported as a single isomer class. For example: ortho-, meta-, and para-xylene are the three structural isomers of dimethyl benzene and their sum is reported as xylenes. All other isomers such as trimethylbenzenes, dimethylphenols, and several other compound classes are also treated and reported in a similar manner.

Figures 3-1 to 3-3 present a graphical depiction of the five emissions indicators as well as selected individual HAP, organic analyte, and criteria pollutant and greenhouse gas emissions data from Test HE to Test FK given in Table 3-1.

Two methods were employed to measure undifferentiated hydrocarbon emissions as emission indicators: TGOC as Propane, performed in accordance with EPA Method 25A, and HC as Hexane, performed in accordance with Wisconsin Cast Metals Association – Maximum Potential to Emit (WCMA – MPTE) Method revised 07-26-01. EPA Method 25A is weighted to the detection of the more volatile hydrocarbon species, beginning at methane, the single carbon alkane (C_1), with results calibrated against propane, which is the three-carbon alkane (C_3). The methane contribution from these results has not been determined or removed, as allowed by Method 25A. The HC as hexane method detects hydrocarbon compounds in the alkane range between C_6 and C_{16}, with results calibrated against the six-carbon alkane, hexane (C_6).

The emissions indicator called the "Sum of Target Organic Analytes" is the sum of all individual target organic analytes (compounds which were chosen for analysis based on chemical and operational parameters) targeted for collection and analysis that were detected at a level above the practical quantitation limit. The sum includes compounds which may also be defined as HAPs and POMs. By definition, HAPs are specific compounds listed in the Clean Air Act Amendments of 1990. The term POM defines not one compound, but a broad class of compounds based on chemical structure and boiling point. POMs as a class are a listed HAP. A subset of organic compounds from the current list of EPA HAPs was targeted for collection and analysis. These individual target HAPs (which may also be POMs by nature of their chemical properties) detected in the samples are summed together and defined as the "Sum of Target Organic

Figure 3-1 Emissions Indicators, Average Results – Lb/Tn Metal

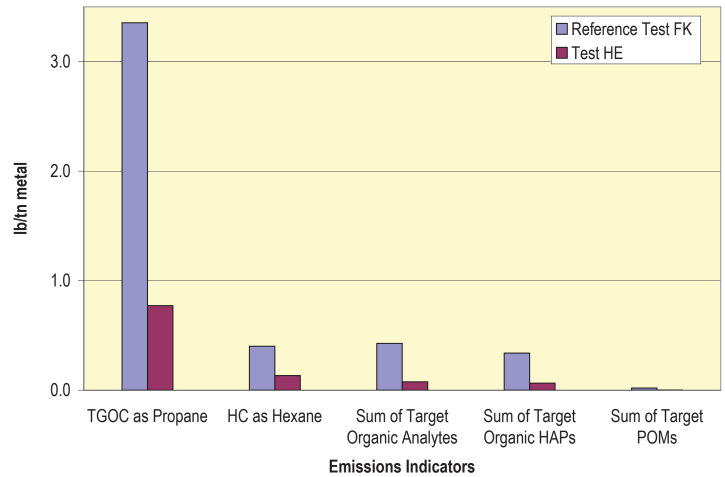


Figure 3-2 Selected HAP and VOC Emissions, Average Results – Lb/Tn Metal

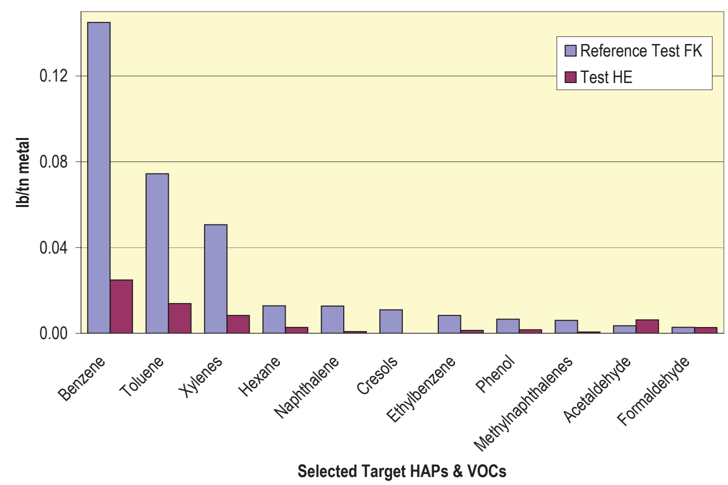
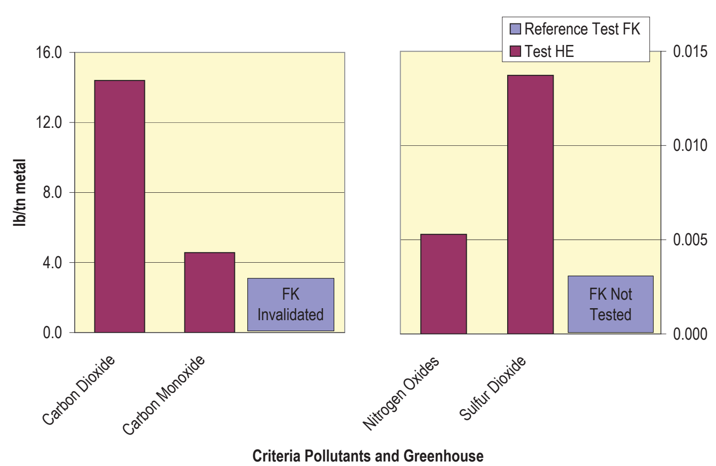


Figure 3-3 Criteria Pollutants and Greenhouse Gases, Average Results – Lb/Tn Metal



HAPs", while the "Sum of Target POMs" only sums those organic HAPs that are also defined as POMs.

The average process parameters are reported in Table 3-2 and Appendix C.

Table 3-2 Summary of Test Plan Process Parameters

Greensand PCS	Test FK	Test HE
Test Dates	8/12/03 - 8/21/03	1/9/06 - 1/13/06
Cast Weight - All Metal Inside Mold (lbs.)	100.5	107.29
Pouring Time (sec.)	19	11
Pouring Temp (°F)	2681	2685
Pour hood process air temp at start of pour, F	87	87
Muller Batch Weight (lbs.)	895	901
GS Mold Sand Weight, (lbs.)	648	644
Mold Temperature (°F)	84	77
Average Green Compression (psi)	12.47	27.32
GS Compactability (%)	40.4	42
GS Moisture Content (%)	2.04	2.38
GS MBClay Content (%)	6.88	7.21
MB Clay reagent, ml	27	37
1800°F LOI - Mold Sand (%)	5.19	2.24
900°F Volatiles (%)	1.01	0.53

The comparative ranking of casting appearance is presented in Table 3-3. Each casting from the third cavity of the mold from the baseline test FK was compared to the other third cavity castings produced in this test. Three benchmark visual casting quality rankings consisting of the best, the median, and the worst casting were then assigned to three of the nine castings. The "best" designation means that a casting is the best appearing casting of the lot of nine, and is given a rank of "1". The "median" designation, given a 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 a rank of "9". The three-benchmark castings from Test HE then were compared and collated to the benchmark castings from Test FK. The best casting of the test group HE was ranked just below the median casting of test group FK. The removal of volatile carbons such as seacoal reduces air emissions, but the tradeoff is casting surface finish. This may be acceptable for certain castings and problematic for others.

Table 3-3 Casting Quality Rank Order

Emissions Mold Number	Rank Order of Overall Casting	Test FK Baseline	Test HE Comparative
FK001	1	Best	
FK008	2	Median	
HE004	3		Best
HE005	4		
HE001	5		
HE003	6		
HE002	7		Median
HE006	8		
HE009	9		
HE008	10		
HE007	11		Worst
FK004	12	Worst	

Castings from Test HE had more sand burn-in on the faces of the sand, and slightly more burn-in where the X, Y, and Z surfaces meet in the castings than the castings from Test FK. The castings from Test HE had a fairly consistent amount of burn-in over the entire test. The difference in burn-in accounts for the difference in the photos. The castings from Test FK are much more reflective, but had more pits in them probably due to loose sand in the mold.

The four appendices in this report contain detailed information regarding testing, sampling, data collection and results for each sampling event. Appendix A contains test plans, instructions and the sampling plan for Test HE. Appendix B contains detailed emissions data and average results for all targeted analytes. Target analyte practical quantitation reporting limits expressed in both pounds per pound of binder and pounds per ton of metal are also shown in Appendix B. These values are based on the practical quantitation limit which is related to the detection limitations of an analytical method and the capabilities of analytical instrumentation. 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, and oxides of nitrogen time-dependent emissions profiles for each pour. Appendix E contains acronyms and abbreviations.

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4.0 DISCUSSION OF RESULTS

The individual chemical compounds from airborne emissions were targeted for collection and analyses based on the chemistry of the binder and were identical for Test HE to those of the baseline reference Test FK except for the speciated alkanes methane, ethane, propane, isobutane, butane, neopentane, isopentane, pentane. Subsequent to Test FK, the alkane results were found to be inaccurate. The inaccuracy is thought to be due to contamination of the Tedlar bag samples between the time of collection and the time they were analyzed. Therefore, these data are not shown in this report for Test FK.

Observation of measured process parameters indicates that both tests were run within acceptable ranges. A determination of whether the means of the baseline test and the current test were different was made by calculating a statistical T-test at a 95% significance level (α=0.05). Results at this significance level for the T-test indicate that there is a 95% probability that the mean values for HE are not equivalent to those of FK. Therefore, it may be said that the differences in the average emission values are real differences, and not due to test, sampling, or analysis methodologies. In Table 3-1, the "Percent Change from Test FK" emissions values presented **bold** indicate a greater than 95% probability that the differences in the average values were not the result of variability in the test protocol as determined from T-statistic calculations.

The results of the tests performed for the comparison of Test HE to Test FK show a 77% reduction in TGOC as propane, a 67 % reduction in HC as hexane, an 82% reduction in Sum of Target Organic Analytes, an 81% reduction in Sum of Target Organic HAPs, and a 93% reduction in Sum of Target POMs when expressed in pounds per ton of metal. Benzene was found to be the largest individual contributor to the Sum of Target Organic Analytes for both Tests FK and HE at 34 and 32%, respectively, but an 83% decrease in benzene occurred for Test HE compared to the baseline Test FK.

Including benzene, fifteen target analytes and isomer classes accounted for more than 95% of the concentration in lb/ton metal of all targeted organic analytes detected from Test HE, while eighteen were responsible in Test FK as can be seen in Table 3-1. Toluene and xylenes contributed 18 and 11% for Test HE, and 17 and 12% for Test FK. All remaining contributors in the top 95% for both tests were 4% or less. Acetaldehyde is not in the top 95% of analytes for Test FK, contributing less than 1% to the emissions.

Appendix A Test & Sample Plans and Process Instructions

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TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1412 TASK NUMBER: 1.1.3 SERIES: HE
- **SAMPLE EVENTS:** 9
- **SITE:** X PRE-PRODUCTION ______ FOUNDRY
- **TEST TYPE:** Vendor Seacoal replacement premix and with black diamond pattern release; PCS
- **METAL TYPE** Class 30 gray iron
- **MOLD TYPE:** 4-on coreless star greensand with S&B IKOQuick Bond
- **NUMBER OF MOLDS:** 9 + 3 pattern spray conditioning.
- **CORE TYPE:** None
- **TEST DATE** **START** 9 Jan 2006
  FINISHED 13 Jan 2006

TEST OBJECTIVES:

Measure the Pouring, Cooling, & Shakeout air emissions from molds made from greensand containing an S&B IKOQuick Bond. Results shall be reported as pounds of emission /ton of metal poured. The results of this test series will be compared to the Greensand baseline with seacoal FK.

VARIABLES:

The pattern will be the 4-on star. The mold will be made with virgin Wexford W450 sand and S&B IKOQuick Bond to yield 7% western and southern bentonite in a 5:2 ratio, no seacoal, tempered to 40-45% compactability, and mechanically compacted. The molds will be maintained at 80-90°F prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2680 +/- 10°F. Mold cooling will be 45 minutes follow by 15 minutes of shakeout, or until no more material remains to be shaken out. The initial process air temperature will be maintained at 85-90°F. Emission testing will be a total of 75 minutes.

BRIEF OVERVIEW:

The molds will be compacted on an Osborn Jolt squeeze mold. The sand from each run will be collected and sand from the original sand mixture will be added as necessary to maintain the sand heap size. Burned out pre-mix will be replaced to maintain the clay content.

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and testing environmental temperatures to reduce seasonal and daily temperature dependent influence on the emissions

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

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

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/9/2006											
CONDITIONING - 2											
THC, CO, CO_2 & NOx	HE CR-2	X									TOTAL

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/9/2006											
CONDITIONING - 3											
THC, CO, CO_2 & NOx	HE CR-3	X									TOTAL

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/10/2006											
THC, CO, CO_2 & NOx	HE001	X									TOTAL
TO-17	HE00101		1						60	1	Carbopak charcoal
TO-17	HE00102				1				0		Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00103		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HE00104				1				0		100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00105		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HE00106				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00107		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HE00108				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
1/10/2006											
THC, CO, CO_2 & NOx	HE002	X									TOTAL
TO-17	HE00201		1						60	1	Carbopak charcoal
TO-17	HE00202			1					60	2	Carbopak charcoal
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00203		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HE00204			1					1000	7	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HE00205		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HE00206			1					1000	9	100/50 mg Charcoal (SKC 226-01)
TO11	HE00207		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HE00208			1					1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/10/2006											
THC, CO, CO_2 & NOx	HE003	X									TOTAL
TO-17	HE00301		1						60	1	Carbopak charcoal
TO-17 MS	HE00302		1						60	2	Carbopak charcoal
TO-17 MS	HE00303			1					60	3	Carbopak charcoal
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00304		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00305		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00306		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
1/11/2006											
THC, CO, CO_2 & NOx	HE004	X									TOTAL
TO-17	HE00401		1						60	1	Carbopak charcoal
TO-17	HE00402					1			60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00403		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00404		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00405		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/11/2006											
THC, CO, CO_2 & NOx	HE005	X									TOTAL
TO-17	HE00501		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00502		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00503		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00504		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/11/2006											
THC, CO, CO_2 & NOx	HE006	X									TOTAL
TO-17	HE00601		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00602		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00603		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00604		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/12/2006											
THC, CO, CO_2 & NOx	HE007	X									TOTAL
TO-17	HE00701		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00702		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00703		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00704		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HE00705				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
1/12/2006											
THC, CO, CO_2 & NOx	HE008	X									TOTAL
TO-17	HE00801		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00802		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00803		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00804		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

RESEARCH FOUNDRY HE - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
1/12/2006											
THC, CO, CO_2 & NOx	HE009	X									TOTAL
TO-17	HE00901		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HE00902		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HE00903		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HE00904		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

1412-113-HE

PCS product test: Virgin Greensand with S & B IKOQuick Bond & Mechanized Molding

Process Instructions

A. Experiment

1. Measure pouring, cooling, & shakeout emissions from a coreless greensand mold made with all virgin Wexford W450 sand, bonded with S & B IKOQuick Bond to yield 7.0 +/- 0.5% MB Clay. The molds shall be tempered with potable water to 45-50% compactability in the mold, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new Premix materials after each casting cycle. Emissions & surface appearance will be compared to the greensand baseline with seacoal FK.

B. Materials

1. Mold sand
   a. Virgin mix of **Wexford W450** lake sand and S & B IKOQuick Bond

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

3. Pattern release
   a. Black Diamond, hand wiped

4. 20 ppi 2 x 2 x 0.5 ceramic foam filter

C. Briefing

1. The Process Engineer, Emissions Engineer, and the area Supervisor will brief the operating personnel on the requirements of the test at least one (1) day prior to the test.
2.

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

D. Sand preparation

1. Start up batch
   a. make 1, HEER1
   b. Thoroughly clean the pre-production muller, elevator, and molding hoppers.
   c. Weigh and add **1180 +/-10** pounds of new Wexford W450 lake sand, per the recipe, to the pre-production muller to make a 1300 batch.
   d. Add 5 pounds of potable to the muller to suppress dust distributing it across the sand.

Allow to mix for 1 minute.

- **e.** Add **120** pounds of S & B IKOQuick Bond slowly to the muller to allow it to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.
- **f.** Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
- **g.** Temper the sand-clay mixture slowly, with potable water, to allow for distribution.
- **h.** After about 12-14 pounds of water have been added allow 30 seconds of mixing then start taking compactability test samples.
- **i.** Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 45-50%.
- **j.** Discharge the sand into the mold station elevator.
- **k.** Grab a sufficient sample of sand from the flask after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
- **l.** Record the total sand mixed in the batch, the total premix added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge.
- **m.** The sand will be characterized for Methylene Blue Clay, Moisture content, Compactability, Green Compression strength, 1800°F loss on ignition (LOI), and 900°F volatiles, and permeability. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.
- **n.** 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: HEER2, HEER3, & HE004-HE009

- **a.** Add to the sand recovered from poured mold **HEER1** 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 IKOQuick Bond**, 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 D.1.f.

E. Molding: Star pattern.

1. Pattern preparation:

- **a.** Inspect and tighten all loose pattern and gating pieces.
- **b.** Repair any damaged pattern or gating parts.

2. Making the green sand mold.

- **a.** Mount the cope pattern on one Osborne Whisper Ram molding machine. This pattern will serve for both the cope and drag by removing the sprue when making the drag.

b. Spray on black diamond parting spray, and lightly wipe with a saturated rag.

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. Shovel the sand from the overhead mold sand hopper by actuating the gate via the valve located under the operators panel.
h. Fill the center potion of the flask.
i. Manually move sand from the center portion to the outboard areas and hand tuck the sand.
j. Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
k. 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.

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

m. 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.

n. 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.

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

p. 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.

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

r. Cut the sprue and poke vent holes in the cope half of the mold.

6. Close the cope over the drag being careful not to crush anything.
7. Clamp the flask halves together.
8. Weigh and record the weight of the closed un-poured mold, the pre-weighed flask, and the sand weight by difference.
9. Measure and record the sand temperature.
10. Deliver the mold to the previously cleaned shakeout to be poured.
11. Cover the mold with the emission hood.

F. Pig molds

1. Each day make a 900 pound capacity pig mold for the following day’s use.

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.

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.

H. 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 steel.

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. Pour a spectroscopy sample.

k. 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 H.1.e

3. Emptying the furnace.
   a. Pig the extra metal only after the last pour of the day, avoid contaminating the air sample.

I. Pouring
1. Preheat the ladle.
   a. Tap 480 pounds more or less of 2800°F iron into the cold ladle while pouring inoculating alloys onto the metal stream near its base.
   b. Carefully pour a small amount of the metal back into the furnace.
   c. Move the ladle to the pour position and wait until the metal temperature reaches 2680 +/- 10°F.
   d. Commence pouring keeping the sprue full.
   e. Upon completion return the extra metal to the furnace, and cover the ladle.
   f. Record the pour temperature and pour time on the heat log

J. Rank order evaluation.
1. The supervisor shall select a group of five persons to make a collective subjective judgment of the casting relative surface appearance.
2. Review the general appearance of the castings and select specific casting features to compare.
3. For cavity 3 only:
   a. Place each casting initially in sequential mold number order.
   b. Beginning with casting from mold HE001 compare it to castings from mold HE002.
   c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   d. Repeat this procedure with HE001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than HE001 and the next casting farther down the line is inferior.
   e. Repeat this comparison to next neighbors for each casting number.
   f. When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
   g. Repeat this comparison until all concur with the ranking order.

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

Thomas J Fennell Jr.
Process Engineer

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APPENDIX B DETAILED EMISSION RESULTS AND QUANTITATION LIMITS

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FK Detailed Emission Results - Lb/Tn Metal

VOC	POM	HAP		FK001	FK002	FK003	FK004	FK005	FK006	FK007	FK008	FK009	Average	Standard Deviation
			Test Dates	**12-Aug-03**	**12-Aug-03**	**12-Aug-03**	**19-Aug-03**	**19-Aug-03**	**20-Aug-03**	**20-Aug-03**	**20-Aug-03**	**21-Aug-03**	—	—
			Emission Indicators											
			TGOC as Propane	3.41E+00	3.36E+00	3.66E+00	3.44E+00	3.05E+00	3.03E+00	3.39E+00	3.54E+00	3.30E+00	3.35E+00	2.05E-01
			HC as Hexane	4.66E-01	4.38E-01	3.85E-01	3.76E-01	3.53E-01	3.60E-01	4.20E-01	4.11E-01	4.05E-01	4.02E-01	3.68E-02
			Sum of Target Organic Analytes	4.39E-01	I	4.73E-01	4.00E-01	4.38E-01	4.27E-01	4.16E-01	4.04E-01	4.16E-01	4.27E-01	1.40E-01
			Sum of Target Organic HAPs	3.55E-01	I	3.77E-01	3.23E-01	3.48E-01	3.33E-01	3.32E-01	3.15E-01	3.28E-01	3.39E-01	1.12E-01
			Sum of Target POMs	1.05E-02	I	2.08E-02	1.02E-02	2.66E-02	2.83E-02	1.58E-02	1.80E-02	2.73E-02	1.97E-02	7.29E-03
			Selected Target HAPs and POMs											
V		H	Benzene	1.67E-01	I	1.68E-01	1.51E-01	1.39E-01	1.34E-01	1.41E-01	1.34E-01	1.26E-01	1.45E-01	1.54E-02
V		H	Toluene	8.02E-02	I	7.86E-02	7.32E-02	7.44E-02	7.13E-02	7.52E-02	6.91E-02	7.32E-02	7.44E-02	3.63E-03
V		H	Xylene, mp-	3.26E-02	I	3.46E-02	3.09E-02	3.40E-02	3.22E-02	3.32E-02	3.03E-02	3.45E-02	3.28E-02	1.59E-03
V		H	Xylene, o-	1.82E-02	I	1.86E-02	1.69E-02	1.84E-02	1.69E-02	1.82E-02	1.69E-02	1.86E-02	1.78E-02	7.72E-04
V		H	Hexane	1.47E-02	I	1.41E-02	1.32E-02	1.22E-02	1.19E-02	1.22E-02	1.30E-02	1.12E-02	1.28E-02	1.18E-03
V	P	H	Naphthalene	7.85E-03	I	1.41E-02	7.04E-03	1.65E-02	1.69E-02	1.05E-02	1.17E-02	1.70E-02	1.27E-02	4.04E-03
V		H	Ethylbenzene	8.45E-03	I	9.11E-03	7.90E-03	8.51E-03	7.73E-03	8.69E-03	7.96E-03	8.49E-03	8.35E-03	4.61E-04
V		H	Phenol	4.19E-03	I	9.04E-03	2.73E-03	9.11E-03	8.50E-03	6.44E-03	5.81E-03	6.83E-03	6.58E-03	2.31E-03
V		H	Cresol, o-	4.02E-03	I	7.68E-03	3.76E-03	7.72E-03	5.85E-03	5.59E-03	5.57E-03	6.86E-03	5.88E-03	1.50E-03
V		H	Cresol, mp-	2.96E-03	I	6.46E-03	2.55E-03	7.06E-03	6.42E-03	4.58E-03	4.60E-03	5.64E-03	5.03E-03	1.66E-03
V		H	Styrene	3.89E-03	I	4.07E-03	3.46E-03	3.92E-03	3.39E-03	3.71E-03	3.41E-03	3.96E-03	3.73E-03	2.73E-04
V	P	H	Methylnaphthalene, 2-	1.56E-03	I	3.42E-03	1.66E-03	5.17E-03	5.69E-03	2.64E-03	3.12E-03	5.18E-03	3.55E-03	1.62E-03
V		H	Acetaldehyde	3.97E-03	4.25E-03	3.59E-03	3.47E-03	3.32E-03	3.41E-03	3.52E-03	3.44E-03	2.85E-03	3.53E-03	3.95E-04
V		H	Formaldehyde	3.90E-03	3.12E-03	2.46E-03	3.40E-03	2.88E-03	3.07E-03	2.77E-03	1.59E-03	1.77E-03	2.77E-03	7.40E-04
V	P	H	Methylnaphthalene, 1-	1.11E-03	I	2.35E-03	1.13E-03	3.39E-03	3.87E-03	1.87E-03	2.28E-03	3.61E-03	2.45E-03	1.08E-03
V	P	H	Dimethylnaphthalene, 1,3-	ND	I	9.26E-04	4.06E-04	1.49E-03	1.78E-03	7.78E-04	8.98E-04	1.49E-03	9.71E-04	5.98E-04
V		H	Propionaldehyde (Propanal)	7.18E-04	7.89E-04	6.58E-04	6.35E-04	6.36E-04	6.10E-04	6.84E-04	6.50E-04	5.66E-04	6.61E-04	6.45E-05
V	P	H	Acenaphthalene	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,2-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,5-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,6-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,8-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,3-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,6-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,7-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Trimethylnaphthalene, 2,3,5-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Biphenyl	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA

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FK Detailed Emission Results - Lb/Tn Metal

VOC	POM	HAP		FK001	FK002	FK003	FK004	FK005	FK006	FK007	FK008	FK009	Average	Standard Deviation
			Test Dates	**12-Aug-03**	**12-Aug-03**	**12-Aug-03**	**19-Aug-03**	**19-Aug-03**	**20-Aug-03**	**20-Aug-03**	**20-Aug-03**	**21-Aug-03**	—	—
			Additional Selected Target Organic Analytes											
V			Heptane	1.40E-02	I	1.37E-02	1.24E-02	1.15E-02	1.14E-02	1.20E-02	1.19E-02	1.04E-02	1.22E-02	1.18E-03
V			Octane	1.24E-02	I	1.23E-02	1.11E-02	1.09E-02	1.02E-02	1.09E-02	1.13E-02	1.04E-02	1.12E-02	7.97E-04
V			Trimethylbenzene, 1,2,4-	9.43E-03	I	1.12E-02	8.72E-03	1.23E-02	1.24E-02	1.07E-02	1.08E-02	1.33E-02	1.11E-02	1.53E-03
V			Nonane	8.29E-03	I	8.59E-03	7.64E-03	8.01E-03	7.60E-03	7.72E-03	7.70E-03	7.74E-03	7.91E-03	3.57E-04
V			Decane	5.16E-03	I	7.06E-03	5.05E-03	7.14E-03	7.10E-03	5.68E-03	6.26E-03	7.15E-03	6.33E-03	9.16E-04
V			Indene	5.52E-03	I	7.28E-03	4.74E-03	7.25E-03	5.64E-03	6.11E-03	5.85E-03	7.05E-03	6.18E-03	9.29E-04
V			Ethyltoluene, 3-	4.81E-03	I	5.24E-03	4.45E-03	5.74E-03	6.11E-03	5.31E-03	5.01E-03	6.02E-03	5.34E-03	5.86E-04
V			Undecane	3.29E-03	I	5.17E-03	3.99E-03	5.89E-03	5.97E-03	5.03E-03	5.37E-03	5.79E-03	5.06E-03	9.59E-04
V			Trimethylbenzene, 1,2,3-	3.67E-03	I	4.46E-03	3.48E-03	4.85E-03	5.03E-03	4.29E-03	4.15E-03	5.15E-03	4.38E-03	6.11E-04
V			Cyclohexane	4.54E-03	I	4.40E-03	4.21E-03	3.92E-03	3.96E-03	3.71E-03	3.79E-03	3.38E-03	3.99E-03	3.82E-04
V			Trimethylbenzene, 1,3,5-	3.07E-03	I	3.26E-03	2.83E-03	3.36E-03	4.83E-03	3.27E-03	3.09E-03	4.49E-03	3.52E-03	7.26E-04
V			Indan	2.94E-03	I	2.69E-03	2.25E-03	3.12E-03	2.72E-03	2.52E-03	2.54E-03	3.08E-03	2.73E-03	3.01E-04
V			Ethyltoluene, 2-	3.04E-03	I	ND	2.75E-03	ND	ND	3.17E-03	3.03E-03	ND	1.50E-03	1.61E-03
V			2-Butanone (MEK)	1.38E-03	1.45E-03	1.33E-03	1.13E-03	1.21E-03	1.23E-03	1.54E-03	1.59E-03	1.43E-03	1.37E-03	1.56E-04
V			Dimethylphenol, 2,4-	ND	I	2.95E-03	ND	3.15E-03	2.35E-03	ND	2.13E-03	ND	1.32E-03	1.45E-03
V			Benzaldehyde	1.02E-03	1.12E-03	1.02E-03	8.36E-04	9.25E-04	9.37E-04	1.14E-03	1.03E-03	9.29E-04	9.95E-04	9.80E-05
V			Dodecane	ND	I	3.15E-03	ND	ND	2.87E-03	ND	1.90E-03	ND	9.90E-04	1.41E-03
V			o,m,p-Tolualdehyde	I	7.07E-04	6.70E-04	7.25E-04	5.13E-04	5.62E-04	5.85E-04	6.88E-04	5.86E-04	6.29E-04	7.76E-05
V			Tetradecane	ND	I	ND	ND	ND	2.08E-03	ND	ND	1.92E-03	5.00E-04	9.26E-04
V			Butyraldehyde/Methacrolein	4.67E-04	5.26E-04	4.49E-04	4.00E-04	4.39E-04	4.30E-04	4.99E-04	3.85E-04	ND	3.99E-04	1.56E-04
V			Hexaldehyde	3.08E-04	3.20E-04	2.91E-04	2.29E-04	2.39E-04	2.10E-04	2.67E-04	1.89E-04	ND	2.28E-04	9.63E-05
V			Pentanal (Valeraldehyde)	2.48E-04	2.93E-04	2.61E-04	ND	1.97E-04	1.92E-04	2.49E-04	2.46E-04	ND	1.87E-04	1.10E-04
V			Crotonaldehyde	2.17E-04	2.01E-04	ND	ND	ND	ND	ND	ND	ND	4.65E-05	9.23E-05
V			Diethylbenzene, 1,3-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Dimethylphenol, 2,6-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Propylbenzene, n-	ND	I	ND	ND	ND	ND	ND	ND	ND	ND	NA
			Criteria Pollutants and Greenhouse Gases											
			Sulfur Dioxide	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
			Carbon Monoxide	I	I	I	I	I	I	I	I	I	I	I
			Carbon Dioxide	I	I	I	I	I	I	I	I	I	I	I
			Nitrogen Oxides	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

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HE Detailed Emissions - Lb/Tn Metal

VOC	POM	HAP		HE001	HE002	HE003	HE004	HE005	HE006	HE007	HE008	HE009	Average	Standard Deviation
				10-Jan-06	10-Jan-06	10-Jan-06	11-Jan-06	11-Jan-06	11-Jan-06	12-Jan-06	12-Jan-06	12-Jan-06	—	—
			Emission Indicators											
			TGOC as Propane	9.45E-01	7.54E-01	7.79E-01	8.29E-01	7.49E-01	7.57E-01	7.58E-01	6.90E-01	6.86E-01	7.72E-01	7.79E-02
			HC as Hexane	1.68E-01	1.50E-01	1.40E-01	1.41E-01	1.28E-01	1.28E-01	1.16E-01	1.16E-01	1.13E-01	1.33E-01	1.83E-02
			Sum of Target Organic Analytes	4.74E-02	9.59E-02	9.42E-02	9.32E-02	7.84E-02	7.94E-02	7.65E-02	6.97E-02	5.58E-02	7.67E-02	1.70E-02
			Sum of Target Organic HAPs	3.96E-02	7.97E-02	7.85E-02	7.79E-02	6.53E-02	6.62E-02	6.41E-02	5.91E-02	4.74E-02	6.42E-02	1.39E-02
			Sum of Target POMs	6.19E-04	2.13E-03	1.86E-03	1.65E-03	1.45E-03	1.45E-03	1.55E-03	1.19E-03	7.43E-04	1.41E-03	4.90E-04
			Selected Target Organic HAPs and POMs											
V		H	Benzene	1.38E-02	3.04E-02	3.12E-02	2.97E-02	2.52E-02	2.62E-02	2.56E-02	2.34E-02	1.80E-02	2.48E-02	5.77E-03
V		H	Toluene	7.31E-03	1.77E-02	1.69E-02	1.75E-02	1.40E-02	1.40E-02	1.40E-02	1.30E-02	1.01E-02	1.38E-02	3.44E-03
V		H	Acetaldehyde	6.40E-03	6.43E-03	6.68E-03	6.92E-03	6.30E-03	6.30E-03	5.89E-03	5.94E-03	5.64E-03	6.28E-03	3.99E-04
V		H	Xylene, mp-	3.17E-03	7.75E-03	7.20E-03	7.37E-03	5.81E-03	5.81E-03	5.75E-03	5.00E-03	4.05E-03	5.77E-03	1.53E-03
V		H	Hexane	1.60E-03	3.25E-03	3.18E-03	3.39E-03	2.94E-03	2.94E-03	2.79E-03	2.60E-03	1.95E-03	2.74E-03	6.04E-04
V		H	Formaldehyde	2.69E-03	3.28E-03	2.93E-03	3.17E-03	2.85E-03	2.85E-03	2.17E-03	2.22E-03	2.08E-03	2.69E-03	4.41E-04
V		H	Xylene, o-	1.38E-03	3.32E-03	3.21E-03	3.32E-03	2.63E-03	2.63E-03	2.64E-03	2.27E-03	1.86E-03	2.59E-03	6.66E-04
V		H	Phenol	8.83E-04	2.45E-03	2.41E-03	1.94E-03	1.59E-03	1.59E-03	1.44E-03	1.27E-03	1.07E-03	1.63E-03	5.49E-04
V		H	Ethylbenzene	6.49E-04	1.70E-03	1.67E-03	1.70E-03	1.40E-03	1.40E-03	1.39E-03	1.20E-03	9.69E-04	1.34E-03	3.56E-04
V	P	H	Naphthalene	4.12E-04	1.17E-03	1.09E-03	9.43E-04	8.34E-04	8.34E-04	8.53E-04	6.38E-04	5.32E-04	8.12E-04	2.49E-04
V		H	Propionaldehyde (Propanal)	8.71E-04	8.26E-04	8.34E-04	9.19E-04	7.81E-04	7.81E-04	6.78E-04	7.81E-04	7.15E-04	7.98E-04	7.43E-05
V	P	H	Methylnaphthalene, 2-	2.07E-04	6.28E-04	4.94E-04	4.56E-04	4.03E-04	4.03E-04	4.72E-04	3.73E-04	2.11E-04	4.05E-04	1.34E-04
V		H	Styrene	1.75E-04	4.90E-04	4.92E-04	3.41E-04	2.47E-04	2.47E-04	2.34E-04	2.06E-04	1.42E-04	2.86E-04	1.29E-04
V	P	H	Methylnaphthalene, 1-	ND	3.32E-04	2.75E-04	2.51E-04	2.15E-04	2.15E-04	2.30E-04	1.81E-04	ND	1.89E-04	1.15E-04
V	P	H	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V	P	H	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Cresol, mp-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V		H	Cresol, o-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

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HE Detailed Emissions - Lb/Tn Metal

VOC	POM	HAP		HE001	HE002	HE003	HE004	HE005	HE006	HE007	HE008	HE009	Average	Standard Deviation
				10-Jan-06	10-Jan-06	10-Jan-06	11-Jan-06	11-Jan-06	11-Jan-06	12-Jan-06	12-Jan-06	12-Jan-06	—	—
			Additional Selected Target Organic Analytes											
V			Heptane	1.30E-03	2.45E-03	2.60E-03	2.78E-03	2.45E-03	2.45E-03	2.37E-03	2.07E-03	1.65E-03	2.23E-03	4.78E-04
V			Octane	1.19E-03	2.27E-03	2.49E-03	2.57E-03	2.26E-03	2.26E-03	2.25E-03	1.95E-03	1.56E-03	2.09E-03	4.50E-04
V			Trimethylbenzene, 1,2,4-	1.05E-03	2.97E-03	2.48E-03	2.22E-03	1.87E-03	1.87E-03	1.62E-03	1.31E-03	1.13E-03	1.83E-03	6.41E-04
V			Nonane	8.83E-04	1.72E-03	1.88E-03	1.88E-03	1.56E-03	1.56E-03	1.62E-03	1.31E-03	1.09E-03	1.50E-03	3.43E-04
V			2-Butanone (MEK)	1.33E-03	1.40E-03	1.32E-03	1.28E-03	1.13E-03	1.13E-03	1.08E-03	1.03E-03	1.01E-03	1.19E-03	1.44E-04
V			Decane	6.81E-04	1.36E-03	1.40E-03	1.27E-03	1.04E-03	1.04E-03	1.06E-03	8.39E-04	7.24E-04	1.05E-03	2.65E-04
V			Trimethylbenzene, 1,2,3-	4.88E-04	1.48E-03	1.32E-03	1.30E-03	1.02E-03	1.02E-03	9.52E-04	7.74E-04	6.30E-04	9.98E-04	3.31E-04
V			Ethyltoluene, 3-	ND	1.57E-03	1.30E-03	1.10E-03	1.02E-03	1.02E-03	8.34E-04	6.91E-04	ND	8.38E-04	5.37E-04
V			Pentanal (Valeraldehyde)	4.25E-04	4.77E-04	4.78E-04	4.69E-04	4.02E-04	4.02E-04	3.80E-04	3.75E-04	3.64E-04	4.19E-04	4.53E-05
V			Butyraldehyde/Methacrolein	2.92E-04	3.09E-04	3.19E-04	3.05E-04	2.77E-04	2.77E-04	2.57E-04	2.31E-04	2.31E-04	2.78E-04	3.23E-05
V			Benzaldehyde	1.60E-04	1.57E-04	1.36E-04	1.46E-04	1.30E-04	1.30E-04	ND	ND	ND	9.56E-05	7.24E-05
V			Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Diethylbenzene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Dimethylphenol, 2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Dimethylphenol, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Hexaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Propylbenzene, n-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
V			Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
			Criteria Pollutants and Greenhouse Gases											
			Sulfur Dioxide	1.38E-02	1.42E-02	1.03E-02	1.99E-02	1.53E-02	1.53E-02	1.07E-02	1.12E-02	1.27E-02	1.37E-02	2.97E-03
			Carbon Monoxide	4.73E+00	3.72E+00	3.97E+00	4.96E+00	4.59E+00	4.62E+00	4.93E+00	4.72E+00	4.84E+00	4.57E+00	4.31E-01
			Carbon Dioxide	1.44E+01	1.49E+01	1.44E+01	1.70E+01	1.43E+01	1.30E+01	1.47E+01	1.36E+01	1.32E+01	1.44E+01	1.19E+00
			Nitrogen Oxides	4.76E-03	5.00E-03	2.93E-03	8.42E-03	6.13E-03	4.29E-03	6.73E-03	4.54E-03	4.75E-03	5.29E-03	1.60E-03

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FK Quanitation Limits - Lb/Tn Metal

Analyte	Practical Reporting Limit lb/ton	Analyte	Practical Reporting Limit lb/ton
Carbon Monoxide	5.30E-02	Ethyltoluene, 2-	5.19E-04
Carbon Dioxide	8.32E-02	Ethyltoluene, 3-	2.59E-03
Nitrogen Oxides	5.67E-02	Formaldehyde	2.47E-04
THC as Propane	5.67E-02	Heptane	2.59E-03
2-Butanone (MEK)	2.47E-04	Hexaldehyde	2.47E-04
Acenaphthalene	2.59E-03	Hexane	5.19E-04
Acetaldehyde	2.47E-04	Indan	2.59E-03
Acrolein	2.47E-04	Indene	2.59E-03
Benzaldehyde	2.47E-04	Methylnaphthalene, 1-	5.19E-04
Benzene	5.19E-04	Methylnaphthalene, 2-	5.19E-04
Biphenyl	2.59E-03	Naphthalene	5.19E-04
Butyraldehyde/Methacrolein	4.11E-04	Nonane	2.59E-03
Cresol, mp-	2.59E-03	o,m,p-Tolualdehyde	6.58E-04
Cresol, o-	2.59E-03	Octane	2.59E-03
Crotonaldehyde	2.47E-04	Pentanal (Valeraldehyde)	2.47E-04
Cyclohexane	2.59E-03	Phenol	2.59E-03
Decane	2.59E-03	Propionaldehyde (Propanal)	2.47E-04
Diethylbenzene, 1,3-	2.59E-03	Propylbenzene, n-	2.59E-03
Dimethylnaphthalene, 1,2-	2.59E-03	Styrene	5.19E-04
Dimethylnaphthalene, 1,3-	5.19E-04	Tetradecane	2.59E-03
Dimethylnaphthalene, 1,5-	2.59E-03	THCs as n-Hexane	8.33E-03
Dimethylnaphthalene, 1,6-	2.59E-03	Toluene	5.19E-04
Dimethylnaphthalene, 1,8-	2.59E-03	Trimethylbenzene, 1,2,3-	5.19E-04
Dimethylnaphthalene, 2,3-	2.59E-03	Trimethylbenzene, 1,2,4-	5.19E-04
Dimethylnaphthalene, 2,6-	2.59E-03	Trimethylbenzene, 1,3,5-	5.19E-04
Dimethylnaphthalene, 2,7-	2.59E-03	Trimethylnaphthalene, 2,3,5-	2.59E-03
Dimethylphenol, 2,4-	2.59E-03	Undecane	5.19E-04
Dimethylphenol, 2,6-	2.59E-03	Xylene, mp-	5.19E-04
Dodecane	2.59E-03	Xylene, o-	5.19E-04
Ethylbenzene	5.19E-04		

HE Quanitation Limits - Lb/Tn Metal

Analyte	Practical Reporting Limit lb/ton	Analyte	Practical Reporting Limit lb/ton
Carbon Monoxide	8.23E-02	Methylnaphthalene, 1-	1.75E-04
Carbon Dioxide	1.29E-01	Methylnaphthalene, 2-	1.75E-04
Nitrogen Oxides	8.82E-02	Naphthalene	1.75E-04
THC as Propane	1.29E-01	Nonane	8.73E-04
Acenaphthalene	8.73E-04	Octane	8.73E-04
Benzene	1.75E-04	Phenol	8.73E-04
Biphenyl	8.73E-04	Propylbenzene, n-	8.73E-04
Cresol, mp-	8.73E-04	Styrene	1.75E-04
Cresol, o-	8.73E-04	Tetradecane	8.73E-04
Cyclohexane	8.73E-04	Toluene	1.75E-04
Decane	8.73E-04	Trimethylbenzene, 1,2,3-	1.75E-04
Diethylbenzene, 1,3-	8.73E-04	Trimethylbenzene, 1,2,4-	1.75E-04
Dimethylnaphthalene, 1,2-	8.73E-04	Trimethylbenzene, 1,3,5-	1.75E-04
Dimethylnaphthalene, 1,3-	1.75E-04	Trimethylnaphthalene, 2,3,5-	8.73E-04
Dimethylnaphthalene, 1,5-	8.73E-04	Undecane	1.75E-04
Dimethylnaphthalene, 1,6-	8.73E-04	Xylene, mp-	1.75E-04
Dimethylnaphthalene, 1,8-	8.73E-04	Xylene, o-	1.75E-04
Dimethylnaphthalene, 2,3-	8.73E-04	Sulfur Dioxide	2.20E-03
Dimethylnaphthalene, 2,6-	8.73E-04	THCs as n-Hexane	5.32E-03
Dimethylnaphthalene, 2,7-	8.73E-04	2-Butanone (MEK)	1.68E-04
Dimethylphenol, 2,4-	8.73E-04	Acetaldehyde	1.68E-04
Dimethylphenol, 2,6-	8.73E-04	Acrolein	1.68E-04
Dodecane	8.73E-04	Benzaldehyde	1.68E-04
Ethylbenzene	1.75E-04	Butyraldehyde/Methacrolein	2.80E-04
Ethyltoluene, 2-	1.75E-04	Crotonaldehyde	1.68E-04
Ethyltoluene, 3-	8.73E-04	Formaldehyde	1.68E-04
Heptane	8.73E-04	Hexaldehyde	1.68E-04
Hexane	1.75E-04	o,m,p-Tolualdehyde	4.48E-04
Indan	8.73E-04	Pentanal (Valeraldehyde)	1.68E-04
Indene	8.73E-04	Propionaldehyde (Propanal)	1.68E-04

APPENDIX C DETAILED PROCESS DATA AND CASTING QUALITY PHOTOS

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FK Detailed Process Data

Greensand PCS										
Test Dates	**8/12/2003**	**8/12/2003**	**8/12/2003**	**8/19/2003**	**8/19/2003**	**8/20/2003**	**8/20/2003**	**8/20/2003**	**8/21/2003**	**Average**
Emissions Sample # / **Production Sample #**	**FK 001**	**FK 002**	**FK 003**	**FK 004**	**FK 005**	**FK 006**	**FK 007**	**FK 008**	**FK 009**	
Cast Weight (all metal inside mold), Lbs	97.5	103.0	96.0	96.5	107.5	104.0	96.5	103.0	100.5	**100.5**
Pouring Time, sec.	22	19	24	19	17	23	16	15	15	**19**
Pouring Temp ,°F	2673	2682	2688	2684	2689	2671	2684	2680	2682	**2681**
Pour Hood Process Air Temp at Start of Pour, °F	85	88	89	88	88	86	88	88	87	**87**
Muller Batch Weight, Lbs.	895.07	895.10	894.60	1294.88 [1]	894.99	894.88	894.88	894.88	894.88	**894.91** [2]
GS Mold Sand Weight, Lbs.	650	646	650	646	640	656	650	646	650	**648**
Mold compactability, %	45	43	48	46	45	45	50	50	45	**46**
Mold Temperature, °F	80	86	90	75	85	79	90	90	81	**84**
Average Green Compression , psi	12.16	11.42	10.48	13.65	13.62	12.61	12.24	11.89	14.15	**12.47**
GS Compactability, %	35	42	28	42	40	41	47	44	45	**40**
GS Moisture Content, %	1.89	1.92	1.98	1.98	2.02	2.00	2.20	2.16	2.18	**2.04**
GS Clay Content, %	7.00	6.74	6.74	7.00	7.26	7.00	6.74	6.74	6.74	**6.88**
MB Clay reagent, ml	27.0	26.0	26.0	27.0	28.0	27.0	26.0	26.0	26.0	**26.6**
1800°F LOI - Mold Sand, %	4.86	4.95	4.86	5.10	5.18	5.31	5.35	5.48	5.64	**5.19**
900°F Volatiles , %	0.98	1.16	0.96	1.02	0.96	0.94	1.02	1.24	0.80	**1.01**

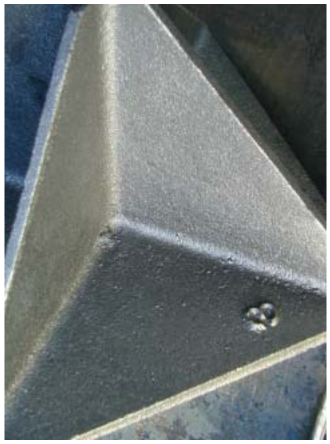
Note 1: The procedure for accumulating return sand components had not been strictly adhered to, so all sand materials were gathered together and reblended to maintain constitutional integri

Note 2: Average of all muller batch weights except FK004. See Note 1

HE Detailed Process Data

Greensand PCS													
Pour Date	**1/9/2006**	**1/9/2006**	**1/9/2006**	**1/10/2006**	**1/10/2006**	**1/10/2006**	**1/11/2006**	**1/11/2006**	**1/11/2006**	**1/12/2006**	**1/12/2006**	**1/12/2006**	**Average**
Emissions Sample #	**HECR1**	**HECR2**	**HECR3**	**HE001**	**HE002**	**HE003**	**HE004**	**HE005**	**HE006**	**HE007**	**HE008**	**HE009**	
Production Sample #	**HE001**	**HE002**	**HE003**	**HE004**	**HE005**	**HE006**	**HE007**	**HE008**	**HE009**	**HE010**	**HE011**	**HE012**	
Cast Weight - All Metal Inside Mold (lbs.)	**101.10**	**100.90**	**100.80**	**107.90**	**107.75**	**105.00**	**106.30**	**108.50**	**107.05**	**105.10**	**109.90**	**108.10**	107.3
Pouring Time (sec.)	12	12	12	11	11	11	13	11	11	13	11	11	11
Pouring Temp (°F)	2671	2686	2685	2685	2687	2690	2678	2690	2685	2685	2690	2672	2685
Pour Hood Process Air Temp at Start of Pour (°F)	85	87	87	88	86	87	87	86	88	87	88	86	87
Muller Batch Weight (lbs.)	1300	900	900	900	900	900	900	900	900	900	900	910	901
GS Mold Sand Weight, (lbs.)	650.00	650	642	649	645	652	641	647	646	646	630	640	644
Mold Temperature (°F)	74.9	77	77	69	79	82	71	79	82	74	81	81	77
Average Green Compression (psi)	26.6	23.5	25.8	26.9	26.0	27.2	26.4	28.0	26.6	29.9	28.9	26.0	27.3
GS Compactability (%)	46	51	47	45	41	40	50	40	39	43	42	38	42
GS Moisture Content (%)	2.65	2.65	2.52	2.50	2.24	2.32	2.68	2.38	2.15	2.39	2.38	2.38	2.38
GS MBClay Content (%)	7.58	7.58	7.78	7.20	7.20	7.20	7.20	7.39	7.20	7.20	7.29	7.00	7.21
MB Clay reagent, ml	39	39	40	37	37	37	37	38	37	37	38	36	37
1800°F LOI - Mold Sand (%)	2.47	2.61	2.47	2.36	2.24	2.25	2.30	2.24	2.23	2.24	2.17	2.16	2.24
900°F Volatiles (%)	0.66	0.70	0.56	0.50	0.52	0.52	0.58	0.56	0.52	0.48	0.54	0.52	0.53
Rank order 1=best, 5 = median, 9 = worst	1a	3a	5a	3	5	4	1	2	6	9	8	7	**5**

Casting Surface Quality Comparison Photos

	FK	HE
Best	**FK001** 	**HE004** 
Median	**FK008** 	**HE002** 
Worst	**FK004** 	**HE007** 

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APPENDIX D CONTINUOUS EMISSION MONITORING CHARTS

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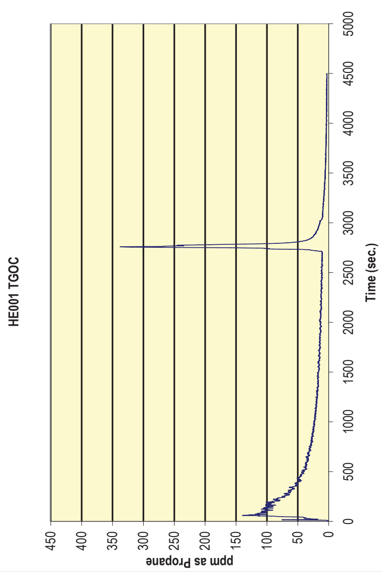
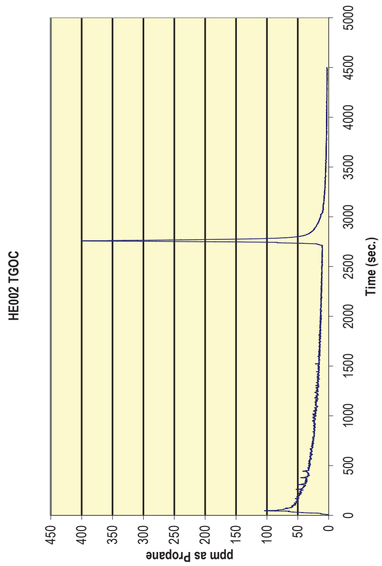
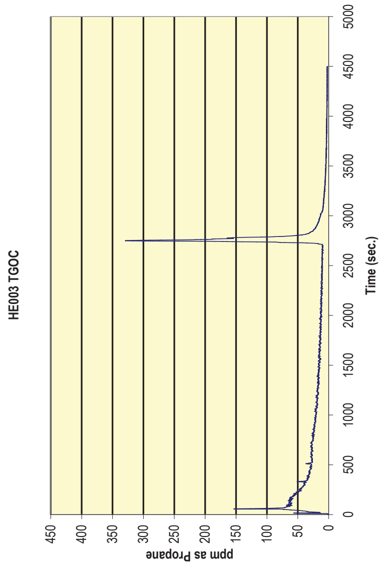
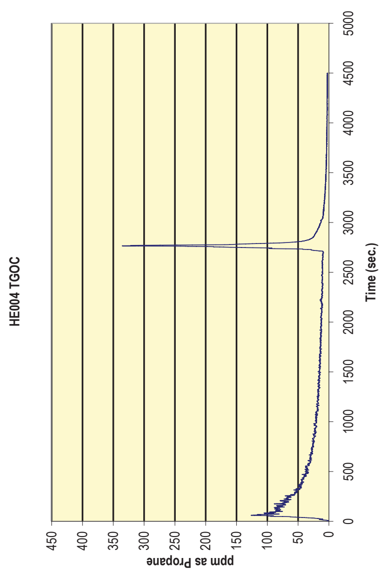
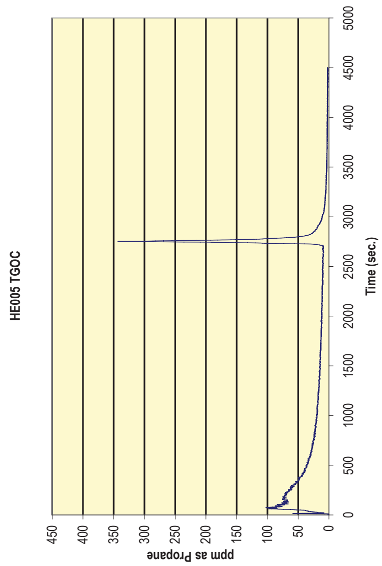
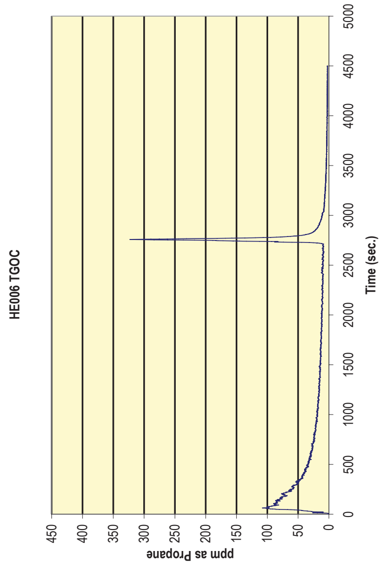

HE001 TGOC
ppm as Propane
Time (sec.)

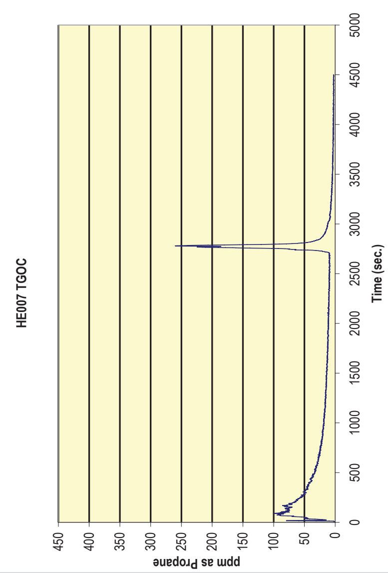

HE002 TGOC
ppm as Propane
Time (sec.)

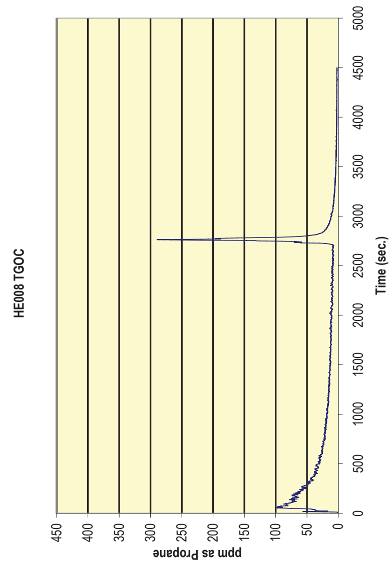

HE003 TGOC
ppm as Propane
Time (sec.)

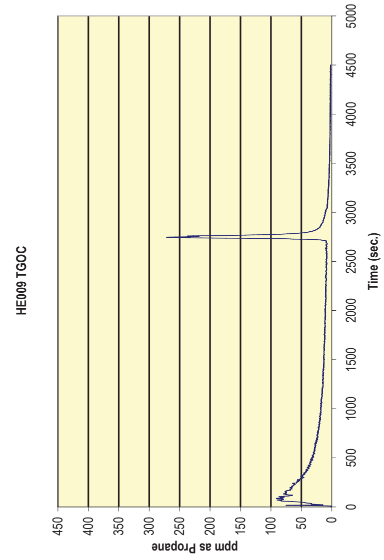

HE004 TGOC
ppm as Propane
Time (sec.)

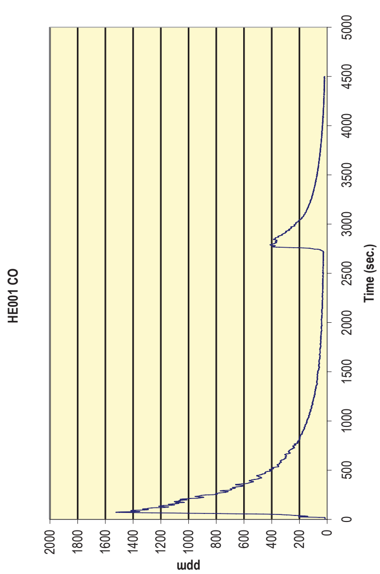

HE005 TGOC
ppm as Propane
Time (sec.)

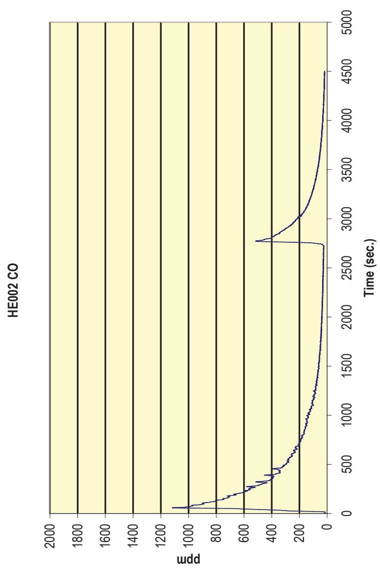

HE006 TGOC
ppm as Propane
Time (sec.)

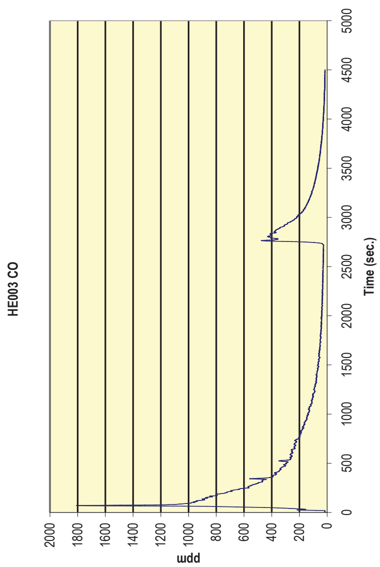

HE007 TGOC
ppm as Propane
Time (sec.)

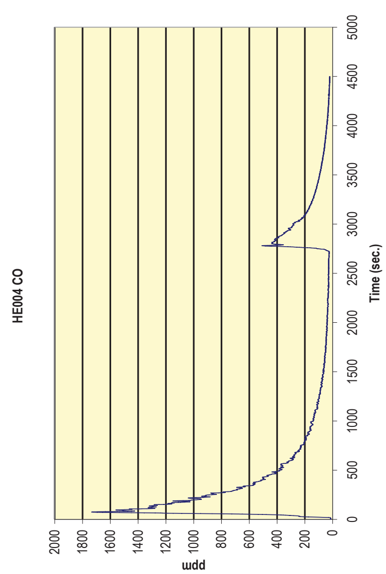

HE008 TGOC
ppm as Propane
Time (sec.)

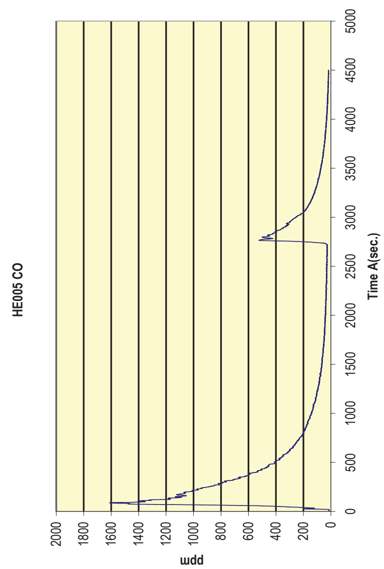

HE009 TGOC
ppm as Propane
Time (sec.)

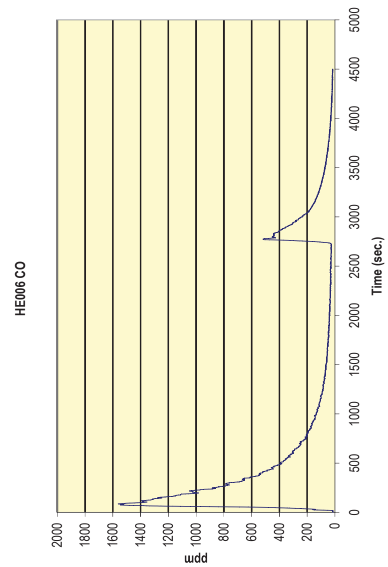

HE001 CO
ppm
Time (sec.)

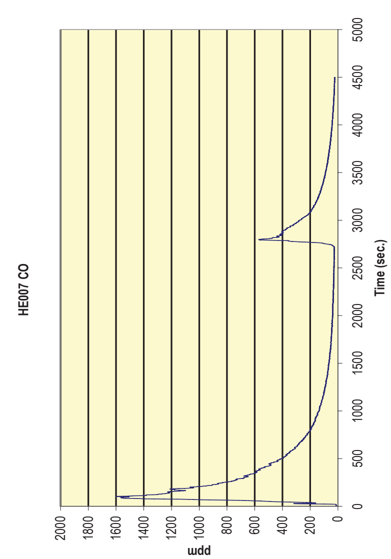

HE002 CO
ppm
Time (sec.)

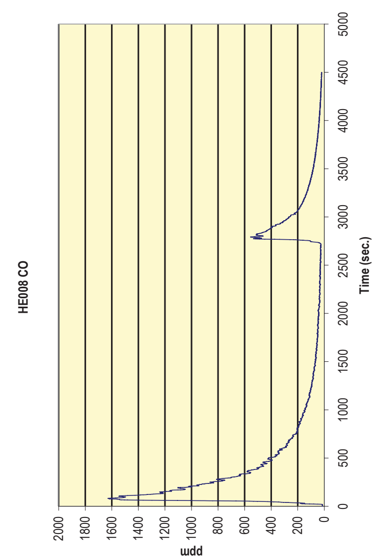

HE003 CO
ppm
Time (sec.)

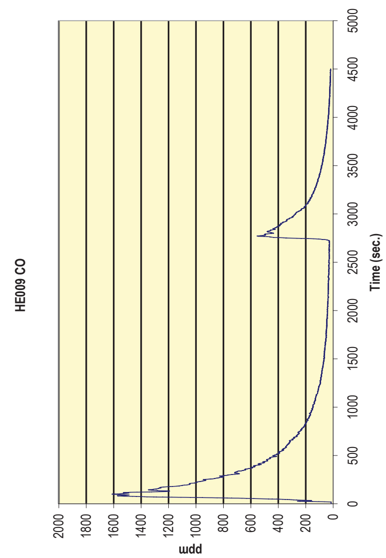

HE004 CO
ppm
Time (sec.)

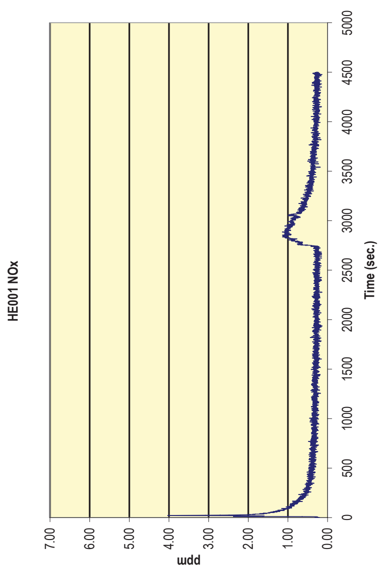

HE005 CO
ppm
Time A(sec.)

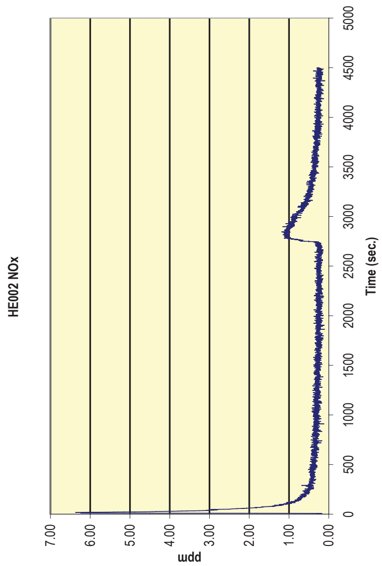

HE006 CO
ppm
Time (sec.)

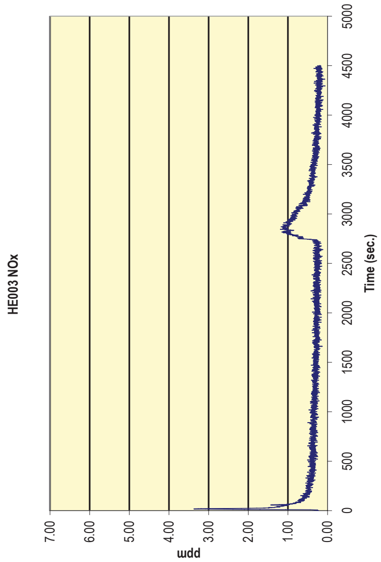

HE007 CO
ppm
Time (sec.)

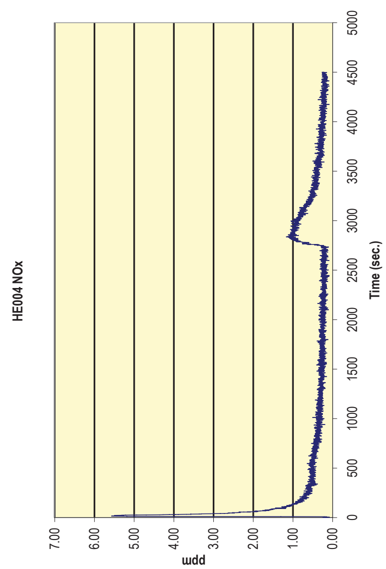

HE008 CO
ppm
Time (sec.)

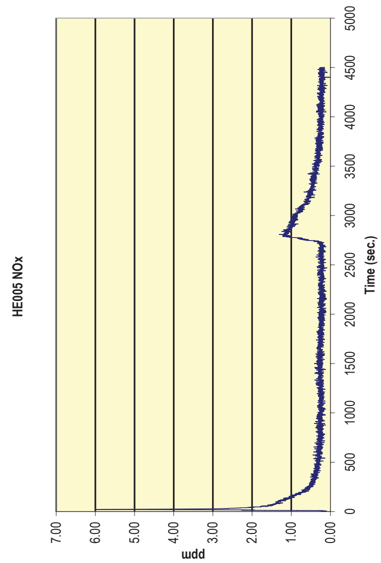

HE009 CO
ppm
Time (sec.)

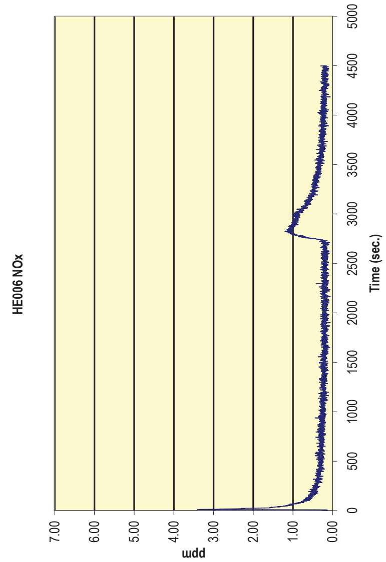

HE001 NOx
ppm
Time (sec.)

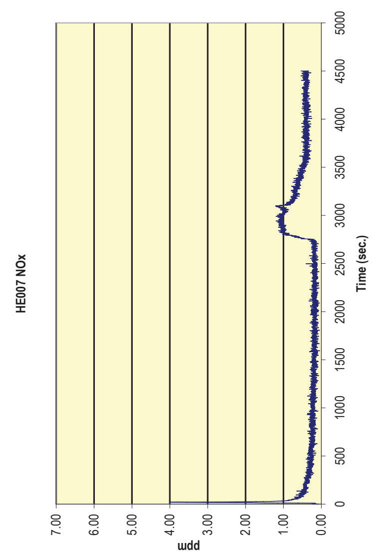

HE002 NOx
ppm
Time (sec.)

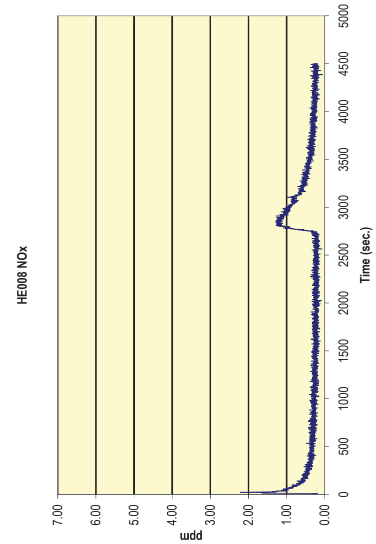

HE003 NOx
ppm
Time (sec.)

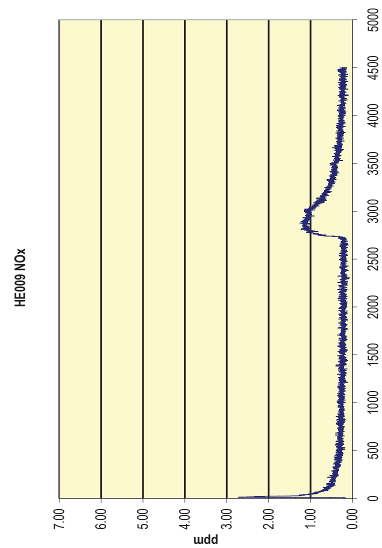

HE004 NOx
ppm
Time (sec.)

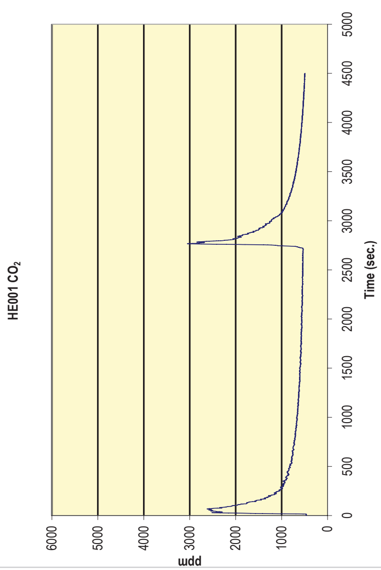

HE005 NOx
ppm
Time (sec.)

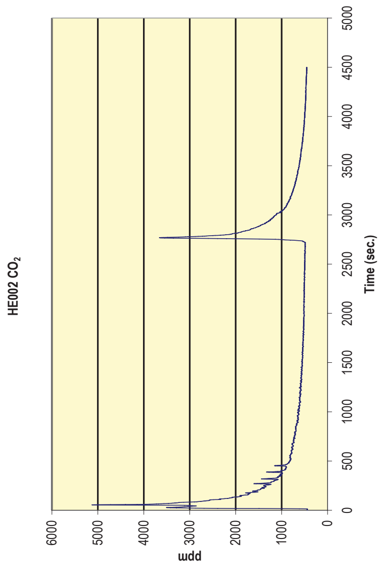

HE006 NOx
ppm
Time (sec.)

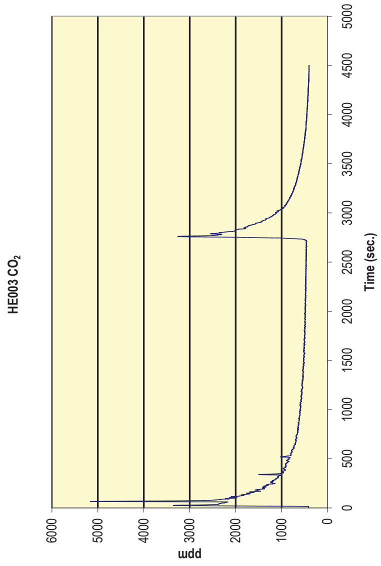

HE007 NOx
ppm
Time (sec.)

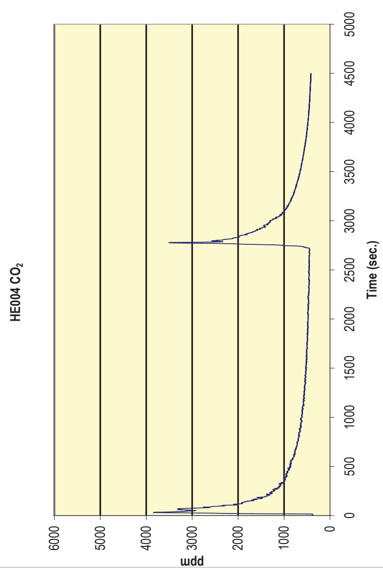

HE008 NOx
ppm
Time (sec.)

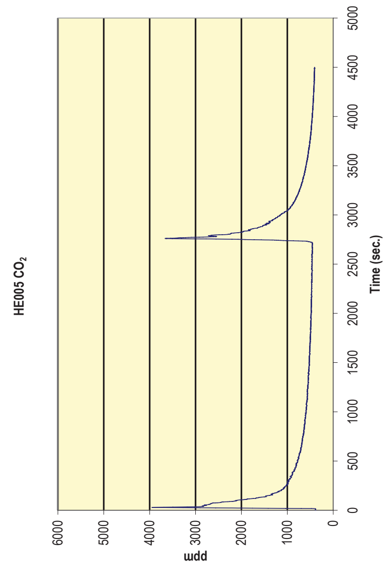

HE009 NOx
ppm
Time (sec.)

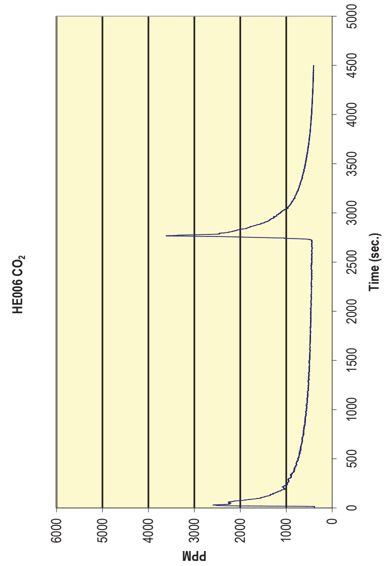

HE001 CO2
ppm
Time (sec.)

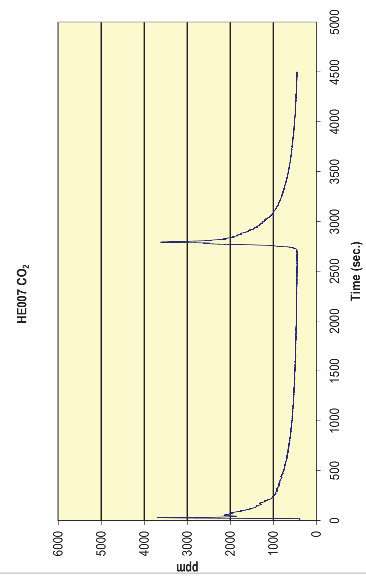

HE002 CO2
ppm
Time (sec.)

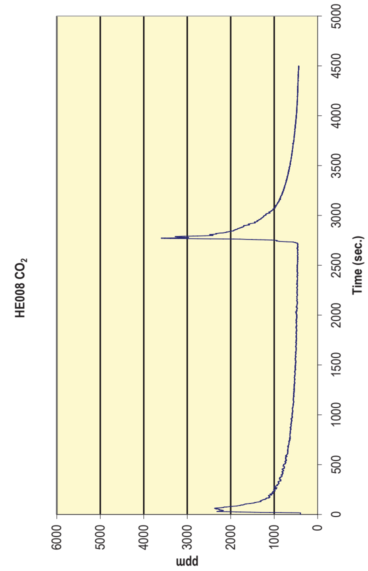

HE003 CO2
ppm
Time (sec.)


HE004 CO2
ppm
Time (sec.)


HE005 CO2
ppm
Time (sec.)


HE006 CO2
PPM
Time (sec.)


HE007 CO2
ppm
Time (sec.)


HE008 CO2
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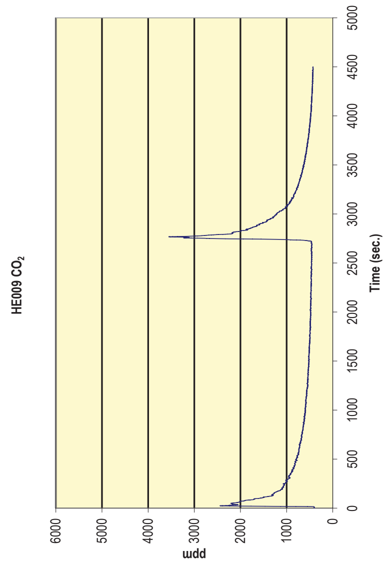
Time (sec.)


HE009 CO2
ppm
Time (sec.)

APPENDIX E ACRONYMS AND ABBREVIATIONS

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APPENDIX E ACRONYMS AND ABBREVIATIONS

AFS	American Foundry Society
BO	Based on ( ).
BOS	Based on Sand.
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CEMS	Continuous Emissions Monitoring Systems
CERP	Casting Emission Reduction Program
CO	Carbon Monoxide
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
ERC	Environmental Research Consortium
FID	Flame Ionization Detector
GC	Gas Chromatography
GS	Greensand
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC as Hexane	The quantity of undifferentiated hydrocarbons determined by Wisconsin Cast Metals Association – maximum potential to emit method, revised 07/26/01.
I	Invalidated Data
Lb/Tn	Pound per ton of metal poured
LOI	Loss on ignition
MB	Methylene Blue
NA	Not Applicable; Not Available
ND	Non-Detect; Not Detected
NIST	National Institute of Standards and Technology
NT	Not Tested - Lab testing was not done
OSHA	Occupational Safety & Health Administration
PCS	Pouring, Cooling, Shakeout
POM	Polycyclic Organic Matter
QA/QC	Quality Assurance/Quality Control

SO_2	Sulfur Dioxide
TGOC	Total Gaseous Organic Concentration
TGOC as Propane	Quantity of undifferentiated hydrocarbons including methane determined by EPA Method 25A.
THC	Total Hydrocarbon Concentration
TTE	Temporary Total Enclosure
US EPA	United States Environmental Protection Agency
USCAR	United States Council for Automotive Research
VOC	Volatile Organic Compound
WBS	Work Breakdown Structure