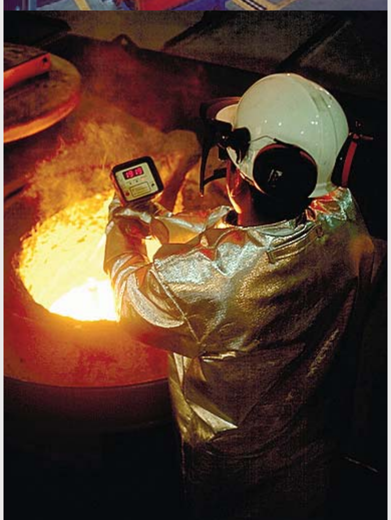
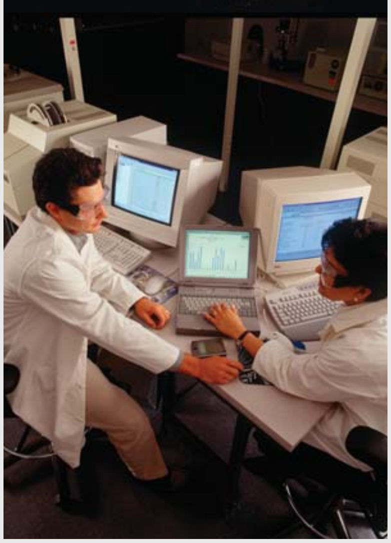
Casting Emission Reduction Program

www.cerp-us.org





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Aluminum Mold Curing and Pouring/Ablation

1412-146 HG

January 2007
(Revised for public distribution - May 2007)

CASTING INDUSTRY SUPPLIERS ASSOCIATION

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Aluminum Mold Curing and Pouring/Ablation

1412-146 HG

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 producibility.

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EXECUTIVE SUMMARY

This report contains the results of CERP Test HG. This test was designed to sample air emissions from two aluminum foundry processes at Eck Industries in Manitowoc, Wisconsin. The test was conducted on-site at Eck. Samples were collected from both a mold curing and a pouring/ablation process. Molds were made from an inorganic binder specifically designed for the ablation process. The ablation process is unique in that poured molds are subjected to a water spray that removes the sand and eliminates the need for the normal cooling and shakeout cycles. Testing was designed to capture evolved air emissions over a representative time period for each process. All materials and patterns were supplied by Eck Industries, and were specific to the two processes tested.

Both speciated target analytes and total gaseous organic compounds (TGOC calibrated as propane) were collected and analyzed. No criteria or greenhouse gas compounds were targeted for collection or monitoring with the exception of sulfur dioxide (SO_2). Presented speciated results in the tables of this report are background corrected for determination of the emissions resulting from the specific processes tested and not the total emissions present in the foundry during the testing period. TGOC results are included for the mold curing process, although the data may not be indicative of process emissions, but most likely represent total foundry processes occurring at the same time as testing. This was due to the sampling equipment being located and collecting data in the foundry during daily operations. As a result, background levels for this instrument were constantly fluctuating and nearby emissions sources were sampled throughout the testing period. The TGOC instrument failed at the conclusion of the mold curing test, and was unavailable for monitoring the pouring and ablation process emissions. The TGOC results which are presented also include the exempted compound methane. At present, the methane contribution has not been determined or removed. Emissions results are reported in pounds of analyte per ton (lb/ton) of metal poured or pounds of analyte per pound (lb/lb) of binder as applicable.

In the data validation, verification and reporting of results from this test, an analyte is defined as non-detect if its concentration is equal to or less than the practical quantitation limit (PQL). Non-detect results are shown as ND in the Tables and Figures of this report.

Table 1a Mold Curing Average Emission Indicators Summary Table – Lb/Lb Binder

Analyte Name	Average	Standard Deviation
Emission Indicators		
TGOC as Propane	0.00542	0.00074
HC as Hexane	ND	NA
Sum of Target Analytes	0.00002	0.00001
Sum of Target HAPs	0.00002	0.00001
Sum of Target POMs	ND	NA

Table 1b Pouring and Ablation Average Emission Indicators Summary Table – Lb/Tn Metal

Analyte Name	Average	Standard Deviation
Emission Indicators		
TGOC as Propane	NA	NA
HC as Hexane	0.0106	0.0022
Sum of Target Analytes	0.0235	0.0053
Sum of Target HAPs	0.0206	0.0055
Sum of Target POMs	0.0008	0.0003

The emissions measurements and results presented in this report are unique to the specific castings produced, materials used, and testing methodology associated with these tests.

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.

Eck Industries, Inc. is a privately-owned family business well experienced in the aluminum foundry industry. They have a wide range of aluminum casting capabilities, ranging from prototype casting and casting processes through long production runs, simple to complex designs, and sizes ranging from a 1/2 pound to 2000 pounds. Sand casting mold processes range from the basics through advanced core assembly cells. A variety of shell molding processes are used at the facility and several types of low pressure permanent molding are also in use.

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 test that was designed to evaluate the airborne emissions from a prototype pouring and ablation of aluminum, and the associated mold curing process.

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 of this report, with detailed data included in the report appendices. 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

CERP was requested to test air emissions from an experimental process for the pouring and simultaneous cooling and shakeout (ablation process) of aluminum. Both the ablation process and the associated core and mold curing processes were tested at the Eck Industries Foundry. To determine whether these processes would contribute additional emissions to the overall plant emissions required testing on-site for both processes. Testing was conducted over a three day period during the first week of May, 2006. The test summary is given in Table 1-1.

Table 1-1 Test Summary

Test Plan	Core/Mold Curing	Pouring/Ablation
Test Plan Number	1412-146	
Test Dates	May 02, 2006	May 03 and May 04, 2006
Sample Numbers	HG001-HG003 and system blank 001	HG020-HG022 and system blank 002
Number of Sampling Runs	3	3
Number of Molds	Seven copes and drags run 1; five copes and drags each, run 2 and run 3	10 molds each for run 1 through run 3
Metal Poured	none	Aluminum
Emissions Measured	Selected target analytes, including HAPs and TGOC	Selected target analytes, including HAPs
Process Parameters Measured	Mold and binder weights; temperature, moisture content, volumetric flow rate	Total casting and mold weights; Metallurgical data; stack temperature, moisture content, and volumetric flow rate

2.0 TEST METHODOLOGY

2.1. DESCRIPTION OF PROCESS AND TESTING EQUIPMENT

A unique sampling protocol and collection equipment were required and developed for each of the tested processes as described below.

Figure 2-1 Custom Mold Curing Emissions Enclosure

Core/Mold Making: A specially designed hinged box was made to enclose either a cope or drag during curing to provide a site for representative measurement and collection for mold curing emissions (Figure 2-1), and to facilitate quick sample turnaround times. Samples were drawn from a duct at the bottom of the box connected to the recirculation pump (Figure 2-2). Air was continually re-circulated from the pump into the box and through the mold during curing. Venting holes

Figure 2-2 Emissions Collection and Sampling

were located at the rear of the box to prevent overheating of the mold (Figure 2-3) during curing.

Figure 2-3 Emissions Enclosure Venting

Mold Pouring and Ablation: The second process sampled was a combined pouring and mold ablation process. This is an experimental process wherein after molten aluminum is poured into a mold, the casting is immediately conveyed through a water curtain for simultaneous cooling and removal of the mold (Figure 2-4). As soon as the mold encounters the water curtain, the aluminum is quenched and the mold begins breaking up (ablation), thus eliminating the necessity for a separate mechanical mold removal process. The binder used in this process was a water soluble inorganic system specifically designed for the ablation process. During ablation, sand and water were collected in a tank located at the bottom of the ablation apparatus. Water was reused for the ablation and cooling of subsequent molds, while the sand was collected in the tank.

Figure 2-4 The Ablation Process

For capturing emissions of the pouring and ablation process, a polyethylene "tent" was constructed over the equipment (Figure 2-5) with a 4" opening at the apex (Figure 2-6). Ducting was connected from the opening to a pump, and samples were drawn through a 4" unheated PVC pipe (Figure 2-7) located on the outside of the enclosure.

Figure 2-5 Tent for Emissions Capture

Details of the sampling methodologies used for collecting and analyzing emissions from both processes can be found in Section 2.2.

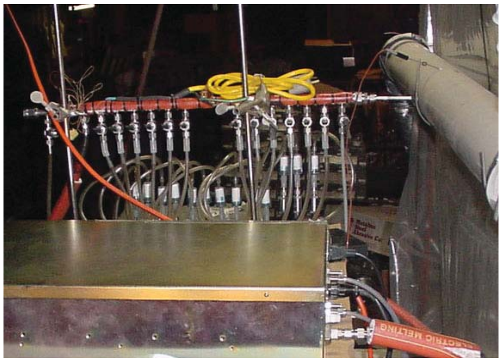
2.2. DESCRIPTION OF TESTING PROGRAM

Figure 2-6 Vent for Emissions

Air emission testing of two foundry processes was conducted. Three emissions runs each of a mold curing process and a novel pouring and combined ablation process were tested, as well as a system blank for each. Each run consisted of multiple parts as described in Section 2.2.3.

Key parameters were monitored and recorded prior to and during the emission tests. Process measurements taken for these tests included the weights of the casting and mold sand. Measured emission source parameters included stack temperature, pressure, volumetric flow rate, and moisture content.

Figure 2-7 Ablation Sample Collection Apparatus



Emissions testing for hydrocarbons included several methods. Method 18 is one of the US Environmental Protection Agency (EPA) reference methods for volatile organic compound (VOC) analysis. This method is a guideline and a system of quality assurance checks (QA) for VOC analysis rather than a rigorous, explicit manual for sampling or 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).

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

Two methods were employed to measure undifferentiated hydrocarbon emissions as Emission Indicators: TGOC as Propane, performed in accordance with EPA Method 25A, and HC as Hexane.

Method 25A is an instrumental based method in which 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 any other exempt compounds are included in the results, as per the method design. For the current test, the contributions from these compounds have not been determined or removed from the averaged results. In addition, as described above, plant as well as process emissions were recorded during sampling, and cannot be subtracted from the results.

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

Mass emission rates for all analytes were calculated using collected source data and appropriate process data. Detailed emission results are presented in Appendix B. In addition to the individual analyte emission calculations, five “Emission Indicators” were determined: TGOC as Propane, HC as Hexane, Sum of Target Analytes, Sum of Target Hazardous Air Pollutants (HAPs), and the Sum of Target Polycyclic Organic Matter (POMs). Full descriptions and explanations of these indicators can be found in Section 3.0 of this report.

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

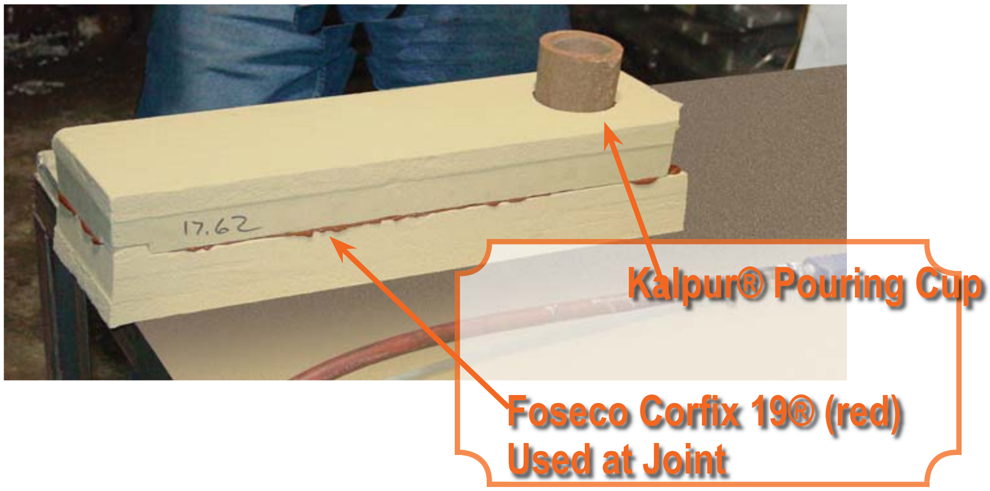
2.2.1. Test Plan Review and Approval

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

2.2.2. Mold, and Metal Preparation

Molds were made to a standard composition by personnel at the Eck Foundry using a proprietary water soluble inorganic binder at 1.2% BOS (based on sand). This binder is amenable to the ablation process by its high solubility in water, thus making molds easily erodible by the flowing water curtain. An example of a cured and finished mold which was used in the combined pouring/ablation process is shown in Figure 2-8. A Foseco Kalpur® pouring cup with foam filter was used in each mold.

Figure 2-8 Finished Mold



2.2.3. Individual Sampling Events

Each mold curing run consisted of sampling multiple individual copes and drags. For each mold, either the cope or drag from a single mold was first placed into the specially designed testing chamber (Figure 2-1) and the lid closed. The circulation and sampling pumps were started, and valves leading to the sampling tubes for emission collection were opened. After curing, which usually took about 3 - 4 minutes for the cope or 7 to 8 minutes for the drag, pumps and valves were closed and the first mold part replaced with its complement in the sampling chamber. Pumps and valves were restarted, and sampling continued. At the end of the curing time for the mold, the sampling stopped. For the first run, seven molds were sampled, for an elapsed run time of approximately 80 minutes. Run 2 and Run 3 sampled 5 molds (combined copes and drags) for a sampling time of 57 minutes each. A summary of sampling times and events is given in Table 2-1.

Table 2-1 Mold Curing Summary

	Drag				Cope				Cope & Drag	
	Sample Number	Sand Wt, Lb	Cure Time, decimal min.	Box Temp, °F	Sample Number	Sand Wt, Lb	Cure Time, decimal min.	Box Temp, °F	Total Wt, Lb	Total Cure Time, decimal min.
Run HG001 May 2, 2006	01	19.02	8.14	118	01	18.16	3.70	108	37.18	11.84
	02	19.54	8.00	124	02	18.40	3.58	120	37.94	11.58
	03	10.72	8.17	125	03	18.02	3.24	117	28.74	11.41
	04	10.96	7.61	128	04	18.74	3.59	125	29.70	11.20
	05	11.38	8.06	115	05	18.62	3.41	127	30.00	11.47
	06	11.46	8.12	122	06	17.96	3.38	118	29.42	11.50
	07	11.30	8.08	N/A	07	19.40	3.18	N/A	30.70	11.27
Run 1 Totals		94.38	56.18			129.30	24.08		223.68	80.27
Run HG002 May 2, 2006	01	10.36	8.06	113	01	18.62	3.36	102	28.98	11.42
	02	11.30	8.15	121	02	19.02	3.27	117	30.32	11.42
	03	11.02	8.06	120	03	18.28	3.25	123	29.30	11.31
	04	11.12	8.08	127	04	18.16	3.26	122	29.28	11.34
	05	11.16	8.18	129	05	18.38	3.25	128	29.54	11.43
Run 2 Totals		54.96	40.53			92.46	16.39		147.42	56.92
Run HG003 May 2, 2006	01	10.82	8.12	112	01	18.24	3.24	114	29.06	11.36
	02	18.88	8.05	121	02	18.48	3.21	122	37.36	11.26
	03	19.44	8.02	125	03	18.44	3.21	126	37.88	11.23
	04	11.16	8.26	128	04	18.50	3.26	126	29.66	11.52
	05	10.86	8.08	128	05	18.22	3.20	127	29.08	11.28
Run 3 Totals		71.16	40.53			91.88	16.12		163.04	56.65

Sampling for the pouring and ablation process also consisted of combining emissions from multiple molds for each run. The procedure for each run began with the polyethylene doors being opened for pouring. The clock was started as soon as the molten aluminum hit the mold. The doors were then immediately closed and sampling continued until the ablation water was turned off. The turn around or cycle time was the period between when the casting was removed until the next mold was placed on the conveyor and the ladle was manually raised to pour the new mold. A summary of sampling times and events is given in Table 2-2.

Table 2-2 Pouring and Ablation Summary

	Mold Sample Number	Sand Total Wt., lb	Pour Temp, °F	Total Pour Time, decimal min.	Ablation Time, decimal min.	Metal Gross Wt., lb
Run HG020 May 3, 2006	01	29.04	1186	0.14	4.54	8.50
	02	29.44	1181	0.08	4.54	8.54
	03	28.94	1182	0.15	4.56	8.24
	04	29.12	1185	0.10	4.56	8.26
	05	28.92	1178	0.10	4.62	8.40
	06	29.62	1179	0.09	4.66	8.40
	07	29.40	1179	0.12	4.57	8.26
	08	28.92	1181	0.11	4.59	8.14
	09	29.52	1177	0.10	4.56	8.24
	10	30.28	1180	0.10	5.09*	8.02
Run 1 Total:		293.20		1.09	46.29	83.00
Run HG021 May 4, 2006	01	30.22	1180	0.13	4.58	8.72
	02	29.98	1180	0.14	4.57	8.60
	03	29.14	1179	0.11	4.59	8.64
	04	28.66	1179	0.11	4.59	8.12
	05	30.62	1180	0.14	4.55	8.86
	06	29.70	1179	0.12	4.60	8.52
	07	29.54	1182	0.13	4.58	8.76
	08	29.64	1180	0.11	4.63	8.76
	09	29.96	1180	0.14	4.60	8.90
	10	29.42	1180	0.13	4.58	8.74
Run 2 Total:		296.88		1.26	45.87	86.62
Run HG022 May 4, 2006	01	29.62	1174	0.14	4.57	8.70
	02	29.26	1176	0.12	4.57	8.82
	03	38.00	1176	0.14	4.58	8.56
	04	29.96	1178	0.12	4.65	8.74
	05	29.72	1180	0.14	4.59	8.68
	06	28.56	1180	0.13	NA	8.76
	07	29.34	1175	0.14	4.59	8.72
	08	38.20	1179	0.21	4.56	8.66
	09	29.82	1179	0.13	4.57	8.88
	10	29.82	1181	0.12	4.64	9.08
Run 3 Total:		312.30		1.39	41.32**	87.60

Note: * indicates Test 1, Mold 10 Ablation Time are estimated

Note: ** indicates Test 3, Mold 6 Ablation time not included in test total

2.2.4. Parameter Measurements

Parameters such as sand weight and temperature, binder weight and total mold weight were measured and are summarized in Table 2-3 for both mold curing and pouring/ablation processes.

Table 2-3 Monitored Process and Metallurgical Parameters

Curing	Pouring/Ablation
Mold Weight	Pouring Temperature
Core Weight	Casting Weight
Muller Water Weight	Sand Weight
Binder Weight	Binder Weight
Sand Weight	Metal Weight
Sand Temperature	
Box Temperature	

2.2.5. Air Emissions Analysis

The specific sampling and analytical methods used for the tests conducted at Eck Foundry are based on federal regulatory reference methods shown in Table 2-4. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Standard Operating Procedures.

Table 2-4 Measurement Equipment and 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 and HAPs	US EPA Methods TO17, TO11; NIOSH Method 1500
TGOC	US EPA Method 25A
SO_2	OSHA ID 200

Some methods are 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 emission results for each event are given in Section 3.0, Table 3-1 and Table 3-2.

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

The average emission results for individual target analytes and emission indicators for Test HG are summarized in Table 3-1 for the mold curing portion as pounds per pound (lb/lb) of binder, and for the pouring and ablation process in Table 3-2 as pounds per ton (lb/ton) of metal. Individual target compounds or isomer classes included in the tables are those that comprise at least 95% of the total targeted analytes measured, as well as the "Sum of Target Analytes", the "Sum of Target HAPs", and the "Sum of Target POMs". These three analyte sums are part of the group termed "Emission Indicators." Also included in this group and reported on the tables are "TGOC as Propane" and "HC as Hexane". In addition, the average value for the selected criteria

Table 3-1 Summary of Top 95% of Analytes for HG Curing Process (Background Corrected) Average Results - Lb/Lb Binder

Analyte Name	Average	Standard Deviation
Emission Indicators		
TGOC as Propane	0.00542	0.00074
HC as Hexane	ND	NA
Sum of Target Analytes	0.00002	0.00001
Sum of Target HAPs	0.00002	0.00001
Sum of Target POMs	ND	NA
Selected Target HAPs and POMs		
Formaldehyde	0.00002	0.00001
Criteria Pollutants and Greenhouse Gases		
Sulfur Dioxide	ND	NA
Carbon Dioxide	NT	NT
Carbon Monoxide	NT	NT
Nitrogen Oxides	NT	NT

NT= Not Tested

ND= Not Detected

NA= Not Applicable

Selected results constitute >95% of the mass of all detected target analytes.

<0.00001= less than reporting limit of 0.00001 lb/lb binder

TGOC as Propane not corrected by system blank.

Table 3-2 Summary of Top 95% of Analytes for HG Pouring/Ablation Process (Background Corrected) Average Results - Lb/Tn Metal

Analyte Name	Average	Standard Deviation
Emission Indicators		
TGOC as Propane	NT	NT
HC as Hexane	0.0106	0.0022
Sum of Target Analytes	0.0235	0.0053
Sum of Target HAPs	0.0206	0.0055
Sum of Target POMs	0.0008	0.0003
Selected Target HAPs and POMs		
Formaldehyde	0.0105	0.0070
Phenol	0.0029	0.0004
Toluene	0.0024	0.0007
Benzene	0.0019	0.0005
Xylenes	0.0010	0.0004
Cresols	0.0008	0.0001
Naphthalene	0.0008	0.0003
Additional Selected Target Analytes		
Indan	0.0009	0.0000
Heptane	0.0008	0.0008
Dimethylphenols	0.0008	0.0001
Criteria Pollutants and Greenhouse Gases		
Sulfur Dioxide	0.0021	0.0036
Carbon Dioxide	NT	NT
Carbon Monoxide	NT	NT
Nitrogen Oxides	NT	NT

NT= Not Tested

Selected results constitute >95% of the mass of all detected target analytes.

<0.0001= less than reporting limit of 0.0001 lb/ton metal

pollutant, sulfur dioxide, is given.

Results for individual analytes for the test calculated averages which were below the generally stated reporting limit of 0.00001 lb/lb binder or 0.0001 lb/ton metal are shown with a less than sign (<) in the tables. The reporting limit for the mold curing was decreased from 0.0001 to 0.00001 in order to show numerical results in the tables. Using the higher value would result in only zero results showing in the table.

Compounds which were chosen for analysis based on chemical and operational parameters are the target analytes. The emissions indicator called the "Sum of Target Analytes" is the sum of all individual analytes 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 compounds from the current list of EPA organic HAPs was targeted for collection and analysis. These individual target HAPs (which may also be POMs by nature of their chemical properties) detected in the samples are summed together and defined as the "Sum of Target HAPs", while the "Sum of Target POMs" only sums those organic HAPs that are also defined as POMs.

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.

Both total gaseous organic compounds (TGOC as propane) and speciated target analytes were collected and analyzed. No criteria or greenhouse gas compounds were targeted for collection with the exception of sulfur dioxide (SO_2). Presented speciated results were background corrected prior to calculation of emission factors for determination of the emissions resulting from the specific processes tested rather than unrelated emissions present in the foundry during the testing period.

TGOC results are presented in this report for the mold curing process, although the data represents the emissions from total foundry processes occurring at the same time as testing. This was due to the sampling equipment being located and collecting data in the foundry during daily operations. As a result, background levels for this instrument were constantly fluctuating and nearby emissions sources were sampled throughout the testing period. This can be seen in the profiles presented in Appendix D. The TGOC results also include the exempted compound methane. At present, the methane contribution has not been determined or removed. The TGOC instrument failed at the conclusion of the mold curing test, and was unavailable for monitoring the pouring and ablation process emissions.

Additional compounds other than those specifically targeted for collection and analysis were present on all the thermal desorption and GC/MS chromatograms, including the system blanks for both the curing process and the pouring and ablation process. At least one of those compounds was a HAP. Since they were present in all samples, including those from the foundry background air, subtracting the background from the results ensures that only those compounds emanating from the test source are reported.

In the data validation, verification and reporting of results from this test, an analyte is defined as non-detect if its concentration is below the experimentally measured limit of detection (practical quantitation limit, PQL). The PQL is statistically related to the detection limitations of an analytical method and the capabilities of analytical instrumentation. In individual runs where an analyte is reported as below this limit, the non-detect value is substituted by the value of zero for calculation purposes. If an analyte average concentration falls below the PQL when all individual runs are averaged over the entire test (in this case there are three runs for each process which are averaged together), the test average for that analyte is shown as ND in the Tables and Figures of this report.

Figures 3-1a to 3-2c graphically present the data from the tables for Test HG of the five emissions indicators as well as selected individual HAP, organic analyte, and criteria pollutant and greenhouse gas emissions data as lb/ton of metal and/or lb/lb of binder as applicable.

Figure 3-1a Emissions Indicators, Test HG Core Making (Background Corrected), Average Results – Lb/Lb Binder

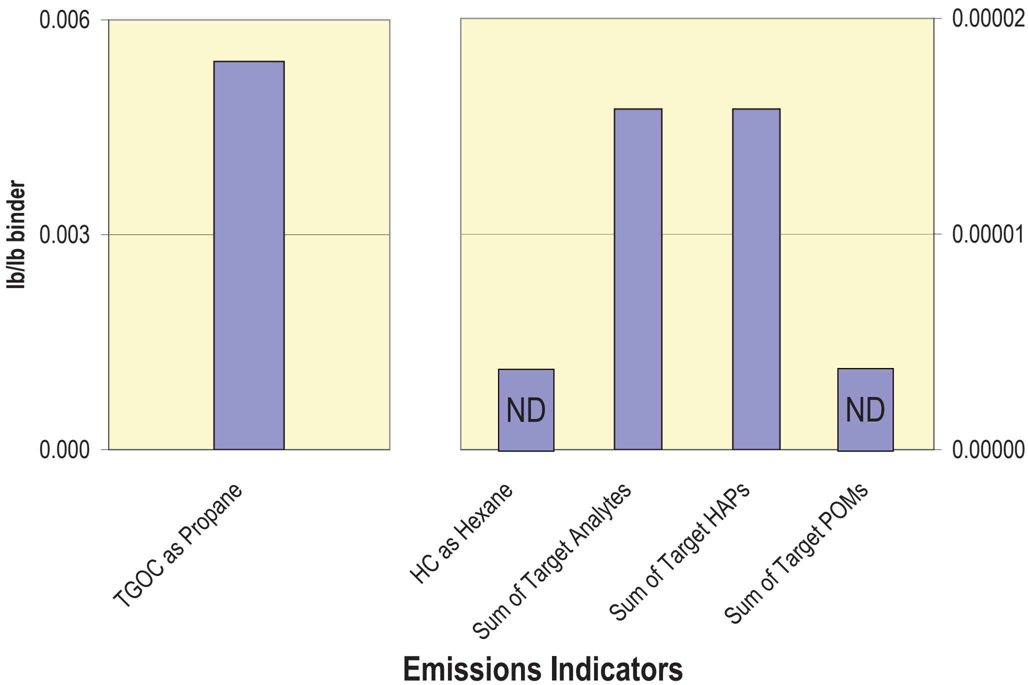


Figure 3-1b Selected HAP and POM Emissions, Test HG Core Making (Background Corrected), Average Results – Lb/Lb Binder

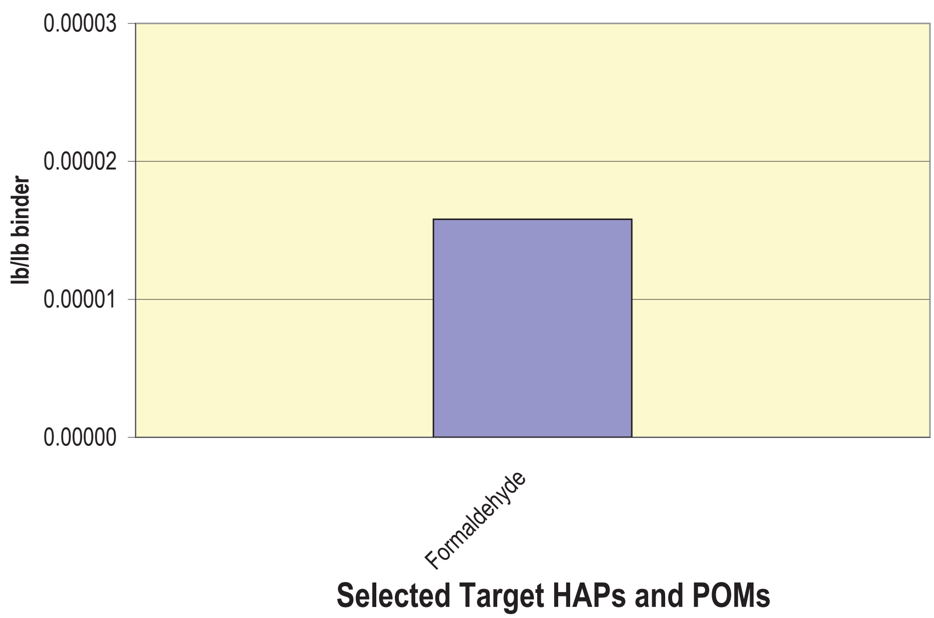


Figure 3-1c Criteria Pollutants and Greenhouse Gases, Test HG Core Making (Background Corrected), Average Results – Lb/Lb Binder

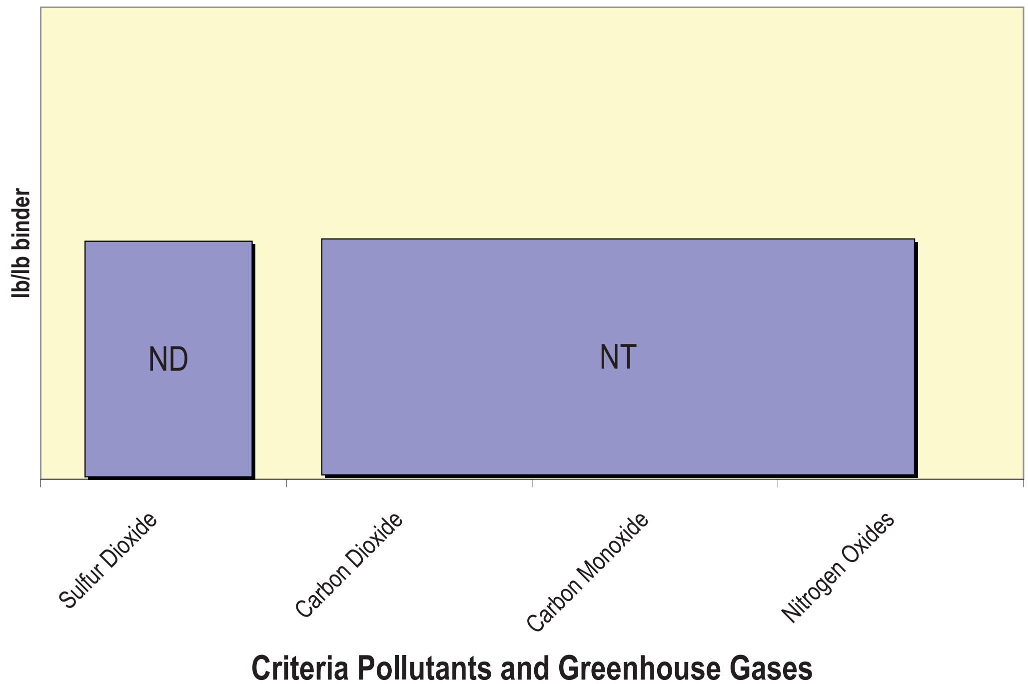


Figure 3-2a Emissions Indicators, Test HG Pouring/Ablation (Background Corrected), Average Results – Lb/Tn Metal

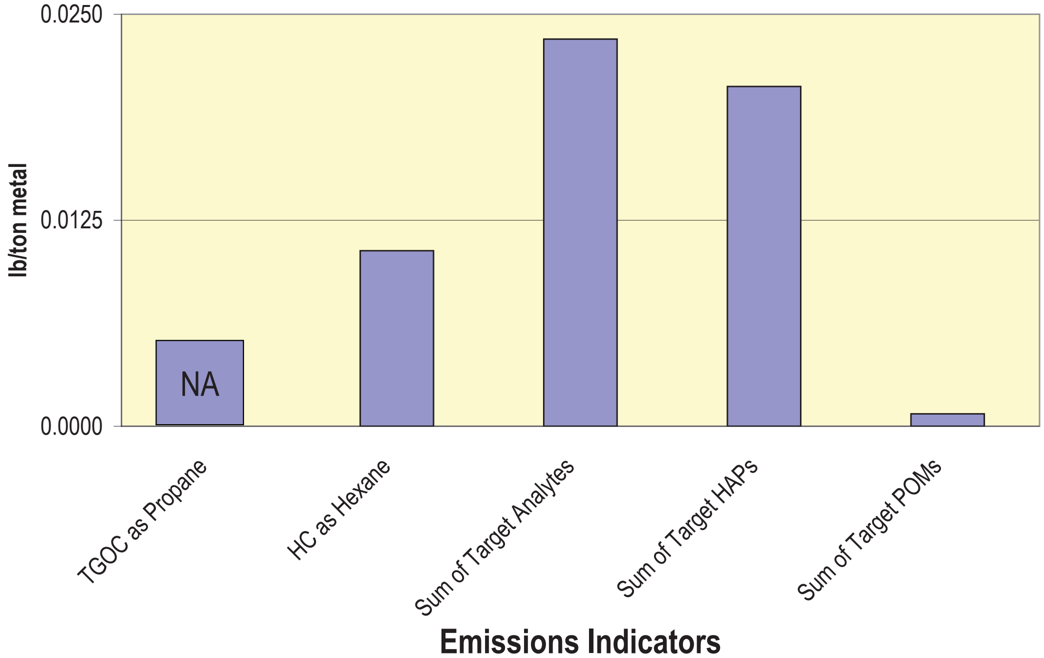


Figure 3-2b Selected HAP and POM Emissions, Test HG Pouring/Ablation (Background Corrected), Average Results – Lb/Tn Metal

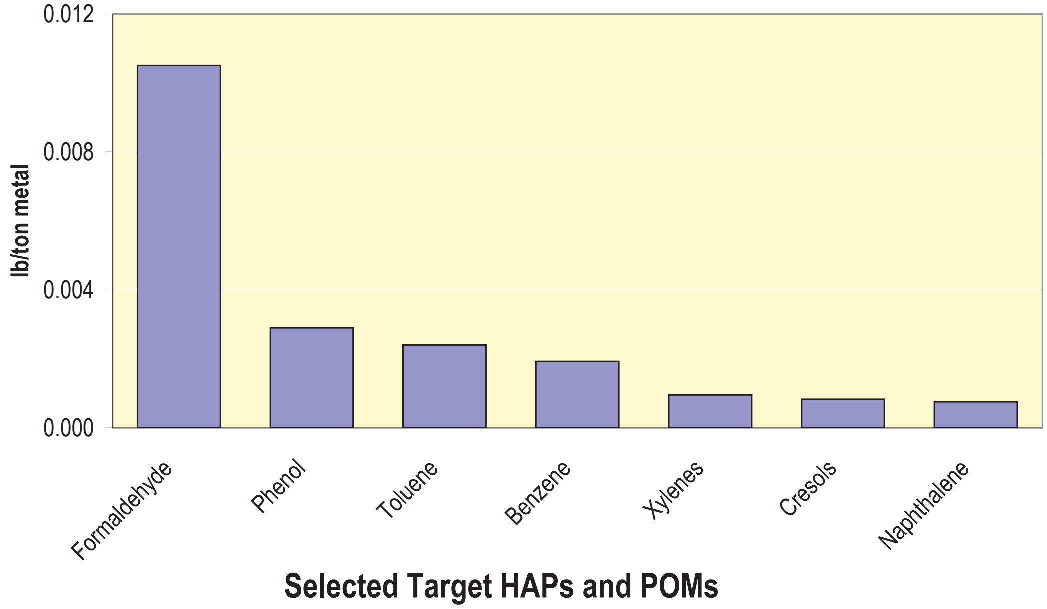
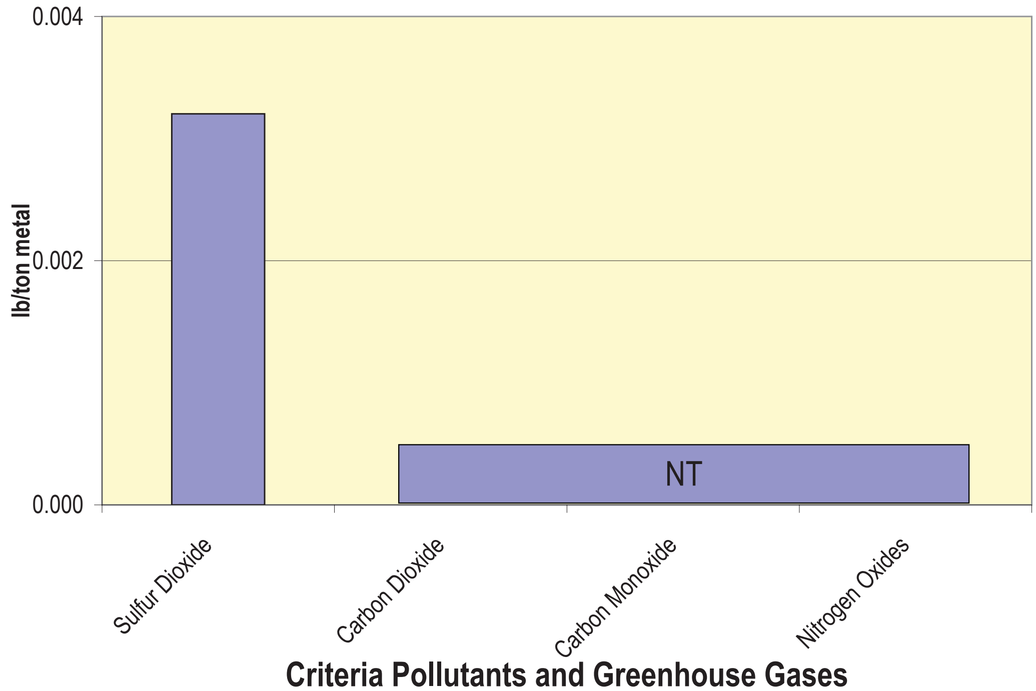


Figure 3-2c Criteria Pollutants and Greenhouse Gases, Test HG Pouring/Ablation (Background Corrected), Average Results – Lb/Tn Metal



Four of the appendices in this report contain detailed information regarding testing, sampling, data collection and results for each sampling event. Appendix A contains the sampling plan for Test HG. Appendix B contains detailed emission and average results for all targeted analytes, both background corrected and as collected. Target analyte practical quantitation reporting limits expressed in both lb/lb binder and lb/ton metal are also shown in Appendix B. Appendix C contains detailed process data for mold mixing and curing and the pouring/ablation processes. Appendix D contains continuous monitor charts. The charts are presented to show TGOC time-dependent emissions profiles for each individual emissions event. Charts show raw data. They have not been background corrected. Appendix E contains acronyms and abbreviations.

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4.0 DISCUSSION OF RESULTS

The individual chemical compounds from airborne emissions specifically targeted for collection and analyses for this test were chosen based on the chemistry of the binder under investigation as well as analytes historically targeted.

Emissions results for the mold curing portion of Test HG are summarized in Table 3-1a in lb/lb of binder. For this process, the only detectable targeted analyte above background levels was formaldehyde.

A total of twelve (12) targeted analytes and isomer classes were detected above background for the pouring and ablation process and ten of them accounted for more than 95% of the concentration of emissions. Formaldehyde again was the highest contributor accounting for 45% of detectable emissions. Phenol, toluene and benzene were responsible for 12%, 10% and 8% of emissions, respectively. The remaining six analytes contributed less than 4% each.

If background emissions are not subtracted from the results, there are additional compounds detected aside from the targeted compounds, some of which are HAPs.

Conventional casting of Al consists of metal pouring, followed by separate cooling and shakeout processes. In comparing emissions from recent CERP pouring, cooling and shakeout tests for aluminum using low emission inorganic based binder systems (Tests HB, HC and HF), an increase of approximately 40% in the summed target and HAP emissions, with a larger increase in the summed POM emissions of greater than 275% on a lb/ton metal basis, was found. Of the top 95% individual target analytes which compose the sums for Test HG, some analytes are also in the top 95% of the other tests. These include formaldehyde, toluene, benzene and the xylenes. Phenol, cresols, and naphthalene were considered non-detect in the PCS test results. Acetaldehyde and propionaldehyde were the two top individual contributors for the PCS tests, but were considered non-detect in the background corrected results for Test HG.

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APPENDIX A TEST SAMPLING PLAN

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HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
MOLD MAKING											**5/2/2006**
THC	HG001	X									TOTAL
TO-17	HG00101		1						60	1	Carbopak charcoal
TO-17	HG00102				1				0		Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG00103		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HG00104				1				0		100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HG00105		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HG00106				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HG00107		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HG00108				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
MOLD MAKING											**5/2/2006**
THC	HG002	X									TOTAL
TO-17	HG00201		1						60	1	Carbopak charcoal
TO-17	HG00202			1					60	2	Carbopak charcoal
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG00203		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HG00204			1					1000	7	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HG00205		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HG00206			1					1000	9	100/50 mg Charcoal (SKC 226-01)
TO11	HG00207		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HG00208			1					1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
MOLD MAKING											**5/2/2006**
THC	HG003	X									TOTAL
TO-17	HG00301		1						60	1	Carbopak charcoal
TO-17 MS	HG00302		1						60	2	Carbopak charcoal
TO-17 MS	HG00303			1					60	3	Carbopak charcoal
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG00304		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HG00305		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HG00306		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
MOLD MAKING											**5/2/2006**
SYSTEM BLANK											
THC	SB001	X									TOTAL
TO-17	SB00101		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	SB00102		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	SB00103		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	SB00104		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
POUR AND ABLATION											**5/3/2006**
THC	HG020	X									TOTAL
TO-17	HG02001		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG02002		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HG02003		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HG02004		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
POUR AND ABLATION											**5/4/2006**
SYSTEM BLANK											
THC	SB002	X									TOTAL
TO-17	SB00201		1						60	1	Carbopak charcoal
	Excess								60	2	Blocked
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	SB00202		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	SB00203		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	SB00204		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments:
POUR AND ABLATION											5/4/2006
THC	HG021	X									TOTAL
TO-17	HG02101		1						60	1	Carbopak charcoal
TO-17	HG02102			1					60	2	Carbopak charcoal
	Excess								60	3	Blocked
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG02103		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	HG02104			1					1000	7	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	HG02105		1						1000	8	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	HG02106			1					1000	9	100/50 mg Charcoal (SKC 226-01)
TO11	HG02107		1						1000	10	DNPH Silica Gel (SKC 226-119)
TO11	HG02108			1					1000	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

HG ECK INDUSTRIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
POUR AND ABLATION											5/4/2006
THC	HG022	X									TOTAL
TO-17	HG02201		1						60	1	Carbopak charcoal
TO-17 MS	HG02202		1						60	2	Carbopak charcoal
TO-17 MS	HG02203			1					60	3	Carbopak charcoal
	Excess								500	4	Blocked
	Excess								500	5	Blocked
OSHA ID200	HG02204		1						1000	6	100/50 mg Carbon Bead (SKC 226-80)
	Excess								1000	7	Blocked
NIOSH 1500	HG02205		1						1000	8	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	9	Blocked
TO11	HG02206		1						1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Blocked
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess
	Excess								5000	13	Excess

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APPENDIX B DETAILED EMISSIONS DATA AND REPORTING LIMITS

Test HG - Detailed Emissions Mold Curing Data (Background Corrected) - Lb/Lb Binder

Target Analytes	POM	HAP		HG001	HG002	HG003	Average	Standard Deviation
			Test Dates	**2-May-06**	**2-May-06**	**2-May-06**	—	—
Emission Indicators								
			TGOC as Propane	6.26E-03	4.92E-03	5.08E-03	5.42E-03	7.35E-04
			HC as Hexane	ND	ND	ND	ND	NA
			Sum of Target Analytes	2.13E-05	1.88E-05	7.34E-06	1.58E-05	7.43E-06
			Sum of Target HAPs	2.13E-05	1.88E-05	7.34E-06	1.58E-05	7.43E-06
			Sum of Target POMs	ND	ND	ND	ND	NA
Selected Target HAPs and POMs								
TA		H	Formaldehyde	2.13E-05	1.88E-05	7.34E-06	1.58E-05	7.43E-06
TA	P	H	Acenaphthalene	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	NA
TA	P	H	Methylnaphthalene, 1-	ND	ND	ND	ND	NA
TA	P	H	Methylnaphthalene, 2-	ND	ND	ND	ND	NA
TA	P	H	Naphthalene	ND	ND	ND	ND	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	NA
TA		H	Acetaldehyde	ND	ND	ND	ND	NA
TA		H	Acrolein	ND	ND	ND	ND	NA
TA		H	Benzene	ND	ND	ND	ND	NA
TA		H	Biphenyl	ND	ND	ND	ND	NA
TA		H	Cresol, mp-	ND	ND	ND	ND	NA
TA		H	Cresol, o-	ND	ND	ND	ND	NA
TA		H	Ethylbenzene	ND	ND	ND	ND	NA
TA		H	Hexane	ND	ND	ND	ND	NA
TA		H	Phenol	ND	ND	ND	ND	NA
TA		H	Propionaldehyde (Propanal)	ND	ND	ND	ND	NA
TA		H	Styrene	ND	ND	ND	ND	NA
TA		H	Toluene	ND	ND	ND	ND	NA
TA		H	Xylene, mp-	ND	ND	ND	ND	NA
TA		H	Xylene, o-	ND	ND	ND	ND	NA

NT= Not Tested
ND= Not Detected
NA= Not Applicable
I=Invalidated Data

Test HG - Detailed Emissions Mold Curing Data (Background Corrected) - Lb/Lb Binder

Target Analytes	POM	HAP		HG001	HG002	HG003	Average	Standard Deviation
			Test Dates	**2-May-06**	**2-May-06**	**2-May-06**	—	—
Additional Selected Target Analytes								
TA			Benzaldehyde	ND	ND	ND	ND	NA
TA			Butyraldehyde/Methacrolein	ND	ND	ND	ND	NA
TA			Crotonaldehyde	ND	ND	ND	ND	NA
TA			Cyclohexane	ND	ND	ND	ND	NA
TA			Decane	ND	ND	ND	ND	NA
TA			Diethylbenzene, 1,3-	ND	ND	ND	ND	NA
TA			Dimethylphenol, 2,4-	ND	ND	ND	ND	NA
TA			Dimethylphenol, 2,6-	ND	ND	ND	ND	NA
TA			Dodecane	ND	ND	ND	ND	NA
TA			Ethyltoluene, 2-	ND	ND	ND	ND	NA
TA			Ethyltoluene, 3-	ND	ND	ND	ND	NA
TA			Heptane	ND	ND	ND	ND	NA
TA			Hexaldehyde	ND	ND	ND	ND	NA
TA			Indan	ND	ND	ND	ND	NA
TA			Nonane	ND	ND	ND	ND	NA
TA			o,m,p-Tolualdehyde	ND	ND	ND	ND	NA
TA			Octane	ND	ND	ND	ND	NA
TA			Pentanal (Valeraldehyde)	ND	ND	ND	ND	NA
TA			Propylbenzene, n-	ND	ND	ND	ND	NA
TA			Tetradecane	ND	ND	ND	ND	NA
TA			Trimethylbenzene, 1,2,3-	ND	ND	ND	ND	NA
TA			Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	NA
TA			Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	NA
TA			Undecane	ND	ND	ND	ND	NA
TA			2-Butanone (MEK)	ND	ND	ND	ND	NA
TA			Indene	ND	ND	ND	ND	NA
Criteria Pollutants and Greenhouse Gases								
			Sulfur Dioxide	ND	ND	ND	ND	NA
			Carbon Dioxide	NT	NT	NT	NT	NT
			Carbon Monoxide	NT	NT	NT	NT	NT
			Nitrogen Oxides	NT	NT	NT	NT	NT

NT= Not Tested
ND= Not Detected
NA= Not Applicable
I=Invalidated Data

Test HG - Detailed Emissions Pouring Data (Background Corrected) - Lb/Ton Metal

Target Analyte	POM	HAP		HG020	HG021	HG022	Average	Standard Deviation
			Test Dates	**3-May-06**	**4-May-06**	**4-May-06**	—	—
Emission Indicators								
			TGOC as Propane	I	NT	NT	NT	NT
			HC as Hexane	1.06E-02	1.29E-02	8.42E-03	1.06E-02	2.24E-03
			Sum of Target Analytes	2.39E-02	2.78E-02	1.74E-02	2.35E-02	5.25E-03
			Sum of Target HAPs	1.86E-02	2.60E-02	1.54E-02	2.06E-02	5.47E-03
			Sum of Target POMs	3.77E-04	1.01E-03	8.71E-04	7.54E-04	3.34E-04
Selected Target HAPs and POMs								
TA		H	Formaldehyde	1.17E-02	1.68E-02	3.03E-03	1.05E-02	6.96E-03
TA		H	Phenol	3.28E-03	2.87E-03	2.55E-03	2.90E-03	3.70E-04
TA		H	Toluene	3.13E-03	1.81E-03	2.28E-03	2.41E-03	6.71E-04
TA		H	Benzene	2.53E-03	1.77E-03	1.50E-03	1.93E-03	5.33E-04
TA		H	Xylene, mp-	1.38E-03	8.18E-04	6.67E-04	9.56E-04	3.78E-04
TA		H	Cresol, mp-	7.71E-04	8.31E-04	8.95E-04	8.32E-04	6.22E-05
TA	P	H	Naphthalene	3.77E-04	1.01E-03	8.71E-04	7.54E-04	3.34E-04
TA		H	Acetaldehyde	5.19E-04	1.38E-04	3.10E-04	3.23E-04	1.91E-04
TA	P	H	Acenaphthalene	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	NA
TA	P	H	Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	NA
TA	P	H	Methylnaphthalene, 1-	ND	ND	ND	ND	NA
TA	P	H	Methylnaphthalene, 2-	ND	ND	ND	ND	NA
TA	P	H	Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	NA
TA		H	Acrolein	ND	ND	ND	ND	NA
TA		H	Biphenyl	ND	ND	ND	ND	NA
TA		H	Cresol, o-	ND	ND	ND	ND	NA
TA		H	Ethylbenzene	ND	ND	ND	ND	NA
TA		H	Hexane	ND	ND	3.15E-03	ND	NA
TA		H	Propionaldehyde (Propanal)	ND	ND	ND	ND	NA
TA		H	Styrene	1.74E-04	ND	1.39E-04	ND	NA
TA		H	Xylene, o-	ND	ND	ND	ND	NA

NT= Not Tested
ND= Not Detected
NA= Not Applicable
I=Invalidated Data

Test HG - Detailed Emissions Pouring Data (Background Corrected) - Lb/Ton Metal

Target Analyte	POM	HAP		HG020	HG021	HG022	Average	Standard Deviation
			Test Dates	**3-May-06**	**4-May-06**	**4-May-06**	—	—
Additional Selected Target Analytes								
TA			Indan	9.17E-04	9.13E-04	9.28E-04	9.19E-04	7.86E-06
TA			Heptane	1.65E-03	ND	7.18E-04	7.88E-04	8.25E-04
TA			Dimethylphenol, 2,4-	8.75E-04	7.42E-04	6.98E-04	7.72E-04	9.23E-05
TA			Trimethylbenzene, 1,2,4-	7.13E-04	2.66E-04	2.13E-04	3.97E-04	2.74E-04
TA			Benzaldehyde	ND	ND	ND	ND	NA
TA			Butyraldehyde/Methacrolein	ND	ND	ND	ND	NA
TA			Crotonaldehyde	ND	ND	ND	ND	NA
TA			Cyclohexane	ND	ND	ND	ND	NA
TA			Decane	ND	ND	ND	ND	NA
TA			Diethylbenzene, 1,3-	7.43E-04	ND	ND	ND	NA
TA			Dimethylphenol, 2,6-	ND	ND	ND	ND	NA
TA			Dodecane	ND	ND	ND	ND	NA
TA			Ethyltoluene, 2-	ND	ND	ND	ND	NA
TA			Ethyltoluene, 3-	ND	ND	ND	ND	NA
TA			Hexaldehyde	ND	ND	ND	ND	NA
TA			Nonane	ND	ND	ND	ND	NA
TA			o,m,p-Tolualdehyde	ND	ND	ND	ND	NA
TA			Octane	ND	ND	ND	ND	NA
TA			Pentanal (Valeraldehyde)	ND	ND	ND	ND	NA
TA			Propylbenzene, n-	ND	ND	ND	ND	NA
TA			Tetradecane	ND	ND	ND	ND	NA
TA			Trimethylbenzene, 1,2,3-	4.58E-04	ND	ND	ND	NA
TA			Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	NA
TA			Undecane	ND	ND	ND	ND	NA
TA			2-Butanone (MEK)	ND	ND	ND	ND	NA
TA			Indene	ND	ND	ND	ND	NA
Criteria Pollutants and Greenhouse Gases								
			Sulfur Dioxide	6.23E-03	ND	ND	2.08E-03	3.60E-03
			Carbon Dioxide	NT	NT	NT	NT	NT
			Carbon Monoxide	NT	NT	NT	NT	NT
			Nitrogen Oxides	NT	NT	NT	NT	NT

NT= Not Tested
ND= Not Detected
NA= Not Applicable
I=Invalidated Data

Test HG - Practical Reporting Limits - Curing

Analyte	Lb/Lb Binder	Analyte	Lb/Lb Binder
Carbon Monoxide	5.03E-04	Ethyltoluene, 2-	2.43E-06
Carbon Dioxide	7.90E-04	Ethyltoluene, 3-	1.22E-05
Nitrogen Oxides	5.39E-04	Formaldehyde	2.38E-06
THC as Propane	7.90E-04	Heptane	1.22E-05
2-Butanone (MEK)	2.38E-06	Hexaldehyde	2.38E-06
Acenaphthalene	1.22E-05	Hexane	2.43E-06
Acetaldehyde	2.38E-06	Indan	1.22E-05
Acrolein	2.38E-06	Indene	1.22E-05
Benzaldehyde	2.38E-06	Methylnaphthalene, 1-	2.43E-06
Benzene	2.43E-06	Methylnaphthalene, 2-	2.43E-06
Biphenyl	1.22E-05	Naphthalene	2.43E-06
Butyraldehyde/Methacrolein	3.97E-06	Nonane	1.22E-05
Cresol, mp-	1.22E-05	o,m,p-Tolualdehyde	6.36E-06
Cresol, o-	1.22E-05	Octane	1.22E-05
Crotonaldehyde	2.38E-06	Pentanal (Valeraldehyde)	2.38E-06
Cyclohexane	1.22E-05	Phenol	1.22E-05
Decane	1.22E-05	Propionaldehyde (Propanal)	2.38E-06
Diethylbenzene, 1,3-	1.22E-05	Propylbenzene, n-	1.22E-05
Dimethylnaphthalene, 1,2-	1.22E-05	Styrene	2.43E-06
Dimethylnaphthalene, 1,3-	2.43E-06	Sulfur Dioxide	3.08E-05
Dimethylnaphthalene, 1,5-	1.22E-05	Tetradecane	1.22E-05
Dimethylnaphthalene, 1,6-	1.22E-05	HC as n-Hexane	7.48E-05
Dimethylnaphthalene, 1,8-	1.22E-05	Toluene	2.43E-06
Dimethylnaphthalene, 2,3-	1.22E-05	Trimethylbenzene, 1,2,3-	2.43E-06
Dimethylnaphthalene, 2,6-	1.22E-05	Trimethylbenzene, 1,2,4-	2.43E-06
Dimethylnaphthalene, 2,7-	1.22E-05	Trimethylbenzene, 1,3,5-	2.43E-06
Dimethylphenol, 2,4-	1.22E-05	Trimethylnaphthalene, 2,3,5-	1.22E-05
Dimethylphenol, 2,6-	1.22E-05	Undecane	2.43E-06
Dodecane	1.22E-05	Xylene, mp-	2.43E-06
Ethylbenzene	2.43E-06	Xylene, o-	2.43E-06

Test HG - Practical Reporting Limits - Pouring/Ablation

Analyte	Lb/Tn Metal	Analyte	Lb/Tn Metal
Carbon Monoxide	9.51E-06	Ethyltoluene, 2-	1.34E-04
Carbon Dioxide	1.49E-05	Ethyltoluene, 3-	6.70E-04
Nitrogen Oxides	1.02E-05	Formaldehyde	1.30E-04
THC as Propane	1.49E-05	Heptane	6.70E-04
2-Butanone (MEK)	1.30E-04	Hexaldehyde	1.30E-04
Acenaphthalene	6.70E-04	Hexane	1.34E-04
Acetaldehyde	1.30E-04	Indan	6.70E-04
Acrolein	1.30E-04	Indene	6.70E-04
Benzaldehyde	1.30E-04	Methylnaphthalene, 1-	1.34E-04
Benzene	1.34E-04	Methylnaphthalene, 2-	1.34E-04
Biphenyl	6.70E-04	Naphthalene	1.34E-04
Butyraldehyde/Methacrolein	2.17E-04	Nonane	6.70E-04
Cresol, mp-	6.70E-04	o,m,p-Tolualdehyde	3.48E-04
Cresol, o-	6.70E-04	Octane	6.70E-04
Crotonaldehyde	1.30E-04	Pentanal (Valeraldehyde)	1.30E-04
Cyclohexane	6.70E-04	Phenol	6.70E-04
Decane	6.70E-04	Propionaldehyde (Propanal)	1.30E-04
Diethylbenzene, 1,3-	6.70E-04	Propylbenzene, n-	6.70E-04
Dimethylnaphthalene, 1,2-	6.70E-04	Styrene	1.34E-04
Dimethylnaphthalene, 1,3-	1.34E-04	Sulfur Dioxide	1.69E-03
Dimethylnaphthalene, 1,5-	6.70E-04	Tetradecane	6.70E-04
Dimethylnaphthalene, 1,6-	6.70E-04	HC as n-Hexane	4.09E-03
Dimethylnaphthalene, 1,8-	6.70E-04	Toluene	1.34E-04
Dimethylnaphthalene, 2,3-	6.70E-04	Trimethylbenzene, 1,2,3-	1.34E-04
Dimethylnaphthalene, 2,6-	6.70E-04	Trimethylbenzene, 1,2,4-	1.34E-04
Dimethylnaphthalene, 2,7-	6.70E-04	Trimethylbenzene, 1,3,5-	1.34E-04
Dimethylphenol, 2,4-	6.70E-04	Trimethylnaphthalene, 2,3,5-	6.70E-04
Dimethylphenol, 2,6-	6.70E-04	Undecane	1.34E-04
Dodecane	6.70E-04	Xylene, mp-	1.34E-04
Ethylbenzene	1.34E-04	Xylene, o-	1.34E-04

Analyte	Lb/Lb Binder	Analyte	Lb/Lb Binder
Carbon Monoxide	NA	Ethyltoluene, 2-	NA
Carbon Dioxide	NA	Ethyltoluene, 3-	NA
Nitrogen Oxides	NA	Formaldehyde	NA
THC as Propane	NA	Heptane	NA
2-Butanone (MEK)	NA	Hexaldehyde	NA
Acenaphthalene	NA	Hexane	NA
Acetaldehyde	NA	Indan	NA
Acrolein	NA	Indene	NA
Benzaldehyde	NA	Methylnaphthalene, 1-	NA
Benzene	NA	Methylnaphthalene, 2-	NA
Biphenyl	NA	Naphthalene	NA
Butyraldehyde/Methacrolein	NA	Nonane	NA
Cresol, mp-	NA	o,m,p-Tolualdehyde	NA
Cresol, o-	NA	Octane	NA
Crotonaldehyde	NA	Pentanal (Valeraldehyde)	NA
Cyclohexane	NA	Phenol	NA
Decane	NA	Propionaldehyde (Propanal)	NA
Diethylbenzene, 1,3-	NA	Propylbenzene, n-	NA
Dimethylnaphthalene, 1,2-	NA	Styrene	NA
Dimethylnaphthalene, 1,3-	NA	Sulfur Dioxide	NA
Dimethylnaphthalene, 1,5-	NA	Tetradecane	NA
Dimethylnaphthalene, 1,6-	NA	HC as n-Hexane	NA
Dimethylnaphthalene, 1,8-	NA	Toluene	NA
Dimethylnaphthalene, 2,3-	NA	Trimethylbenzene, 1,2,3-	NA
Dimethylnaphthalene, 2,6-	NA	Trimethylbenzene, 1,2,4-	NA
Dimethylnaphthalene, 2,7-	NA	Trimethylbenzene, 1,3,5-	NA
Dimethylphenol, 2,4-	NA	Trimethylnaphthalene, 2,3,5-	NA
Dimethylphenol, 2,6-	NA	Undecane	NA
Dodecane	NA	Xylene, mp-	NA
Ethylbenzene	NA	Xylene, o-	NA

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APPENDIX C DETAILED PROCESS DATA

Test HG - Detailed Process Data - Mixing

Run	Mold Number	Total Sand Wt., Lb.	Binder Wt., g	Binder Wt., Lb.	% Binder	Mold Wt., Lb.	Binder in Mold, Lb.	Total Binder in Mold
Run HG001: 05/02/2006	1							
	cope	100	555.0	1.22	1.22	18.16	0.222	
	drag	100	555.0	1.22	1.22	19.02	0.233	0.455
	2							
	cope	100	555.0	1.22	1.22	18.40	0.225	
	drag	100	555.0	1.22	1.22	19.54	0.239	0.464
	3							
	cope	100	558.1	1.23	1.23	18.02	0.222	
	drag	100	558.1	1.23	1.23	10.72	0.132	0.354
	4							
	cope	100	558.1	1.23	1.23	18.74	0.231	
	drag	100	558.1	1.23	1.23	10.96	0.135	0.365
	5							
	cope	100	558.1	1.23	1.23	18.62	0.229	
	drag	100	556.1	1.23	1.23	11.38	0.140	0.369
	6							
	cope	100	556.1	1.23	1.23	17.96	0.220	
	drag	100	556.1	1.23	1.23	11.46	0.141	0.361
	7							
	cope	100	556.1	1.23	1.23	19.40	0.238	
	drag	100	556.1	1.23	1.23	11.30	0.139	0.376
					Total Binder in Run 1			**2.744**
Run HG002: 05/02/2006	1							
	cope	100	556.2	1.23	1.23	18.62	0.228	
	drag	100	556.2	1.23	1.23	10.36	0.127	0.355
	2							
	cope	100	556.2	1.23	1.23	19.02	0.233	
	drag	100	556.2	1.23	1.23	11.30	0.139	0.372
	3							
	cope	100	556.2	1.23	1.23	18.28	0.224	
	drag	100	555.0	1.22	1.22	11.02	0.135	0.359
	4							
	cope	100	555.0	1.22	1.22	18.16	0.222	
	drag	100	555.0	1.22	1.22	11.12	0.136	0.358
	5							
	cope	100	555.0	1.22	1.2238	18.38	0.225	
	drag	100	555.0	1.22	1.22	11.16	0.137	0.362
					Total Binder for Run 2:			**1.806**

Test HG - Detailed Process Data - Mixing

	Mold Number	Total Sand Wt., Lb.	Binder Wt., g	Binder Wt., Lb.	% Binder	Mold Wt., Lb.	Binder in Mold, Lb.	Total Binder in Mold
Run HG003: 05/02/2006	1							
	cope	100	555.0	1.22	1.22	10.82	0.132	
	drag	100	555.0	1.22	1.22	18.24	0.223	0.356
	2							
	cope	100	555.0	1.22	1.22	18.88	0.231	
	drag	100	555.0	1.22	1.22	18.48	0.226	0.457
	3							
	cope	100	555.0	1.22	1.22	19.44	0.238	
	drag	100	555.0	1.22	1.22	18.44	0.226	0.464
	4							
	cope	100	555.0	1.22	1.22	11.16	0.137	
	drag	75	416.2	0.92	1.22	18.50	0.226	0.363
	5							
	cope	75	416.2	0.92	1.22	10.86	0.133	
	drag	75	416.2	0.92	1.22	18.22	0.223	0.356
					Total Binder for Run 3:			**1.995**

Test HG - Detailed Process Data - Mold Curing

Run	Sample Number - Drag	Total Sand Wt., lb	Cure Time, min: sec	Box Temp, °F	Sample Number - Cope	Total Sand Wt., lb	Cure Time, min: sec	Box Temp, °F	Total Combined Wt., lb	Total Cure Time, min: sec	Comments
Run HG001: 05/02/2006	7:43 AM Start - Ambient Air 70° @ 49% Humidity										
	01	19.02	8.14	118.2	01	18.16	3.70	107.6	37.18	11.84	All vents open
	02	19.54	8.00	123.6	02	18.40	3.58	119.7	37.94	11.58	All vents open
	03	10.72	8.17	124.7	03	18.02	3.24	117.3	28.74	11.41	All vents open. No Upset on Drag. Ceiling heaters turned off ~8:15 AM
	04	10.96	7.61	127.6	04	18.74	3.59	125.1	29.70	11.20	All vents open. No Upset on Drag
	05	11.38	8.06	114.8	05	18.62	3.41	127.2	30.00	11.47	Vents closed for drag initially, then open. No Upset on Drag
	Suspended activity ~30+ minutes for Break between Cope and Drag Core boxes - Restart @ ~ 9:05 AM										
	06	11.46	8.12	121.6	06	17.96	3.38	118.0	29.42	11.50	No Upset on Drag
	07	11.30	8.08	N/A	07	19.40	3.18	N/A	30.70	11.27	No Upset on Drag
	Totals	94.38	56.18			129.30	24.08		223.68	80.27	
Run HG002: 05/02/2006	10:35 AM Start - Ambient Air 63° @ 72% Humidity										
	01	10.36	8.06	113.0	01	18.62	3.36	101.5	28.98	11.42	Auxiliary fan being installed for PCS during drag (forklift operating) (Note: 1)
	02	11.30	8.15	120.6	02	19.02	3.27	117.0	30.32	11.42	Grey/Black Fine Particulate on Drag, forklift on during cope. (Note: 2) Visible (black) emissions from top vent on box (top of cope) near beg. of test. Smell: burning.
	03	11.02	8.06	119.8	03	18.28	3.25	122.5	29.30	11.31	1/2 X 1 Ribbon of blue colored (adhesive?) material stuck to riser at sand joint, forklift operating (Note: 3)
	04	11.12	8.08	127.0	04	18.16	3.26	122.2	29.28	11.34	forklift on and off numerous times during run. (Note: 4)
	05	11.16	8.18	128.8	05	18.38	3.25	127.8	29.54	11.43	propane in box
	Totals	54.96	40.53			92.46	16.39		147.42	56.92	
Run HG003: 05/02/2006	1:02 PM Start - Ambient Air 65° @ 68% Humidity										
	01	10.82	8.12	111.9	01	18.24	3.24	113.8	29.06	11.36	No Upset on Drag
	02	18.88	8.05	120.9	02	18.48	3.21	121.8	37.36	11.26	
	03	19.44	8.02	125.1	03	18.44	3.21	125.6	37.88	11.23	
	04	11.16	8.26	127.8	04	18.50	3.26	126.0	29.66	11.52	No Upset on Drag
	05	10.86	8.08	127.8	05	18.22	3.20	126.8	29.08	11.28	No Upset on Drag
	Totals	71.16	40.53			91.88	16.12		163.04	56.65	

Notes:
1: forklift start: 10:43:49 (3100 on data logger), THC 2.3, forklift off at 10:45:00 (3214 on data logger)
2: forklift started when data logger at 3520, off at 3544.5
3: forklift on when data logger at 4831, (after cope), off at 4854
4: forklift start when data logger at 4831 (THC 2.9ppm), off at 4854 (during cope), forklift again on at 6419 (THC at 10.3ppm), stop at 6480 (during drag)
NA: Not Available

Test HG - Detailed Process Data - Pouring/Ablation

Run	Sample Number Mold	Total Wt. Sand, lb	Pour Temp, °F	Pour Times, min: sec. Start	Pour Times, min: sec. End	Pour Duration, min: sec.	Ablation Times, min: sec.	Ablation Duration, min: sec.	Gross Wt. Metal, lb	Comments
RUN HG020: 05/03/2006	1:40 PM Start - Ambient Air 68° @ 64% Humidity									
	01	29.04	1185.6	0.00	0.14	0.14	4.68	4.54	8.50	Turnaround time: 54 sec mold. Tent steamy throughout.
	02	29.44	1180.8	7.50	7.58	0.08	12.12	4.54	8.54	Note: Missed recording minutes - Presume 7. Turnaround time: 30sec mold, 1:51 mold+metal
	03	28.94	1182.0	14.23	14.38	0.15	18.94	4.56	8.24	Mold out 14:00, Turnaround time 2:47 mold+metal
	04	29.12	1185.0	21.20	21.30	0.10	25.86	4.56	8.26	Turnaround time: 20 sec. mold, 2:05 mold+metal
	05	28.92	1178.0	28.21	28.31	0.10	32.93	4.62	8.40	Turnaround time: 27 sec. mold, 1:50 mold+metal
	06	29.62	1178.6	34.73	34.82	0.09	39.48	4.66	8.40	Turnaround time: 21sec mold, 1:27 mold+metal
	07	29.40	1178.6	41.13	41.25	0.12	45.82	4.57	8.26	Turnaround time: 22sec. mold, 1:27 mold+metal
	08	28.92	1180.6	47.70	47.81	0.11	52.4	4.59	8.14	Turnaround time: 21 sec. mold, 1:27 mold+metal
	09	29.52	1177.0	54.27	54.37	0.10	58.93	4.56	8.24	Turnaround time: 39 sec. mold, 2:35 mold+metal
	10	30.28	1179.6	61.37	61.47	0.10	66.56*	5.09*	8.02	*Distracted by questions on continuation of Run
	Totals	293.20				1.09		46.29	83.00	3:00 P.M.: Ambient Air 71°F, 58% Humidity
RUN HG021: 05/04/2006	10:17 AM Start - Ambient Air 63°F @ 47% Humidity									
	01	30.22	1180	0.00	0.13	0.13	4.71	4.58	8.72	Turnaround time: 15 sec. mold, 1:29 mold+metal
	02	29.98	1180	7.52	7.66	0.14	12.23	4.57	8.60	Turnaround time: 19 sec. mold, 1:44 mold+metal
	03	29.14	1179	13.20	13.31	0.11	17.90	4.59	8.64	Turnaround time: 20 sec. mold, 2:01 mold+metal
	04	28.66	1179	20.15	20.26	0.11	24.85	4.59	8.12	Turnaround time: 20 sec. mold, 1:53 mold+metal
	05	30.62	1180	26.88	27.02	0.14	31.57	4.55	8.86	
	06	29.70	1179	33.48	33.60	0.12	38.20	4.60	8.52	Turnaround time: 19 sec. mold, 2:08 mold+metal
	07	29.54	1182	40.58	40.71	0.13	45.29	4.58	8.76	Turnaround time: 20 sec. mold, 1:45 mold+metal
	08	29.64	1180	47.30	47.41	0.11	52.04	4.63	8.76	Turnaround time: 1:37 mold+metal
	09	29.96	1180	54.01	54.15	0.14	58.75	4.60	8.90	Turnaround time: 20 sec. mold, 2:51 mold+metal.
	10	29.42	1180	61.77	61.90	0.13	66.48	4.58	8.74	
	Totals	296.88				1.26		45.87	86.62	

Test HG - Detailed Process Data - Pouring/Ablation

Run	Sample Number Mold	Total Wt. Sand, lb	Pour Temp, °F	Pour Times, min: sec. Start	Pour Times, min: sec. End	Pour Duration, min: sec.	Ablation Times, min: sec.	Ablation Duration, min: sec.	Gross Wt. Metal, lb	Comments
RUN HG022: 05/04/2006	1:00 PM Start - Ambient Air 67°F @ 43% Humidity									
	01	29.62	1174	0.00	0.14	0.14	4.71	4.57	8.70	
	02	29.26	1176	6.49	6.61	0.12	11.18	4.57	8.82	Turnaround time: 42 sec. mold, 2:09 mold+metal
	03	38.00*	1176	13.51	13.65	0.14	18.23	4.58	8.56	*Mold Made w/1" Drag Upset. Turnaround time: 12 sec. mold, 1:34 mold+metal
	04	29.96	1178	20.13	20.25	0.12	24.90	4.65	8.74	
	05	29.72	1180	26.95	27.09	0.14	31.68	4.59	8.68	slight overfill when poured (runout). Turnaround time: 17 sec. mold, 1:57 mold+metal
	06	28.56	1180	33.90	34.03	0.13	**missed	**missed	8.76	**Missed Reading - Assisting with Mold 07. Turnaround time: 17 sec. mold, 1:35 mold+metal
	07	29.34	1175	40.45	40.59	0.14	45.18	4.59	8.72	Turnaround time: 1:43 mold+metal
	08	38.20*	1179	47.22	47.43	0.21	51.99	4.56	8.66	*Mold Made w/1" Drag Upset & Drilled Feet. Turnaround time: 17 sec. mold, 1:39 mold+metal
	09	29.82	1179	53.78	53.91	0.13	58.48	4.57	8.88	Turnaround time: 17 sec. mold., 1:47 mold+metal
	10	29.82	1181	60.52	60.64	0.12	65.28	4.64	9.08	Mold made w/Drilled Feet
	Totals	312.30				1.39		41.32	87.60	

Run HG020 - No voltage into data logger on THC after move from mold making area. THC ran out of fuel mix. Connections good externally

Run total for ablation reading does not include mold 10 (furthermore total ablation time is approximate)

Run HG022 - Mold making through beginning of mold 5. Positive pressure in tent

Since Mold 10 appeared identical to Mold 09, it was weighed twice to verify the 29.82 lbs. Run total for ablation reading does not include the value for mold 6

APPENDIX D CONTINUOUS EMISSIONS MONITORING CHARTS

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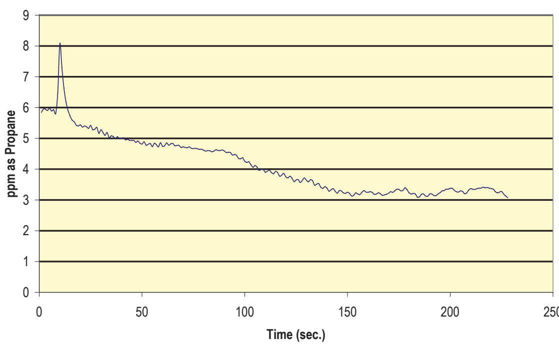
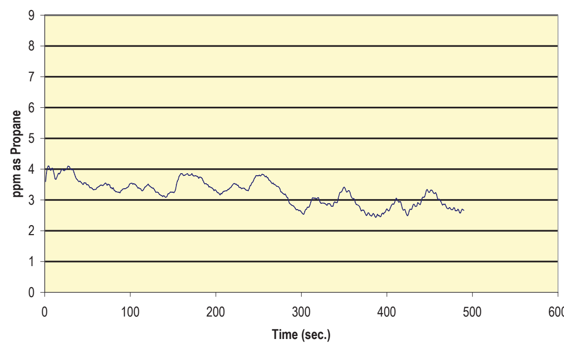
HG001 TGOC Mold 1 (Cope)



HG001 TGOC Mold 1 (Drag)



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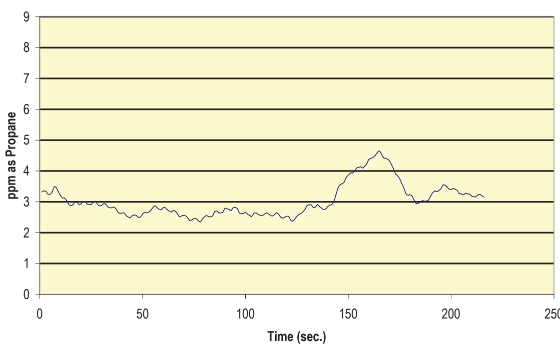

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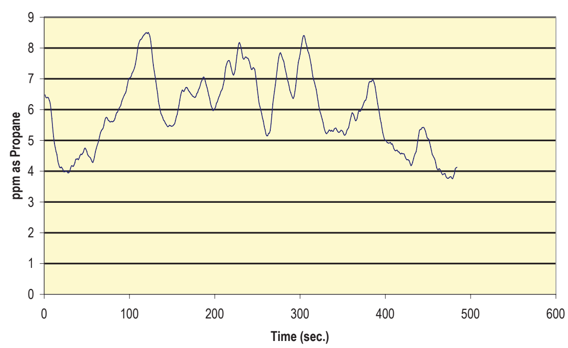

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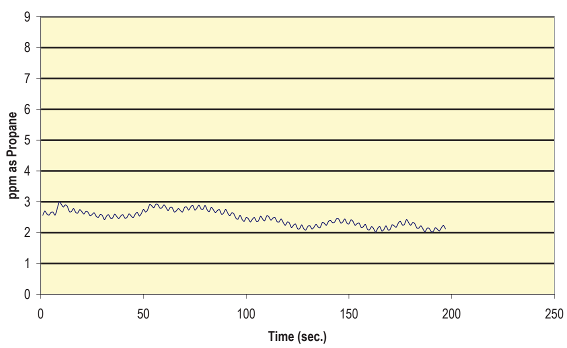
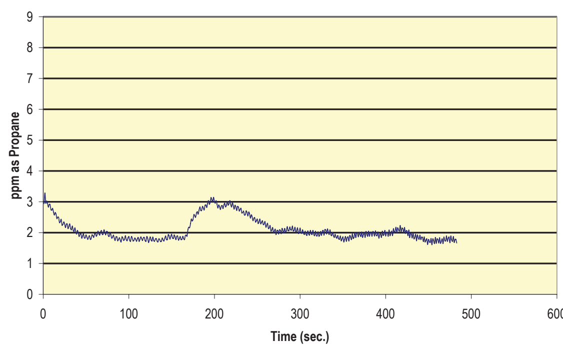


HG001 TGOC Mold 3 (Drag)



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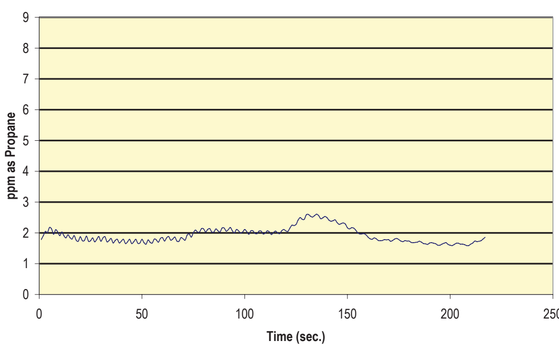

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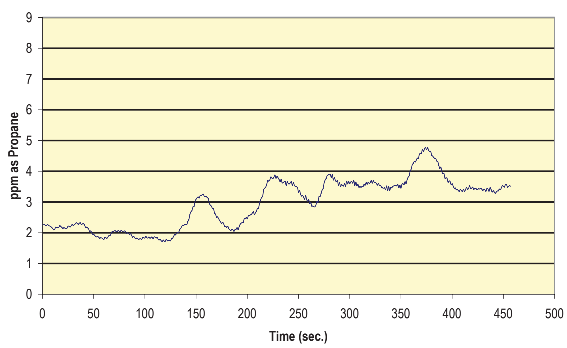
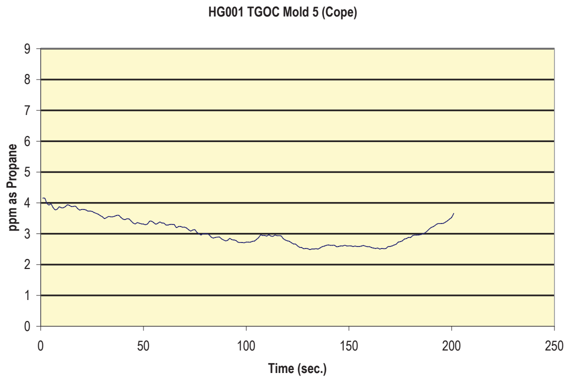
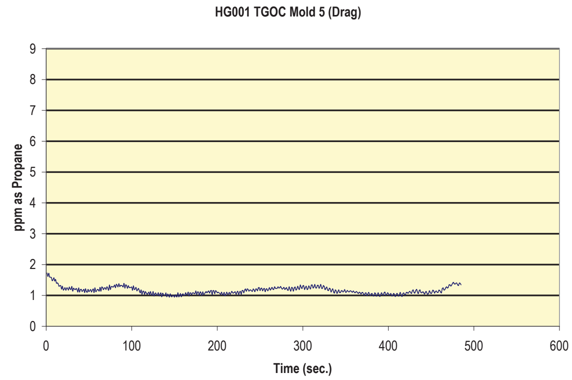



HG001 TGOC Mold 5 (Cope)
ppm as Propane
Time (sec.)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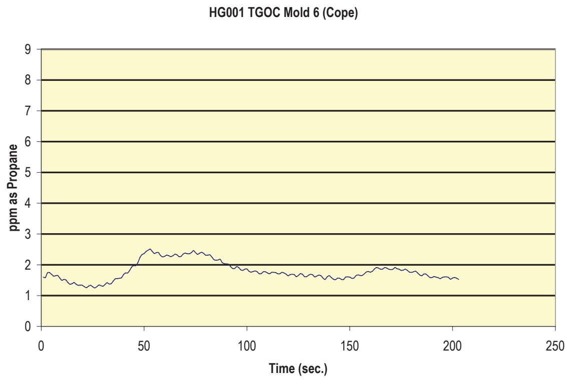
ppm as Propane
Time (sec.)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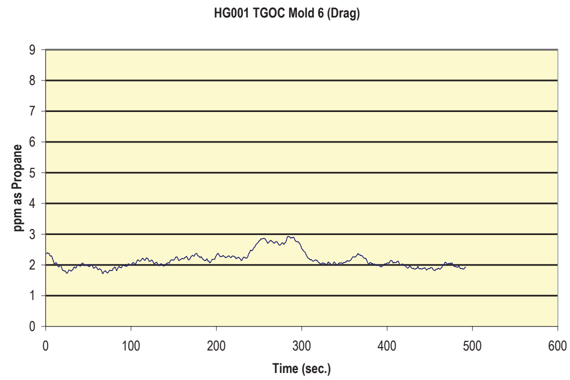
Time (sec.)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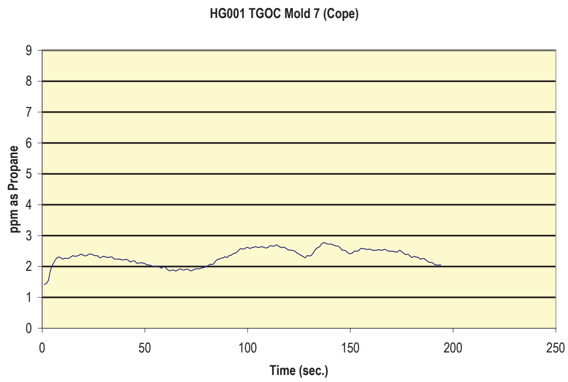
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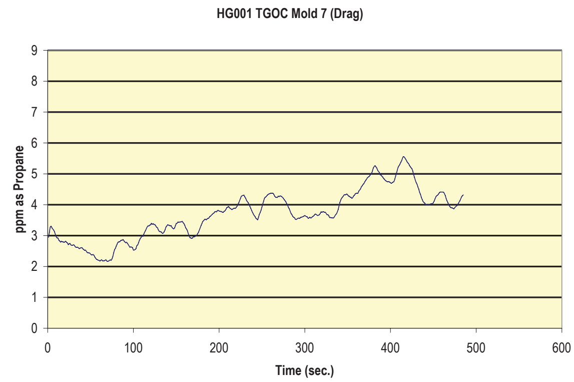
ppm as Propane
Time (sec.)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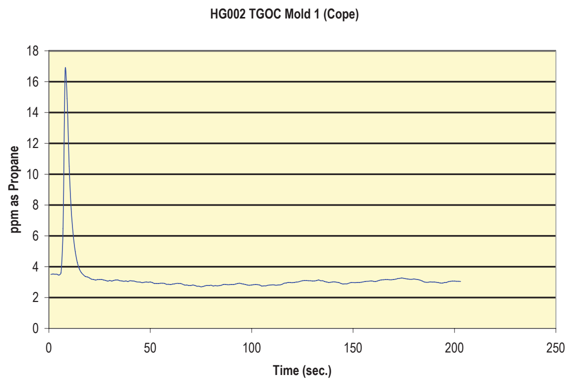
Time (sec.)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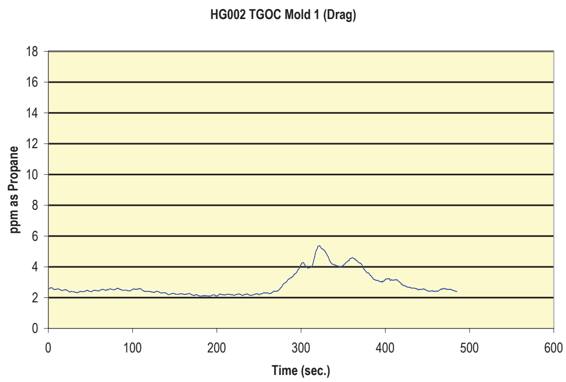
ppm as Propane
Time (sec.)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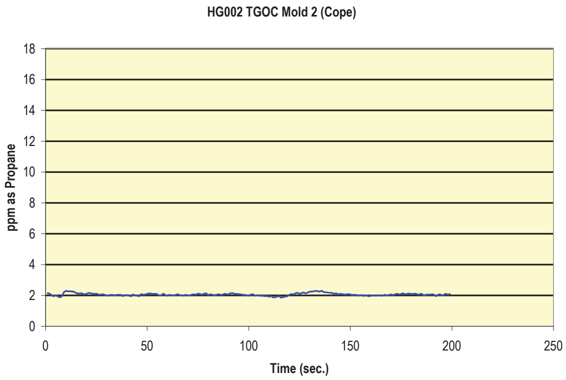
ppm as Propane
Time (sec.)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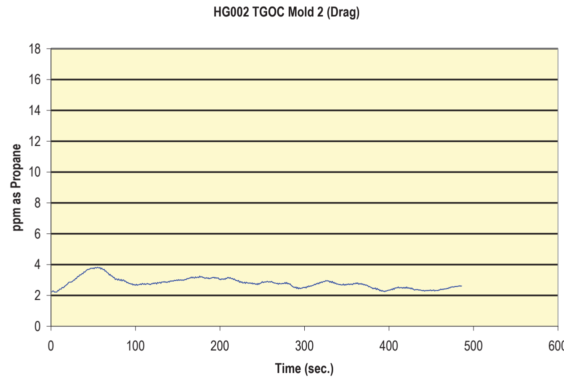
ppm as Propane
Time (sec.)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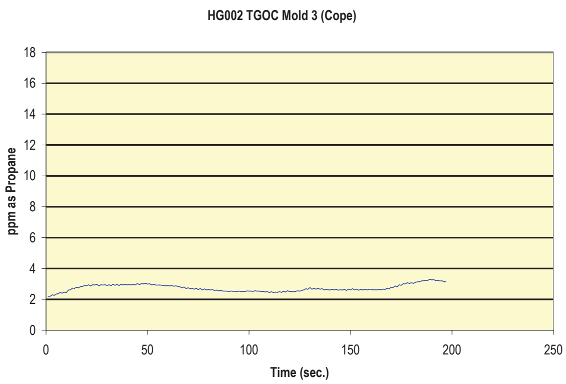
Time (sec.)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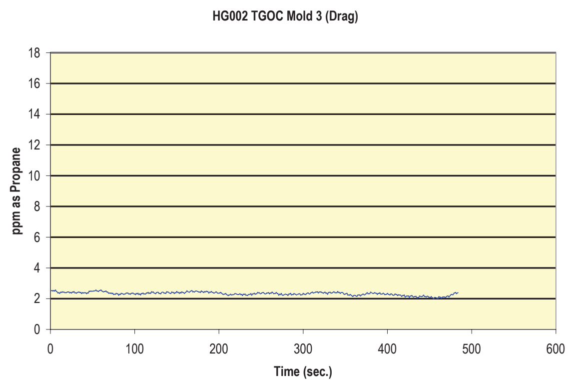
ppm as Propane
Time (sec.)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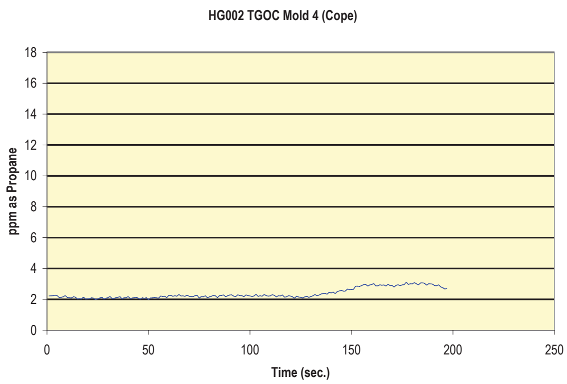
ppm as Propane
Time (sec.)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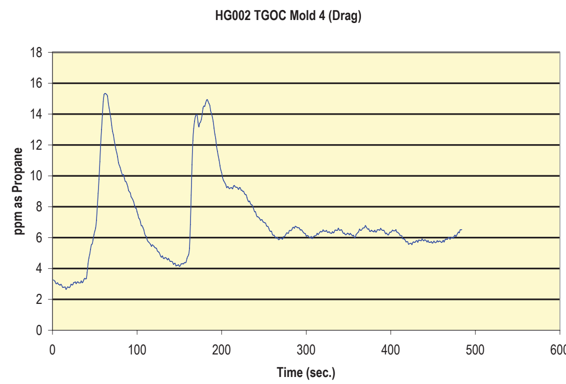
ppm as Propane
Time (sec.)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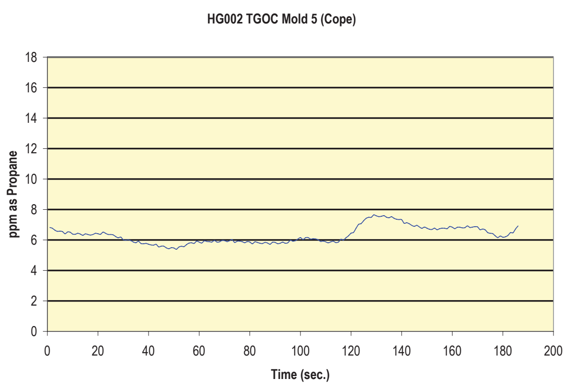
ppm as Propane
Time (sec.)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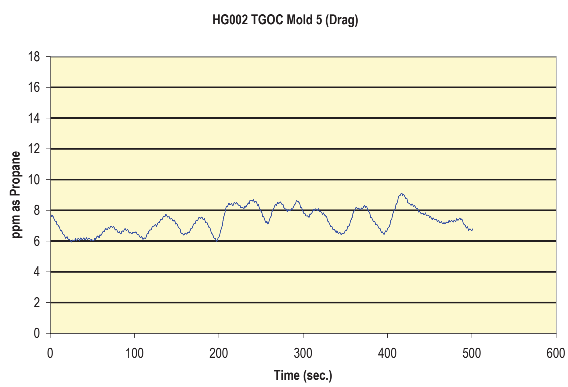
ppm as Propane
Time (sec.)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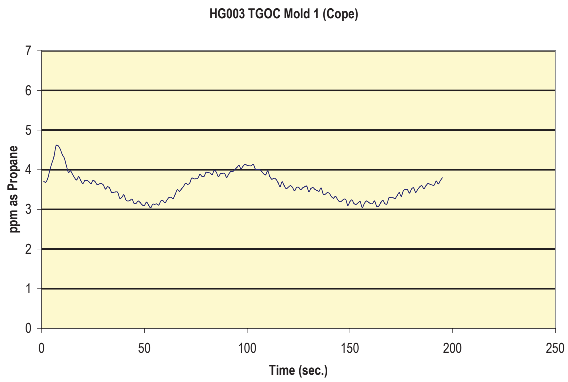
ppm as Propane
Time (sec.)


HG003 TGOC Mold 1 (Cope)
ppm as Propane
Time (sec.)
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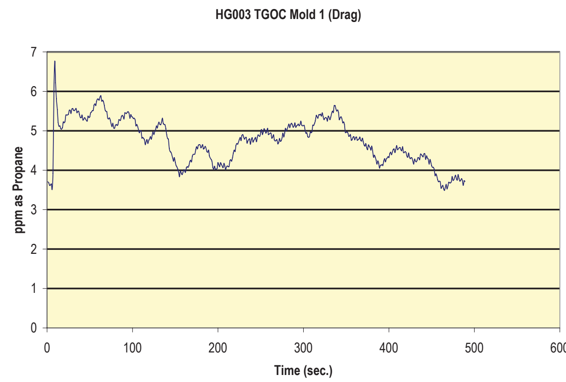
HG003 TGOC Mold 1 (Drag)
ppm as Propane
Time (sec.)
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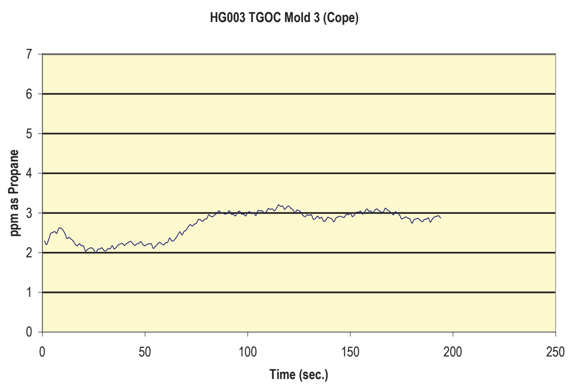
HG003 TGOC Mold 3 (Cope)
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Time (sec.)
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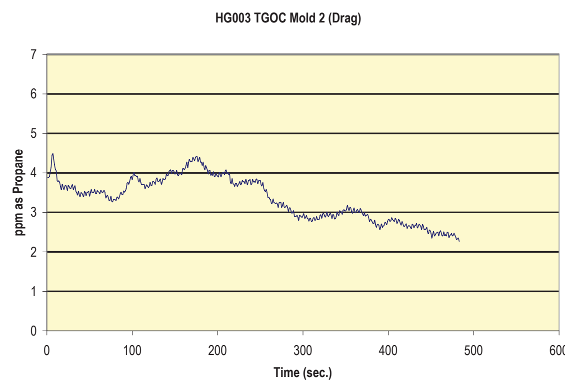
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Time (sec.)
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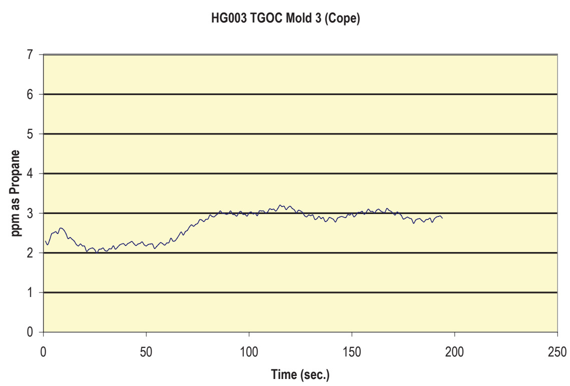
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ppm as Propane
Time (sec.)
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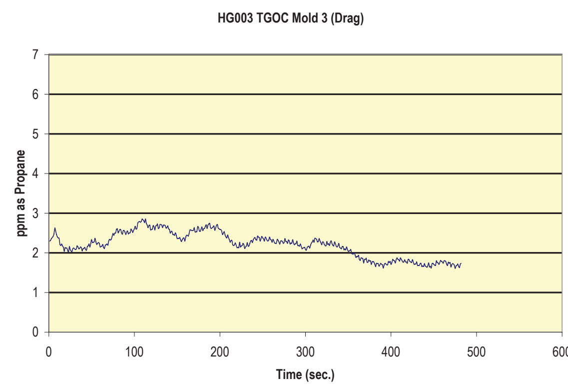
HG003 TGOC Mold 3 (Drag)
ppm as Propane
Time (sec.)
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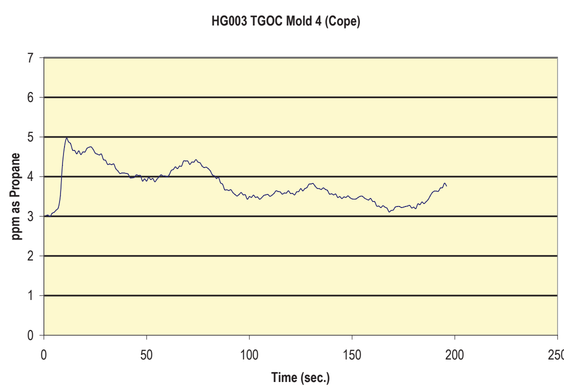
HG003 TGOC Mold 4 (Cope)
ppm as Propane
Time (sec.)
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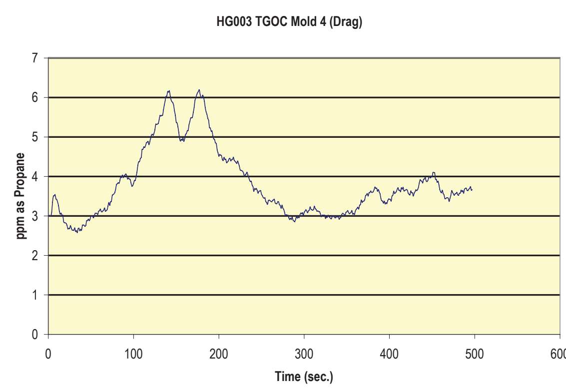
HG003 TGOC Mold 4 (Drag)
ppm as Propane
Time (sec.)
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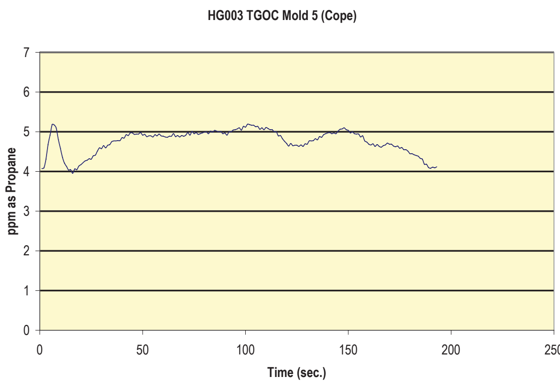
HG003 TGOC Mold 5 (Cope)
ppm as Propane
Time (sec.)
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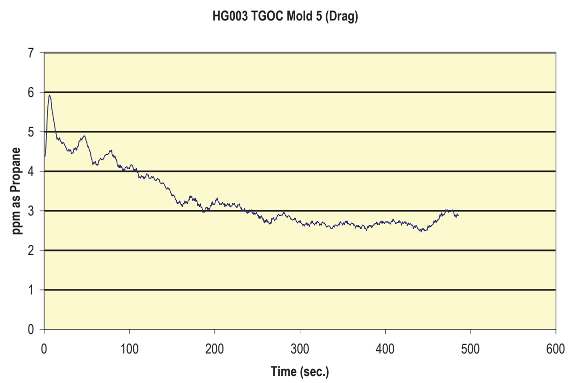
HG003 TGOC Mold 5 (Drag)
ppm as Propane
Time (sec.)
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APPENDIX E ACRONYMS AND ABBREVIATIONS

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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
CFR	Code of Federal Regulations
CISA	Casting Industry Suppliers Association
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRADA	Cooperative Research and Development Agreement
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
ERC	Environmental Research Consortium
FID	Flame Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GS	Greensand
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC	Hydrocarbon
I	Invalidated Data
Lb/Lb	Pound per Pound of Binder used
Lb/Tn	Pound per Ton of Metal poured
LOI	Loss on Ignition
MB	Methylene Blue
NA	Not Applicable; Not Available
ND	Non-Detect
NOx	Oxides of Nitrogen
NT	Not Tested
PCS	Pouring, Cooling, Shakeout
POM	Polycyclic Organic Matter

PQL/PRL	Practical Quantitation Limit/ Practical Reporting Limit
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
SO_2	Sulfur Dioxide
TGOC	Total Gaseous Organic Concentration
THC	Total Hydrocarbon Concentration
US EPA	United States Environmental Protection Agency
USCAR	United States Council for Automotive Research
VOC	Volatile Organic Compound
VOST	Volatile Organic Sampling Train
WBS	Work Breakdown Structure