CERP

Casting Emission Reduction Program

Prepared by:

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US Army Contract DAAE30-02-C-1095

FY 2004

WBS # 1.2.3

Baseline: PCS of Furan Cores, Greensand without Seacoal, Iron

Technikon #1411-123 GJ

August 2005

(revised for public distribution)

United States Environmental Protection Agency

CISA

AFS

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

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DaimlerChrysler Ford Motor Company General Motors

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PCS of Furan Core, Greensand without Seacoal, Iron

Technikon # 1411-123 GJ

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

Process Engineering Manager	*// Original Signed //*	
	Steven M. Knight	Date
V.P. Operations	*// Original Signed //*	
	George Crandell	Date

The data contained in this report were developed to provide a relative emissions profile for future product or process evaluation. You may not obtain the same results in your facility. Data was not collected to assess cost or producibility.

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Executive Summary

This report contains the results of emission testing to evaluate the pouring, cooling, and shakeout emissions from Baseline GJ, an uncoated Furan WARMBOX core in a mold consisting of greensand without seacoal. Baseline GJ will be used as a core baseline against which other WARMBOX products and processes are to be compared. Results are compared, for the convenience of the reader, to Reference Test FR that also used greensand molds without seacoal but with uncoated Phenolic Urethane step cores. All testing was conducted by Technikon, LLC in its Research Foundry. The emissions results are reported in both pounds of analyte per pound of binder and pounds of analyte per ton of metal poured.

The testing performed involved the collection of continuous air samples over a seventy-five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and include: the weights of the casting, mold, and binder; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack temperature, pressure, volumetric flow rate, and moisture content. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the tests runs. Samples were collected and analyzed for sixty-one (61) target compounds using procedures based on US EPA Method 18. Continuous monitoring of the Total Gaseous Organic Concentration (TGOC) and the Carbon Dioxide, Carbon Monoxide, and Nitrogen Oxide concentrations in the emissions was conducted according to US EPA Methods 25A, 3A, 10, and 7E respectively.

Mass emission rates for all analytes were calculated using continuous monitoring data, laboratory analytical results, measured source data and appropriate process data. Results are presented in detail in Appendix B. Individual analyte emissions were calculated in addition to five emission indicators. These indicators include TGOC as propane, Hydrocarbons (HC) as hexane, the Sum of Target VOCs, the Sum of Target HAPS, and the Sum of Target Polycyclic Organic Matter (POM). Detailed descriptions of these indicators can be found in the Results section of this report.

Results for the emission indicators are shown in the following table reported in both pounds per pound (lbs/lb) of binder and pounds per ton (lbs/ton) of metal. For the convenience of the reader, Reference Test FR Phenolic Urethane values are also shown.

Table 1 Test Plans Reference FR & Baseline GJ Emissions Indicators

	TGOC as Propane	HC as Hexane	Sum of Target VOCs	Sum of Target HAPs	Sum of Target POMs
Baseline GJ (LB/LB Binder)	0.0219	0.0033	0.0039	0.0039	<.0001
Baseline GJ (LB/Ton Metal)	0.3357	0.0504	0.0593	0.0584	0.0011
Reference FR (Lb/Lb Binder)	0.1480	0.0482	0.0591	0.0554	0.0169
Reference FR (Lb/Ton Metal)	0.9259	0.3016	0.3705	0.3474	0.1059

A pictorial casting record was made of cavity #3 from each mold for reference to future castings made with vendor products. The pictures are shown in rank-order in Appendix C.

It must be noted that the baseline testing performed is 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, and 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 mobile 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 Research Consortium (ERC), a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC), a laboratory of the United States Army; 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.

1.2. Technikon Objectives

The primary objective of Technikon 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 arena has been specially designed to facilitate the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate emissions from a furan Warmbox cored green sand system without seacoal. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, 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 the report contains discussion of the results.

The raw data for this test series are included in an archive that is maintained 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

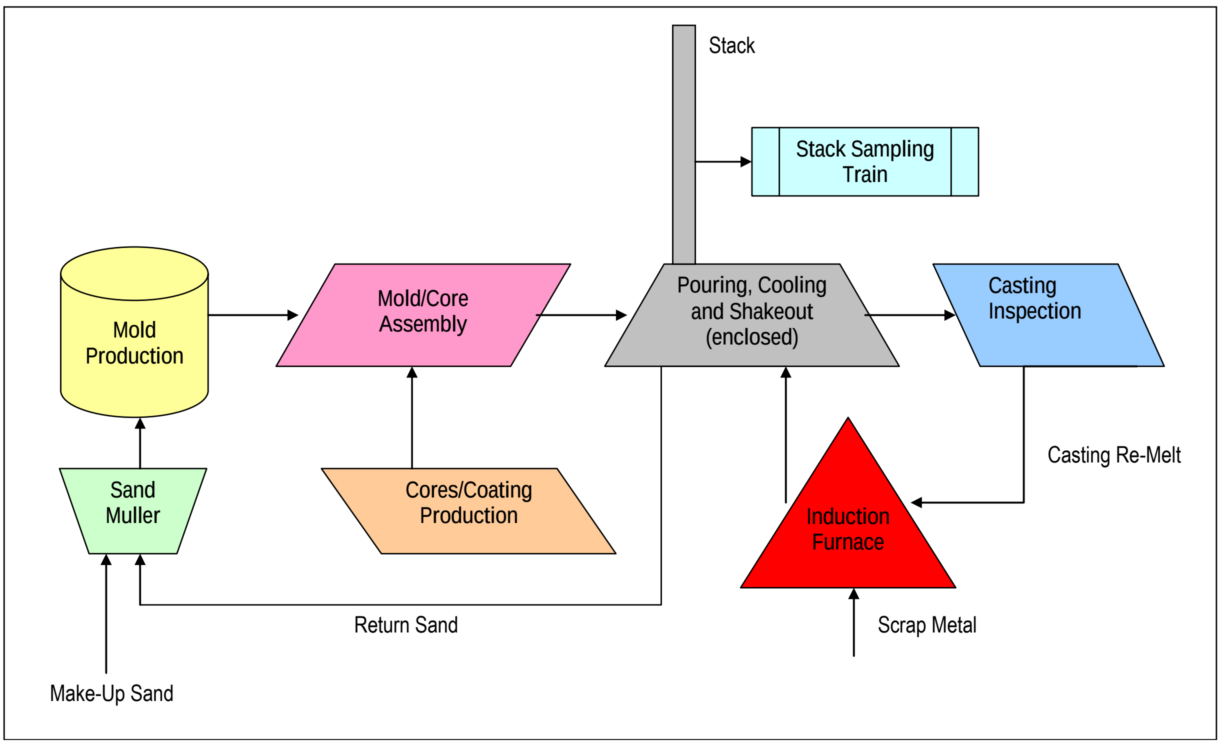
	Reference Test Plan FR	Test Plan GJ
Type of Process tested	Phenolic Urethane Core, Greensand without Seacoal, Iron PCS	Warm Box (Furan) Core, Greensand without Seacoal, Iron PCS Baseline
Test Plan Number	1410 114 FR	1411 123 GJ
Greensand System	Wexford W450 Lakesand, Western and Southern Bentonite, No Seacoal	Wexford W450 Lakesand, Western and Southern Bentonite, No Seacoal
Metal Poured	Iron	Iron
Casting Type	4-on Step Core	4-on Step Core
Core	1.4% Ashland ISOCURE® 305/904 Phenolic Urethane Binder System Amador A-70 Silica Sand	1.4% (BOS) HA International 08-76B ARS6502 Warm Box Binder System, Wedron 530 Silica sand
Core Coating	None	None
Number of molds poured	3 Conditioning and 4 Sampling	3 Conditioning + 9 Sampling
Test Dates	1/15/04 > 1/29/04	2/02/05 < 2/08/05
Emissions Measured	TGOC as Propane, HC as Hexane, 68 Organic HAPs and VOCs	TGOC as Propane, HC as Hexane, 69 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, 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 process equipment.

Figure 2-1 Research Foundry Layout Diagram



2.2. 2.2 Description of Testing Program

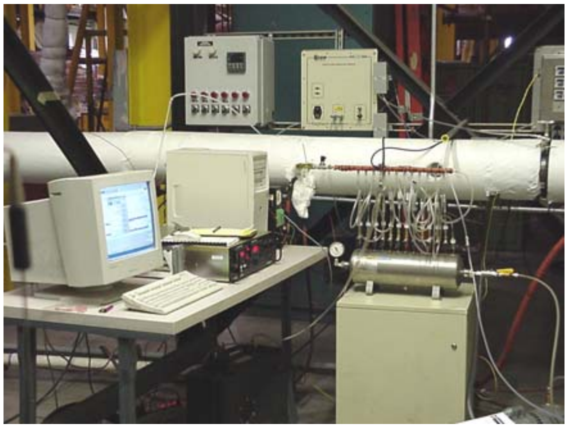
The specific steps used in this sampling program are summarized below:

1. **<u>Test Plan Review and Approval</u>**: The proposed test plan was reviewed and approved by the Technikon staff.

2. **<u>Mold, Core and Metal Preparation:</u>** The molds were prepared to a standard composition by the Technikon production team. The cores were supplied by the University of Northern Iowa to Technikon specification. Relevant process data was collected and recorded. Iron was melted in a 1000 lb. Ajax induction furnace. The amount of metal melted was determined from the poured weight of the casting and the number of molds to be poured. The metal composition was Class-30 Gray Iron as prescribed by a metal composition worksheet. The weight of metal poured into each mold was recorded on the process data summary sheet.

Uncoated Step Cores in mold

Total Enclosure Test Stand



Method 25A (TGOC) and Method 18 Sampling Train

3. **<u>Individual Sampling Events:</u>** Replicate tests were performed on nine (9) mold packages after the conclusion of three (3) conditioning cycles. The mold packages were placed into an enclosed test stand heated to approximately 85°F. Iron was poured through an opening in the top of the emission enclosure, after which the opening was closed.

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

4. **<u>Process Parameter Measurements:</u>** 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 Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Cardinal 748E platform scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale (Gravimetric)
Muller water weight	Cardinal 748E platform scale (Gravimetric)
Binder Weight, Core Weight	Mettler SB12001 Digital Scale (Gravimetric)
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold and Shakeout	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 (Gravimetric)
Mold Compactability	Dietert 319A Sand Squeezer (AFS Procedure 2221-00-S)
Carbon/Silicon	Electro-Nite DataCast 2000 (thermal arrest)

5. **<u>Air Emissions Analysis:</u>** The specific sampling and analytical methods used in the Pre-Production Foundry tests are based on the US EPA 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 Sampling and Analytical Methods

Measurement Parameter	Test Method
Port Location	EPA Method 1
Number of Traverse Points	EPA Method 1
Gas Velocity and Temperature	EPA Method 2
Gas Density and Molecular Weight	EPA Method 3A
Gas Moisture	EPA Method 4, gravimetric
HAPs Concentration	EPA Method 18, TO11, NIOSH 1500, 2002
VOCs Concentration	EPA Method 18, 25A, TO11, NIOSH 1500, 2002
Hydrogen Cyanide	NIOSH 6010
Sulfur Dioxide	OSHA ID200
Carbon Monoxide	EPA Method 10
Carbon Dioxide	EPA Method 3A
Nitrogen Oxides	EPA Method 7E

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 times 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 to provide emissions data in both pounds of analyte per pound of binder and pounds of analyte per ton of metal.

   The results of each of the sampling events are included in the appendices of this report. The emissions results are also averaged and are shown in Tables 3-1 and 3-3.

7. **Report Preparation and Review:** The Preliminary Draft Report is reviewed by the Process Team and Emissions Team to ensure its completeness, consistency with the test plan, and adherence to the prescribed QA/QC procedures. Appropriate observations, con-

clusions and recommendations are added to the report to produce a Draft Report. The Draft Report is reviewed by the Vice President-Measurement Technologies, the Vice President-Operations, the Manager-Process Engineering, and the Technikon President. 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. 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 Manager - Process Engineering to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Manager - Process Engineering and the Vice President - 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 VP-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 in pounds per pound (lbs/lb) of binder and pounds per ton (lbs/ton) of metal are presented for Test GJ and compared to Reference Test FR in Tables 3-1 and 3-2. The tables include the individual target compounds that comprise at least 95% of the VOCs measured, along with the corresponding Sum of Target VOCs, Sum of Target HAPs, and Sum of Target POMs. The tables also include the TGOC as propane, HC as hexane, and selected criteria and greenhouse gases such as carbon monoxide, carbon dioxide, and nitrogen oxides.

Compounds that are structural isomers have been grouped together and are reported as a single quantity. For example: ortho-, meta-, and para-xylene are the three structural isomers of dimethyl benzene and their sum is reported as xylenes. Trimethylbenzenes and dimethylphenols are also treated and reported in a similar manner.

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 C1 (methane), with results calibrated against the three-carbon alkane (propane). The HC as hexane method detects hydrocarbon compounds in the alkane range between C6 and C16, with results calibrated against the six-carbon alkane (hexane).

Other emissions indicators, in addition to TGOC as propane and HC as hexane, were calculated and are presented in these tables. The emissions indicator Sum of Target VOCs is the sum of all the individual target analytes detected and includes targeted HAPs and POMs, as well as other targeted VOCs (volatile organic compounds). 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 the 188 listed EPA HAPs was targeted for collection and analysis. These individual target HAPs (which may also be POMs by nature of their chemical properties) detected in the samples are summed together and defined as the Sum of Target HAPs, while the Sum of Target POMs only sums those HAPs that are also defined as POMs.

A determination of whether the means of the emissions from Reference Test FR and the current test, Baseline Test GJ, were different was made by calculating a statistical T-test at a 95% significance level ($\boldsymbol{a}$ = 0.005). Significance is indicated in Tables 3-1 and 3-2 by a bold format on the values in the "% Change from Baseline" column.

Table 3-3 includes the averages of the key process parameters.

The ranking of casting appearance is in Table 3-4. Each casting from the third cavity of the mold from the Reference Test FR 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 an in-series rank of "1". The "median" designation, given an in-series rank of "5", means that four castings are better in appearance and four are worse. The "worst" designation is assigned to that casting which is of the poorest quality, and is assigned an in-series rank of "9". The castings from Baseline Test GJ underwent the same evaluative procedure. The three-benchmark castings from Test FR then were compared and collated to the benchmark castings from Test GJ.

Figures 3-1 and 3-2 present the comparative five emissions indicators and selected individual HAP and VOC emissions data from Table 3-1 in graphical form. Similarly, Figures 3-3 and 3-4 present the comparative five emissions indicators and selected HAP and VOC emissions data in lb/ton of metal from Table 3-2 in graphical form.

Appendix B contains the detailed emissions data including the results for all analytes measured for both Baseline GJ and Reference FR.

Detailed process data for both tests are presented in Appendix C.

All cavity 3 castings are photographically shown in Appendix C.

TGOC, criteria pollutants, and greenhouse gas charts for both tests are included in Appendix D of this report. The charts are presented to show time-dependent emissions profiles for each pour.

Table 3-1 Comparative Summary of FR to GJ, Average Results – Lb/Lb Binder

Compound	Reference FR Average	Test GJ Average	% Change from Reference
Emission Indicators			
TGOC as Propane	0.1480	0.0219	-85
HC as Hexane	0.0482	0.0033	-93
Sum of Target VOCs	0.0591	0.0039	-93
Sum of Target HAPs	0.0554	0.0039	-93
Sum of Target POMs	0.0169	< 0.0001	-100
Individual Target VOCs			
Benzene	0.0174	0.0018	-89
Phenol	0.0113	0.0007	-94
Methylnaphthalenes	0.0085	NA	NA
Naphthalene	0.0062	< 0.0001	-99
Cresols	0.0030	NA	NA
Toluene	0.0026	0.0004	-86
Dimethylnaphthalenes	0.0022	NA	NA
Trimethylnaphthalene, 2,3,5-	0.0013	NA	NA
Trimethylbenzenes	0.0013	NA	NA
Xylenes	0.0010	0.0002	-85
Acetaldehyde	0.0005	0.0005	-2
Ethyltoluenes	0.0005	< 0.0001	158
Indene	0.0004	NA	NA
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	2.9959*	0.2819	NA
Carbon Monoxide	ND	0.1333	NA
Sulfur dioxide	NT	0.0004	NA
Nitrigen Oxides	NT	0.0003	NA
Hydrogen Cyanide	NT	0.0002	NA

* Not background corrected
Individual results constitute >95% of mass of all detected VOCs for FR. Names in italics are compounds which account for >95% of detected mass for GJ.
<0.0001 indicates the emission value was above the detection limit, but below the reporting limit of 0.0001
NT=Not Tested
NA= Not Applicable
Bold numbers indicate those compounds whose calculated t-statistic is significant at alpha=0.05

Table 3-2 Comparative Summary of FR to GJ, Average Results – Lb/Ton Metal

Compound	Reference FR Average	Test GJ Average	% Change from Reference
Emission Indicators			
TGOC as Propane	0.9259	0.3357	-64
HC as Hexane	0.3016	0.0504	-83
Sum of Target VOCs	0.3705	0.0593	-84
Sum of Target HAPs	0.3474	0.0584	-83
Sum of Target POMs	0.1059	0.0011	-99
Individual Target VOCs			
Benzene	0.1088	0.0280	-74
Phenol	0.0707	0.0106	-85
Methylnaphthalenes	0.0533	NA	NA
Naphthalene	0.0389	0.0011	-97
Cresols	0.0187	NA	NA
Toluene	0.0161	0.0054	-66
Dimethylnaphthalenes	0.0137	NA	NA
Aniline	0.0130	NA	NA
Trimethylbenzenes	0.0079	NA	NA
Xylenes	0.0064	0.0024	-63
Acetaldehyde	0.0034	0.0082	139
2-Butanone	0.0002	0.0014	529
Criteria Pollutants and Greenhouse Gases			
Carbon Dioxide	18.5333*	4.3249	NA
Carbon Monoxide	ND	2.0415	NA
Sulfur Dioxide	NT	0.0037	NA
Nitrigen Oxides	NT	0.0049	NA
Hydrogen Cyanide	NT	0.0059	NA

*Not background corrected
Except for 2-Butanone, individual results constitute >95% of mass of all detected VOCs for FR. Names in italics are compounds which account for >95% of detected mass for GJ.
NA= Not Applicable
Bold numbers indicate those compounds whose calculated t-statistic is significant at alpha=0.05

Table 3-3 Summary of Tests FR and GJ Average Process Parameters

Greensand PCS

	Test Fr	Test GJ
Test Dates	15-16 Jan 04	2-8 Feb 05
Cast Weight (all metal inside mold), Lbs.	111.06	113.49
Pouring Time, sec.	28	16
Pouring Temp ,°F	2632	2632
Pour Hood Process Air Temp at Start of Pour, °F	87	88
Total Uncoated Core Weight in Mold, Lbs.	25.25	29.07
Core Binder Resin Content w/o catalyst, %BOS	1.39	1.43
Core Binder Calculated Resin Content w/o Catalyst , %	1.38	1.41
Core Binder Resin Weight w/o Catalyst, Lbs	NA	0.41
Core Binder Catalyst Reported Content, % BOR	Amine gassed	23.0
Total Binder Weight in Mold, Lbs.	0.347	0.506
Core LOI	1.26	1.35
Average Dogbone Tensile strength, psi	39.5	NA
Approximate core age,hrs	61.25	428
Core box temperature, F	NA	375-410
Average heated investment time, Seconds	NA	45-60
Muller Batch Weight, Lbs.	900	900
GS Mold Sand Weight, Lbs.	620	629
Mold Compactability, %	56	55
Mold Temperature, °F	70	77
Average Green Compression , psi	11.0	24.2
GS Compactability, %	53	36
GS Moisture Content, %	2.27	2.01
GS MB Clay Content, %	6.02	7.65
MB Clay Reagent, ml	26	37
1800°F LOI - Mold Sand, %	0.71	0.89
900°F Volatiles , %	0.24	0.38

Figure 3-1 Comparative Emission Indicators, Tests FR and GJ – Lb/Lb Binder

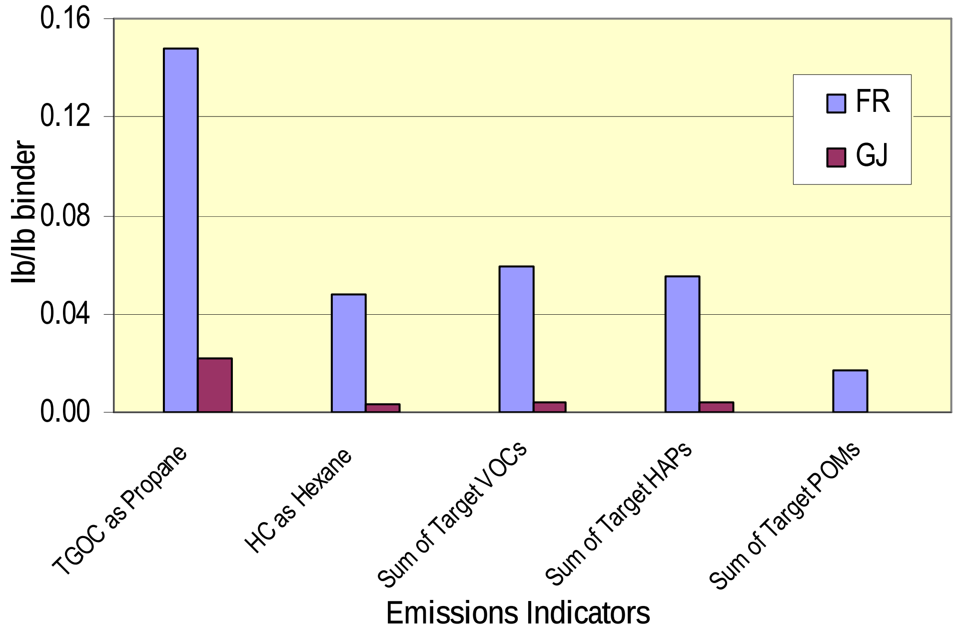

Figure 3-2 Top 95 % Selected HAP & VOC Emissions Tests FR and GJ– Lb/Lb Binder

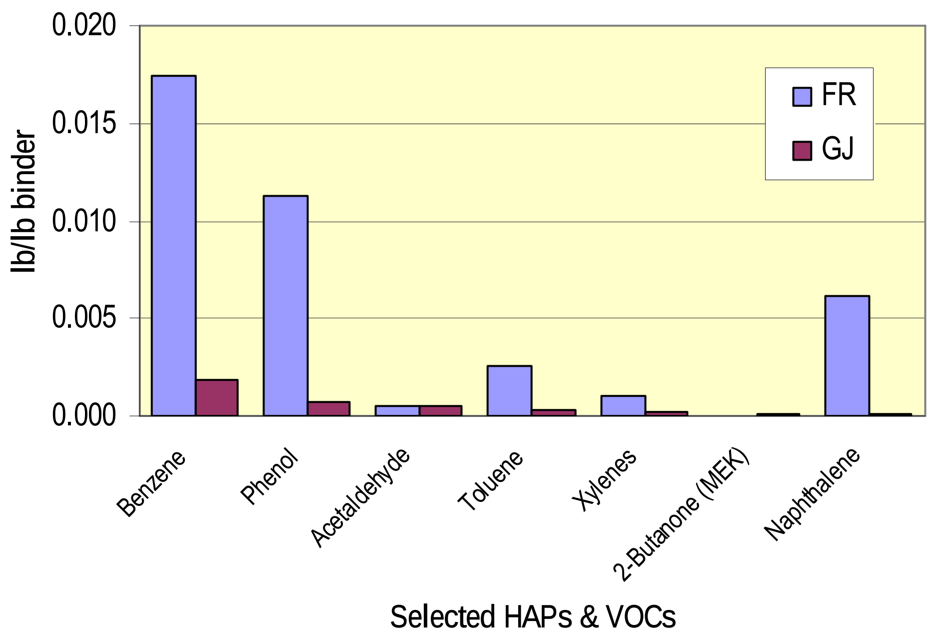

Figure 3-3 Emissions Indicators Tests FR and GJ – Lb/Tn Metal

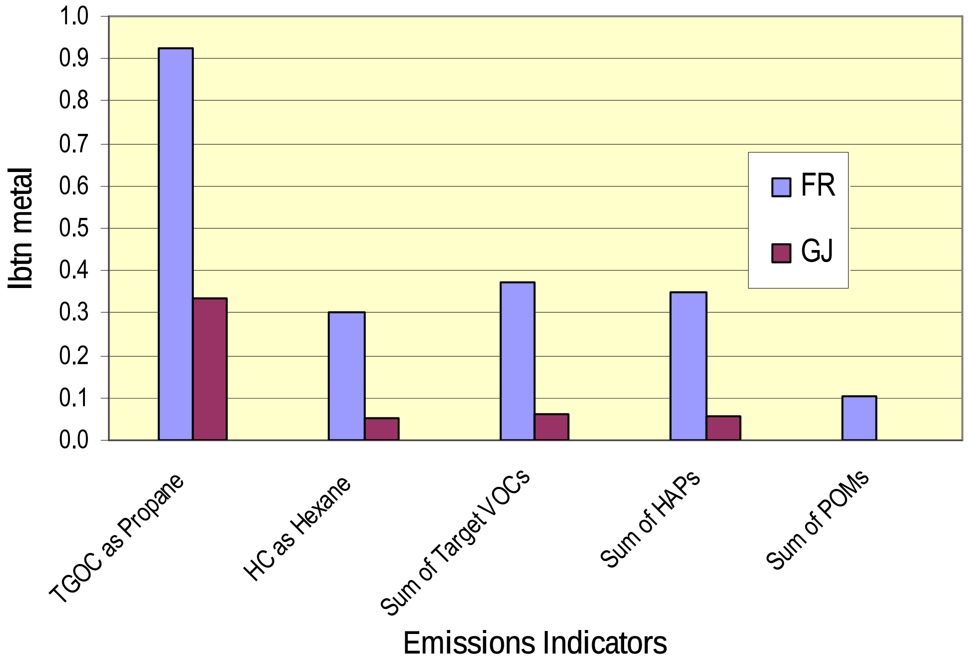

Figure 3-4 Top 95 % Selected HAP & VOC Emissions Tests FR GJ– Lb/Ton Metal

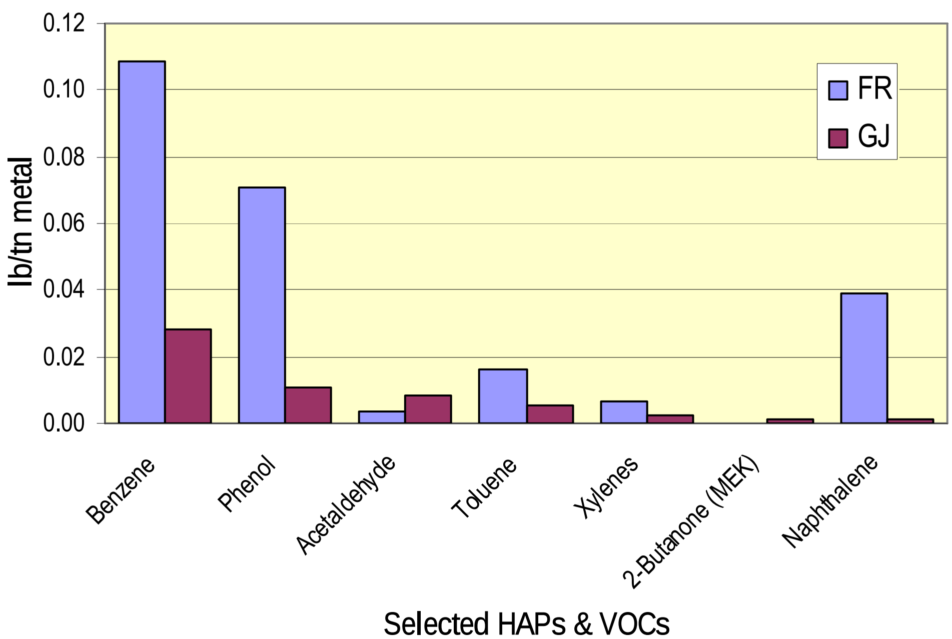

Table 3-4 Rank Order of Casting Surface Quality

Rank Order of Appearance Overall Best Casting to Overall Worst Casting	Production Mold Number	Test FR Benchmark	Test GJ Comparative
Rank1	GJ010		1-Best
Rank2	FR003	1-Best	
Rank3	GJ007		
Rank4	GJ008		
Rank5	GJ004		
Rank6	GJ011		5-Median
Rank7	FR002	2-Median	
Rank8	FR001	3 Median	
Rank9	GJ006		
Rank10	GJ012		
Rank11	GJ009		
Rank12	GJ005		9-Worst
Rank 13	FR004	4-Worst	

4.0 DISCUSSION OF RESULTS

The sampling and analytical methodologies were the same for Test Plans FR and GJ except for the determination of carbon monoxide, carbon dioxide, sulfur dioxide, Hydrogen cyanide, and nitrogen oxides. Carbon monoxide and carbon dioxide were collected in a Tedlar bag for offsite analysis on Test FR and were determined on-line with NIST traceable monitors for Test GJ. The on-line monitors provide significantly more accurate data than the bag samples. Similarly, sulfur dioxide, hydrogen cyanide, and the nitrogen oxides were not tested for under Test FR, but were determined on-line for Test GJ. All of the on-line monitoring results are corrected for ambient background. See Appendix B for the detailed results.

The results in Table 3.1 show an 85% reduction in TGOC (THC) as propane, a 93% reduction in HC as hexane, and 93% reduction in Sum of Target VOCs, a 93% reduction in Sum of HAPs, and a 100% reduction in Sum of POMs for Test GJ compared to Test FR, respectively.

Seven (7) of the measured compounds comprised greater than 96% of the mass of all VOCs detected from Test GJ. Benzene, phenol, acetaldehyde, & toluene, contributed 89, 94, 2, & 86 % respectively to the total VOCs and HAPs. The remaining VOCs listed in Table 3-2 individually contributed 1-4% of the total VOCs and HAPs.

Measured process parameters indicated that all tests were run within acceptable established limits, and replicate tests were conducted following similar procedures.

A determination of whether the results of the reference test FR and the test GJ were different was made using the “Student” T-test at a 95% significance level ($\alpha = 0.05$). Results of the T-test indicate that there is a 95% probability that the mean emission values for GJ are nonequivalent to those of FR. Therefore, it may be said that the differences in the average emission values are not due to test variability, but are real differences. Detailed results of the T-Statistics calculation are found in Appendix B.

Target analyte reporting limits expressed in both pounds per pound of binder and pounds per ton of metal are shown in Appendix B.

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APPENDIX A TEST PLANS, INSTRUCTIONS, SAMPLE PLANS FOR TESTS FR & GJ

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TECHNIKON TEST PLAN

- **CONTRACT NUMBER:** 1410 **TASK NUMBER** 1.1.4 **SERIES** FR
- **SITE:** Pre-production
- **TEST TYPE:** Product Test: Pouring, cooling, & shakeout of uncoated Phenolic urethane step cores with anti-veining compounds.
- **METAL TYPE:** Class 30 gray iron
- **MOLD TYPE:** Virgin, no seacoal, greensand with 4-on PU step-cores recycled after each pour.
- **NUMBER OF MOLDS:** Three engineering & conditioning runs + 4 sampling runs each from reference cores w/o anti-veining additive and two (2) anti-veining compounds. Twenty-one (21) runs total.
- **CORE TYPE:** Step: 1.4% Ashland ISOCURE ® Phenolic Urethane LF305 part I (55%), 904GR Part II (45%), amine cured. 50-120 hrs old. Reference cores shall not contain anti-veining material. Test cores shall contain 1% (BOS) Ashland 070359 red iron oxide fine or 2% (BOS) Chesapeake Specialty Products SpherOX ® black iron oxide fine.
- **CORE COATING:** Cores shall be uncoated.
- **SAMPLE EVENTS:** 4 runs each for reference cores and two core sets containing different anti-veining materials, total twelve sample runs (12).
- **TEST DATE:** **START:** 12 Jan 2004
  FINISH: 30 Jan 2004

TEST OBJECTIVES:

Measure the airborne pouring, cooling, & shakeout emissions for organic step cores containing anti-veining compounds in a mechanically-produced clay, water, and coal-less greensand mold.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford W450 Lakesand, western and southern bentonite in a 5:2 ratio with yield 7.0 +/- 0.5% MB Clay, no seacoal, and tempered to 40-45% compactability, 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 2630 +/- 10°F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes. Cores will be made with Amador-70 silica sand heated to 85-90°F and made in an 80-90° F heated enclosed core machine. No emission sampling will be done during core manufacture.

BRIEF OVERVIEW:

This is the first test to include materials contained in the core in addition to the binder. The purpose of the included core additives is to reduce the veining defect common to silica sand cores poured with iron. This test and test FT, using different anti-veining materials, are intended to determine if the anti-veining compounds impact the emissions from the base binder in an uncoated core poured with iron.

The greensand molds will be produced on the mechanically assisted Osborne 716 molding machines.

The emission results will be compared to an internal baseline of uncoated step cores of the same binder content. In addition to a suite of selected emission analytes TGOC, CO & CO_2 content of the runs will be monitored using instruments specific to those gasses.

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially for each subtest a 1300 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with Amador A-70 silica sand at 85-90°F. The core shall be maintained at 80-90°F awaiting insertion in the mold. The cores shall be stabilized for 50-120 hours when tested.

Series FR

PCS Core Product Test in Greensand with Ashland 305/904 Core Binder, anti-veining compound, & Mechanized Molding

Process Instructions

A. Experiment:

1. Measure pouring, cooling, & shakeout emissions from uncoated organic cores, containing an anti-veining compound, in a greensand mold made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5% MB Clay, & no seacoal. The molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand. Emissions will be compared to those from the same mold configuration containing cores with no anti-veining compound

B. Materials:

1. Mold sand:

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

2. Core:

a. Step cores made with virgin Amador A-70 sand and 1.4% Ashland ISOCURE® LF305/52-904GR regular phenolic urethane binder in a 55/45 ratio, TEA catalyzed. Reference cores shall be made without any anti-veining compound and the test cores shall include an anti-veining compound.

3. Anti Vein Compounds:

a. To the test core sand mixes shall be added:

1) 1 % (BOS) Ashland (070359) Red Iron Oxide Fine (Fe_2O_3) or

2) 2 % (BOS) of Chesapeake Specialty Products SpherOX ® Black Iron Oxide Fine (Fe_3O_4).

4. Metal:

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

5. Pattern Spray: Black Diamond, hand wiped.

C. Briefing:

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

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

D. ISOCURE® regular Step Cores:

1. Premix anti-veining compound in blue R/C mixer.

- **a.** a. Make 2 batches of sand. The first containing 1% (BOS) Ashland red iron oxide fine anti-veining compound, and the other 2% (BOS) Chesapeake Specialty Products' black iron oxide fine anti-veining compound.
- **b.** For each batch add 400 pounds of dry A-70 sand to the R/C mixer.
- **c.** Distribute 4.00 pounds of Ashland red iron oxide to one batch and 8.00 pounds of black iron oxide to the remaining batch. Clean the mixer with 50 pounds of clean sand between batches.
- **d.** Mix each batch for 10 minutes.
- **e.** Place the respective batches in clean containers to be heated to 85-90°F degrees prior to mixing with the core binder.

2. Klein vibratory core sand mixer.

- **a.** Attach the day tanks with the intended part I and part II binder components via respective binder shut-off valves so that they gravity feed to the respective pumps. The binder components should be 80-85°F.
- **b.** On the main control panel turn the AUTO/MAN switch to MANUAL, turn on main disconnect and MASTER START push button.
- **c.** Fill the Part I and Part II pumps and de-air the lines.
- **d.** Calibrate the Klein mixer.
  - **1)** Remove the mixing bowl skirt to gain access to the binder injection tubes and the bottom side of the batch hopper outlet gate.
  - **2)** Calibrate sand. Recalibrate for each sand mixture used.
    - **a)** Turn the AUTO/MAN switch to MANUAL on main control panel.
    - **b)** Place one bucket of preheated sand, raw, or containing one of the iron oxides, of at least fifty-two (52) pounds net weight, into the sand hopper and manually fill batch hopper using max. and min. proximity switches.
    - **c)** Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.
    - **d)** Repeat 3 times to determine the weight variation. The sand should be 80-85°F.
  - **3)** Calibrate the binder pumps.
    - **a)** Adjust the part I dispensing rate by adjusting the part I pump stroke to be 55% of 1.4% (0.77 % BOS) of the average sand batch weight dispensed in D.2.e.2).
    - **b)** Adjust the machine's inlet air pressure to dispense the binder in about the same time as the sand is dispensed, about 10-15 seconds.
    - **c)** Record the pressure and dispensing time, and net weight.
    - **d)** Repeat 3 times to determine the variation in dispensing rate.

e) Adjust the part II dispensing rate by adjusting the part II pump stroke to be 45% of 1.4% (.63% BOS) of the average sand rate dispensed in D.2.e.2).
f) Repeat D.2.d.3).c), & d) for Part II pump.

4) Turn off the mixer and replace the mixing bowl skirt.

e. Turn on the mixer and turn the AUTO/MAN switch to AUTO.
f. Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. Make three (3) batches to start the Redford Carver core machine.
g. Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.
h. Clean the mixer after each material.
i. Approximately 7 batches will be needed for each core material type.
j. Mix the sand without anti-veining compound first, then the material containing the 1% red iron oxide, and finally the material containing the 2 % black iron oxide.

Caution: Do not make more sand than sand magazine will hold plus one (1) batch. If too much sand is made the sand will be exposed to captured TEA and significantly shorten the sand bench life

3. Redford/Carver core machine.
a. Mount the Step-Core core box on the Carver/Redford core machine.
b. Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
c. Set up the core machine in the cold box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
d. Core process setup
1) Set the TEA to a nominal 5 grams per blow (gas time 0.75 sec (R/C), flow .019 lbs/sec (Luber).
2) Set the blow pressure to 30+/-2 psi for 3 seconds (R/C).
3) Set the max purge pressure to 45 psi on the Luber gas generator.
4) Purge for 20 seconds(R/C) with a 10 second rise time (Luber).
5) Total cycle time approximately 1 minute.

e. Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. Make five (5) additional 50 pound sand batches and run the sand out making core. A minimum of 35 cores are required.
f. One half hour to 1 hour after manufacture randomly perform a scratch hardness test on the outer edge of the blow surface on 10% of the cores and record the results on the Core Production Log. Values less than 25 shall be marked with a HOLD TAG until they can be 100% scratch hardness tested to re-qualify. Contact the Process Engineer for disposition on all cores with values less than 15 after 1 hour. Weigh each core and log the results.
g. The sand lab will sample, at the time of manufacture, one (1) core from each row of each shelf (1 of 11) on each core rack. Those cores will be tested for LOI using the

standard 1800°F core LOI test method and reported out associated with the core rack shelf it represents. Qualified cores receiving the green Quality Checked tag must have LOI values between 1.25-1.50%. Individual rows that qualify may have the Quality Checked tag affixed. Only cores with the green Quality Tag bearing the current test series and dates and signature of the lab technician and core rack/shelf/position on shelf may be taken to the mold assembly area.

Note: The core rack position from the Quality Checked tag shall be transferred to the mold assembly check list with the core weights.

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

E. Sand preparation

1. Start up batch: make 3, FRCD1, FRCD4, & FRCD7. One batch is for each type of core material.

- **a.** Thoroughly clean the pre-production muller, elevator, and molding hoppers.
- **b.** Weigh and add 1225 +/-10 pounds of new Wexford W450 Lakesand, per the recipe, to the running pre-production muller to make a 1300 batch.
- **c.** Add 5 pounds of potable to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
- **d.** Add the clays slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.
- **e.** Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
- **f.** Temper the sand-clay mixture slowly, with potable water, to allow for distribution.
- **g.** After about 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
- **h.** Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 40-45%.
- **i.** Discharge the sand into the mold station elevator.
- **j.** Grab sufficient sample after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
- **k.** Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge.
- **l.** 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. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.
- **m.** Empty the extra greensand from the mold hopper into a clean empty dump hopper whose tare weight is known. Set this sand aside to be used to maintain the recycled batch at 900+/-10 pounds

2. Re-mulling: FRCD2, FRCD5, & FRCD8

a. Add to the sand recovered from poured mold FRCD1, FRCD4, or FRCD 7 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.

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

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

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

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

3. Re-mulling: FRCD3, FRCD6, FRCD9 & FR001-FR0XX

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

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

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

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

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

F. Molding:

1. Step core pattern.

a. Pattern preparation:

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

2) Repair any damaged pattern or gating parts.

b. Making the green sand mold.

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

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

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

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

3. Locate a 24 x 24 x4 inch deep wood upset on top of the flask.

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

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

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

a. Open the air supply to the mold machine.

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

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

o. 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.

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

5. Set four (4) step cores that have been weighed and logged into the drag. Verify that the cores are fully set and flush with the parting line.
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, the coated cores, 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.

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

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

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

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

I. Melting:

1. Initial iron charge:

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

2. Back charging.

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

3. Emptying the furnace.

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

J. Pouring:

1. Preheat the ladle.

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

K. Rank order evaluation.

1. The supervisor shall select a group of 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 FR001, compare it to castings from mold FR002.
   c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   d. Repeat this procedure with FR001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than FN001 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.

Steven M. Knight
Mgr. Process Engineering

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/15/2004											
RUN 1											
THC	FR001	X									TOTAL
M-18	FR00101		1						60	1	Carbopak charcoal
M-18 MS	FR00102		1						60	2	Carbopak charcoal
M-18 MS	FR00103			1					60	3	Carbopak charcoal
Gas, CO, CO2	FR00104		1						60	4	Tedlar Bag
Gas, CO, CO2	FR00105				1				0		Tedlar Bag
NIOSH 1500	FR00106		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00107				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00108		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00109				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00110		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00111				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/15/2004											
RUN 2											
THC	FR002	X									TOTAL
M-18	FR00201		1						60	1	Carbopak charcoal
M-18	FR00202			1					60	2	Carbopak charcoal
M-18	FR00203				1				0		Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FR00204		1						60	4	Tedlar Bag
NIOSH 1500	FR00205		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FR00206			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FR00207		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FR00208			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FR00209		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FR00210			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/16/2004											
RUN 3											
THC	FR003	X									TOTAL
M-18	FR00301		1						60	1	Carbopak charcoal
M-18	FR00302					1			60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR00303		1						60	4	Tedlar Bag
NIOSH 1500	FR00304		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00305		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00306		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FR - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
1/16/2004											
RUN 4											
THC	FR004	X									TOTAL
M-18	FR00401		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FR00402		1						60	4	Tedlar Bag
NIOSH 1500	FR00403		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FR00404		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FR00405		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

TECHNIKON TEST PLAN

- ♦ **CONTRACT NUMBER:** 1411 **TASK NUMBER** 1.2.3 **SERIES** GJ
- ♦ **SITE:** Pre-production
- ♦ **TEST TYPE:** Baseline: Uncoated Warmbox (Furan) Core in Greensand: pouring, cooling, shakeout.
- ♦ **METAL TYPE:** Class 30 gray iron.
- ♦ **MOLD TYPE:** 4-on step-cored greensand with no seacoal.
- ♦ **NUMBER OF MOLDS:** 3 engineering/conditioning + 9 Sampling
- ♦ **CORE TYPE:** Step : 1.4% (BOS) HA International Envirotherm ® 08-76B resin and 23% (BOR) ARS 6502 catalyst plus 1% (BOR) silane coupling agent A-1160
- ♦ **CORE COATING:** None
- ♦ **SAMPLE EVENTS:** 9
- ♦ **ANALYTE LIST** List E, furfural, furfuryl alcohol, SO2, and HCN
- ♦ **TEST DATE:** **START:** 10 Jan 2005
  FINISH: 14 Jan 2005

TEST OBJECTIVES:

Establish an emission reference baseline (pouring, cooling, & shakeout) for a typical uncoated Warmbox (furan) core set in a mechanically-produced clay, water, coal-less greensand mold. The baseline will become a reference against which future warm box vendor test materials can be compared.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford W450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5 % MB Clay, no seacoal, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 70-90 oF prior to pouring. The sand heap will be maintained at 900 pounds. Molds will be poured with iron at 2630 +/- 10 oF. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out, followed by 15 minutes additional sampling for a total of 75 minutes.

BRIEF OVERVIEW:

These greensand molds will be produced on mechanically assisted Osborne molding machines. (Ref. CERP test FH). The 4-on step-core standard mold, is a 24 x 24 x 10/10 inch 4-on array of

AFS standard drag only step core castings to make a new baseline against which future hotbox core products can be compared. The cores will be manufactured under the direction of the University of Northern Iowa Metals Casting Center

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially a 1300 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with Wedron 530 silica sand. The cores shall be bagged in plastic as soon as sufficiently cooled. The cores will be approximately 3 weeks old when tested.

Series GJ

PCS Greensand Uncoated Core Baseline with HA International Envirotherm® 08-76B/ARS-6502 Warm box core binder & Mechanized Molding

Process Instructions

A. Experiment:

1. Create an organic Warmbox core-in-greensand baseline. Measure emissions from a greensand mold made with all virgin Wexford W450 sand, bonded with Western & Southern Bentonite in the ratio of 5:2 to yield 7.0 +/- 0.5% MB Clay, & no seacoal. The molds shall be tempered with potable water to 40-45% compactability, poured at constant weight, temperature, surface area, & shape factor. This test will recycle the same mold material, replacing burned clay with new materials after each casting cycle and providing clay for the retained core sand.

B. Materials:

1. Mold sand:

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

2. Core:

a. Uncoated step core made with virgin Wedron 530 silica sand and 1.6% (BOS) HA International Envirothem® 08-76B Furan Warmbox binder in a 100/23 ratio heat activated.

3. Core coating:

a. None

4. Metal:

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

5. Pattern Spray:

a. Black Diamond, hand wiped.

C. Briefing:

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

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

D. Warmbox two-piece Step Cores:

1. Cores will be manufactured under the direction of the University of Northern Iowa Metal Castings Center.
   a. After manufacture and cooling the cores will be sealed in polyethylene bags and packed in a compartmentalized wooden crate for shipping.
   b. The sand lab will sample one (1) core from the shipping box for each mold produced just prior to the emission test to represent the four (4) cores placed in that mold. Those cores will be tested for LOI using the standard 1800°F core LOI test method and reported out associated with the test mold it is to represent.

E. Sand preparation

1. Start up batch: make 1, GJER1.
   a. Thoroughly clean the pre-production muller elevator and molding hoppers.
   b. Weigh and add 1225 +/-10 pounds of new Wexford W450 Lakesand, per the recipe, to the running pre-production muller to make a 1300 batch.
   c. Add 5 pounds of potable water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
   d. Add the clays slowly to the muller to allow them to be distributed throughout the sand mass in proportion to the sand weight per the recipe for this test.
   e. Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
   f. Temper the sand-clay mixture slowly, with potable water, to allow for distribution.
   g. After about 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
   h. Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 40-45%.
   i. Discharge the sand into the mold station elevator.
   j. Grab sufficient sample after the final compactability test to fill a quart zip-lock bag. Label bag with the test series and sequence number, date, and time of day and deliver it immediately to the sand lab for analysis
   k. Record the total sand mixed in the batch, the total of each type of clay added to the batch, the amount of water added, the total mix time, the final compactability and sand temperature at discharge into the mold.
   l. The sand will be characterized for Methylene Blue Clay, AFS clay, Moisture content, Compactability, Green Compression strength, 1800°F loss on ignition (LOI), and 900 oF volatiles. Each volatile and LOI test requires a separate 50 gram sample from the collected sand.
   m. Empty the extra greensand from the mold hopper into a clean empty dump hopper whose tare weight is known. Set this sand aside to be used to maintain the recycled batch at 900+/-10 pounds

2. Re-mulling: GJER2
   a. Add to the sand recovered from poured mold GJER1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.
   b. Return the sand to the muller and dry blend for about one minute.
   c. Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.

d. Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
e. Follow the above procedure beginning at E.1.f.

3. Re-mulling: GJER3, GJ001-GJ0XX
a. Add to the sand recovered from the previous poured mold, mold machine spill sand, the residual mold hopper sand and sufficient pre-blended sand to total 900 +/- 10 pounds.
b. Return the sand to the muller and dry blend for about one minute.
c. Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.
d. Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
e. Follow the above procedure beginning at E.1.f.

F. Molding: Step core pattern.
1. Pattern preparation:
a. Inspect and tighten all loose pattern and gating pieces.
b. Repair any damaged pattern or gating parts.

2. Making the green sand mold.
a. Mount the drag pattern on one Osborne Whisper Ram molding machine and mount the cope pattern on the other Osborne machine.
b. Lightly rub parting oil from a damp oil rag on the pattern particularly in the corners and recesses.

Caution: Do not pour gross amounts of parting oil on the pattern to be blown 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. Set the crow-footed gagger on the support bar. Verify that it is at least ½ inch away from any pattern parts.
h. Manually riddle a half to one inch or so of sand on the pattern using a ¼ inch mesh riddle. Source the sand from the overhead mold sand hopper by actuating the CHATTER GATE valve located under the operators panel.
i. Fill the center potion of the flask.
j. Manually move sand from the center portion to the outboard areas and hand tuck the sand.
k. Finish filling the 24 x 24 x 10 inch flask and the upset with greensand from the overhead molding hopper.
l. Manually level the sand in the upset. By experience manually adjust the sand depth so that the resulting compacted mold is fractionally above the flask only height.
m. The operator will grab a sand sample for the Lab. The sand technician will quickly measure the sand temperature and compactability and record the results.
n. Initiate the settling of the sand in the flask by pressing the PRE-JOLT push button. Allow this cycle to stop before proceeding.
o. Remove the upset and set it aside.

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

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

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

WARNING: Do no re-approach the machine until the squeeze head has stopped at the side of the machine.

q. Screed the bottom of the drag mold flat to the bottom of the flask if required.
r. Press and release the LOWER DRAW/STOP push button to separate the flask and mold from the pattern.
s. Use the overhead crane to lift the mold half and remove it from the machine. If the mold half is a drag, roll it parting line side up, set it on the floor, blow it out.
t. Finally, press and release the DRAW DOWN pushbutton to cause the draw frame to return to the start position.

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

G. Pig molds

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

H. Emission hood:

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

2. Shakeout.
   - **a.** After the 45 minute cooling time prescribed in the emission sample plan has elapsed turn on the shakeout unit and run for it the 15 minutes prescribed in the emission sample plan or until the sand has all fallen through the grating.
   - **b.** Turn off the shakeout.
   - **c.** Sample the emissions for 30 minutes after the start of shakeout, a total of 75 minutes.
   - **d.** When the emission sampling is completed remove the flask, with casting, and recover the sand from the hopper and surrounding floor.
   - **e.** 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.
   - **f.** Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

I. Melting:

1. Initial iron charge:
   - **a.** Charge the furnace according to the heat recipe.
   - **b.** Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
   - **c.** Place a pig on top of the other materials.
   - **d.** Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
   - **e.** Add the balance of the metallics under full power until all is melted and the temperature has reached 2600 to 2700°F.
   - **f.** Slag the furnace and add the balance of the alloys.

- **g.** Raise the temperature of the melt to 2700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
- **h.** Hold the furnace at 2500-2550°F until near ready to tap.
- **i.** When ready to tap raise the temperature to 2700°F and slag the furnace.
- **j.** Record all metallic and alloy additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with an associated time.

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

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

J. Pouring:

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

K. Rank order evaluation.

1. The supervisor shall select a group of 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 each cavity :
- **a.** Place each casting initially in sequential mold number order.
- **b.** Beginning with casting from mold GJ001, compare it to castings from mold GJ002.
- **c.** Place the better appearing casting in the first position and the lesser appearing casting in the second position.
- **d.** Repeat this procedure with GJ001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than GJ001 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.
5. Compare GJ rankings to those in test FR cavity 3.

Steven M. Knight
Mgr. Process Engineering

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 1											
THC, CO, CO2, NOX	GJ001	X									TOTAL
M-18	GJ00101		1						30	1	Carbopak charcoal
M-18	GJ00102				1				0		Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00103		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	GJ00104				1				0		100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00105		1						200	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GJ00106				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00107		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
OSHA 72	GJ00108				1				0		100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00109		1						800	9	150/75 mg Poropak Q (SKC 226-115)
NIOSH 2505	GJ00110				1				0		150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00111		1						800	10	DNPH Silica Gel (SKC 226-119)
TO11	GJ00112				1				0		DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00113		1						800	11	Soda Lime (SKC 226-28)
NIOSH 6010	GJ00114				1				0		Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 2											
THC, CO, CO2, NOX	GJ002	X									TOTAL
M-18	GJ00201		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00202		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00203		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00204		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00205		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00206		1						800	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00207		1						800	11	Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 3											
THC, CO, CO2, NOX	GJ003	X									TOTAL
M-18	GJ00301		1						30	1	Carbopak charcoal
M-18	GJ00302			1					30	2	Carbopak charcoal
	Excess								30	3	Excess
OSHA ID200	GJ00303		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
OSHA ID200	GJ00304			1					80	5	100/50 mg Carbon Bead (SKC 226-80)
NIOSH 1500	GJ00305		1						200	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	GJ00306			1					200	7	100/50 mg Charcoal (SKC 226-01)
OSHA 72	GJ00307		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
OSHA 72	GJ00308			1					800	9	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00309		1						800	10	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00310		1						800	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 4											
THC, CO, CO2, NOX	GJ004	X									TOTAL
M-18	GJ00401		1						30	1	Carbopak charcoal
M-18 MS	GJ00402		1						30	2	Carbopak charcoal
M-18 MS	GJ00403			1					30	3	Carbopak charcoal
OSHA ID200	GJ00404		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00405		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00406		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00407		1						800	9	150/75 mg Poropak Q (SKC 226-115)
NIOSH 2505	GJ00408			1					800	10	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00409		1						800	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 5											
THC, CO, CO2, NOX	GJ005	X									TOTAL
M-18	GJ00501		1						30	1	Carbopak charcoal
M-18	GJ00502					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00503		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00504		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00505		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00506		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00507		1						800	10	DNPH Silica Gel (SKC 226-119)
TO11	GJ00508			1					800	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 6											
THC, CO, CO2, NOX	GJ006	X									TOTAL
M-18	GJ00601		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00602		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00603		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00604		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00605		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00606		1						800	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00607		1						800	11	Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 7											
THC, CO, CO2, NOX	GJ007	X									TOTAL
M-18	GJ00701		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00702		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00703		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00704		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00705		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00706		1						800	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00707		1						800	11	Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 8											
THC, CO, CO2, NOX	GJ008	X									TOTAL
M-18	GJ00801		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00802		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00803		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00804		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00805		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00806		1						800	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00807		1						800	11	Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION GJ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	BreakthrouGJ	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 9											
THC, CO, CO2, NOX	GJ009	X									TOTAL
M-18	GJ00901		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
OSHA ID200	GJ00902		1						80	4	100/50 mg Carbon Bead (SKC 226-80)
	Excess								80	5	Excess
NIOSH 1500	GJ00903		1						200	6	100/50 mg Charcoal (SKC 226-01)
	Excess								200	7	Excess
OSHA 72	GJ00904		1						800	8	100/50 mg Pet Charcoal (SKC 226-38)
NIOSH 2505	GJ00905		1						800	9	150/75 mg Poropak Q (SKC 226-115)
TO11	GJ00906		1						800	10	DNPH Silica Gel (SKC 226-119)
NIOSH 6010	GJ00907		1						800	11	Soda Lime (SKC 226-28)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

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APPENDIX B DETAILED EMISSION RESULTS FOR FR AND GJ

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Test Plan FR Individual Emission Test Results – Lb/Lb

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		TGOC as Propane	1.55E-01	1.41E-01	1.57E-01	1.39E-01	1.48E-01	9.38E-03
		HC as Hexane	4.88E-02	5.06E-02	5.04E-02	4.30E-02	4.82E-02	3.54E-03
		Sum of VOCs	5.77E-02	5.84E-02	6.13E-02	I	5.91E-02	1.92E-03
		Sum of HAPs	5.37E-02	5.44E-02	5.82E-02	I	5.54E-02	2.44E-03
		Sum of POMs	1.47E-02	1.71E-02	1.88E-02	I	1.69E-02	2.06E-03
		Individual Organic HAPs						
x		**Benzene**	1.93E-02	1.45E-02	1.85E-02	I	1.74E-02	2.60E-03
x		**Phenol**	1.02E-02	1.25E-02	1.11E-02	I	1.13E-02	1.18E-03
x	z	**Naphthalene**	5.89E-03	6.21E-03	6.50E-03	I	6.20E-03	3.04E-04
x	z	**2-Methylnaphthalene**	4.72E-03	5.70E-03	6.26E-03	I	5.56E-03	7.77E-04
x	z	**1-Methylnaphthalene**	2.48E-03	3.02E-03	3.30E-03	I	2.94E-03	4.17E-04
x		**Toluene**	2.75E-03	2.29E-03	2.66E-03	I	2.57E-03	2.48E-04
x		**o-Cresol**	2.18E-03	2.67E-03	2.56E-03	I	2.47E-03	2.52E-04
x		**Aniline**	1.80E-03	2.26E-03	1.88E-03	2.34E-03	2.07E-03	2.73E-04
x	z	**1,3-Dimethylnaphthalene**	7.16E-04	9.11E-04	1.02E-03	I	8.84E-04	1.56E-04
x		**m,p-Xylene**	8.81E-04	7.83E-04	8.23E-04	I	8.29E-04	4.93E-05
x		**Acetaldehyde**	4.97E-04	5.86E-04	5.20E-04	5.81E-04	5.46E-04	4.43E-05
x		**m,p-Cresol**	4.20E-04	5.58E-04	5.33E-04	I	5.04E-04	7.35E-05
x	z	**1,6-Dimethylnaphthalene**	2.88E-04	3.65E-04	4.14E-04	I	3.55E-04	6.35E-05
x	z	**2,6-Dimethylnaphthalene**	2.56E-04	3.27E-04	3.72E-04	I	3.18E-04	5.86E-05
x	z	**2,7-Dimethylnaphthalene**	2.56E-04	3.27E-04	3.72E-04	I	3.18E-04	5.86E-05
x		**Styrene**	1.64E-04	4.94E-04	1.56E-04	I	2.71E-04	1.93E-04
x		**o-Xylene**	1.97E-04	1.83E-04	1.81E-04	I	1.87E-04	8.82E-06
x	z	**1,2-Dimethylnaphthalene**	1.24E-04	1.65E-04	1.84E-04	I	1.58E-04	3.04E-05
x		**Formaldehyde**	1.61E-04	1.12E-04	1.15E-04	1.10E-04	1.24E-04	2.46E-05
x	z	**2,3-Dimethylnaphthalene**	ND	5.29E-05	3.15E-04	I	1.23E-04	1.69E-04
x		**Biphenyl**	9.52E-05	1.20E-04	1.43E-04	I	1.19E-04	2.39E-05
x		**Ethylbenzene**	1.11E-04	1.27E-04	1.08E-04	I	1.15E-04	9.96E-06
x		**Hexane**	8.21E-05	9.70E-05	9.69E-05	I	9.20E-05	8.58E-06
x		**Propionaldehyde**	3.85E-05	3.63E-05	3.51E-05	3.85E-05	3.71E-05	1.73E-06
x		**2-Butanone**	3.94E-05	4.46E-05	3.45E-05	2.61E-05	3.61E-05	7.85E-06
x	z	**1,5-Dimethylnaphthalene**	ND	ND	9.79E-05	I	3.26E-05	5.65E-05
x	z	**Acenaphthalene**	ND	ND	ND	I	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	I	ND	NA
x		**Dimethylaniline**	ND	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	NA
		Other VOCs						
		1,2,4-Trimethylbenzene	1.04E-03	8.72E-04	7.74E-04	I	8.94E-04	1.33E-04
		Indene	4.72E-04	4.18E-04	4.23E-04	I	4.38E-04	2.95E-05
		Dodecane	4.12E-04	4.40E-04	2.68E-04	I	3.73E-04	9.24E-05
		1,2,3-Trimethylbenzene	4.16E-04	3.56E-04	3.17E-04	I	3.63E-04	5.03E-05
		2,4-Dimethylphenol	2.19E-04	2.95E-04	2.76E-04	I	2.64E-04	3.94E-05
		3-Ethyltoluene	2.86E-04	2.58E-04	2.22E-04	I	2.55E-04	3.22E-05

Test Plan FR Individual Emission Test Results – Lb/Lb cont.

HAPs	POMs	Compound/Sample Number	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		Other VOCs						
		1,3-Diethylbenzene	3.95E-04	3.25E-04	ND	I	2.40E-04	2.11E-04
		Undecane	1.89E-04	2.54E-04	2.08E-04	I	2.17E-04	3.34E-05
		2-Ethyltoluene	1.99E-04	1.98E-04	1.97E-04	I	1.98E-04	1.13E-06
		Propylbenzene	1.44E-04	1.85E-04	1.42E-04	I	1.57E-04	2.40E-05
		Tetradecane	1.19E-04	1.47E-04	1.74E-04	I	1.47E-04	2.79E-05
		Butyraldehyde/Methacrolein	9.17E-05	6.72E-05	5.53E-05	6.35E-05	6.94E-05	1.56E-05
		Benzaldehyde	4.86E-05	4.04E-05	3.04E-05	3.34E-05	3.82E-05	8.13E-06
		Heptane	ND	1.06E-04	ND	I	3.54E-05	6.14E-05
		Cyclohexane	ND	ND	ND	I	ND	NA
		Decane	ND	ND	ND	I	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	NA
		Indan	ND	ND	ND	I	ND	NA
		Nonane	ND	ND	ND	I	ND	NA
		Octane	ND	ND	ND	I	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	NA
		Other Analytes						
		Carbon Dioxide	2.97E+00	NA	3.13E+00	2.89E+00	3.00E+00	1.22E-01
		Methane	3.52E-03	NA	6.18E-03	5.62E-03	5.11E-03	1.40E-03
		Carbon Monoxide	ND	NA	ND	ND	ND	NA
		Ethane	ND	NA	ND	ND	ND	NA
		Propane	ND	NA	ND	ND	ND	NA
		Isobutane	ND	NA	ND	ND	ND	NA
		Butane	ND	NA	ND	ND	ND	NA
		Neopentane	ND	NA	ND	ND	ND	NA
		Isopentane	ND	NA	ND	ND	ND	NA
		Pentane	ND	NA	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

All "Other Analytes" are not included in the Sum of VOCs or HAPs.

Test Plan FR Individual Emission Test Results – Lb/Ton Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		TGOC as Propane	9.52E-01	9.14E-01	9.71E-01	8.66E-01	9.26E-01	4.67E-02
		HC as Hexane	2.99E-01	3.28E-01	3.12E-01	2.68E-01	3.02E-01	2.53E-02
		Sum of VOCs	3.54E-01	3.78E-01	3.80E-01	I	3.71E-01	1.47E-02
		Sum of HAPs	3.29E-01	3.52E-01	3.61E-01	I	3.47E-01	1.65E-02
		Sum of POMs	9.03E-02	1.11E-01	1.17E-01	I	1.06E-01	1.38E-02
		Individual Organic HAPs						
x		**Benzene**	1.18E-01	9.36E-02	1.14E-01	I	1.09E-01	1.33E-02
x		**Phenol**	6.24E-02	8.11E-02	6.86E-02	I	7.07E-02	9.53E-03
x	z	**Naphthalene**	3.61E-02	4.02E-02	4.03E-02	I	3.89E-02	2.39E-03
x	z	**2-Methylnaphthalene**	2.90E-02	3.69E-02	3.88E-02	I	3.49E-02	5.22E-03
x	z	**1-Methylnaphthalene**	1.52E-02	1.95E-02	2.05E-02	I	1.84E-02	2.80E-03
x		**Toluene**	1.69E-02	1.48E-02	1.65E-02	I	1.61E-02	1.10E-03
x		**o-Cresol**	1.34E-02	1.73E-02	1.58E-02	I	1.55E-02	1.96E-03
x		**Aniline**	1.10E-02	1.47E-02	1.16E-02	1.46E-02	1.30E-02	1.93E-03
x	z	**1,3-Dimethylnaphthalene**	4.39E-03	5.90E-03	6.35E-03	I	5.55E-03	1.03E-03
x		**m,p-Xylene**	5.40E-03	5.07E-03	5.10E-03	I	5.19E-03	1.82E-04
x		**Acetaldehyde**	3.04E-03	3.79E-03	3.22E-03	3.62E-03	3.42E-03	3.46E-04
x		**m,p-Cresol**	2.58E-03	3.62E-03	3.30E-03	I	3.16E-03	5.34E-04
x	z	**1,6-Dimethylnaphthalene**	1.76E-03	2.36E-03	2.56E-03	I	2.23E-03	4.16E-04
x	z	**2,6-Dimethylnaphthalene**	1.57E-03	2.12E-03	2.30E-03	I	2.00E-03	3.83E-04
x	z	**2,7-Dimethylnaphthalene**	1.57E-03	2.12E-03	2.30E-03	I	2.00E-03	3.83E-04
x		**Styrene**	1.01E-03	3.20E-03	9.67E-04	I	1.72E-03	1.28E-03
x		**o-Xylene**	1.21E-03	1.18E-03	1.12E-03	I	1.17E-03	4.46E-05
x	z	**1,2-Dimethylnaphthalene**	7.61E-04	1.07E-03	1.14E-03	I	9.89E-04	2.01E-04
x		**Formaldehyde**	9.87E-04	7.23E-04	7.13E-04	6.84E-04	7.77E-04	1.41E-04
x	z	**2,3-Dimethylnaphthalene**	ND	3.43E-04	1.95E-03	I	7.64E-04	1.04E-03
x		**Biphenyl**	5.84E-04	7.78E-04	8.87E-04	I	7.50E-04	1.53E-04
x		**Ethylbenzene**	6.81E-04	8.20E-04	6.69E-04	I	7.23E-04	8.39E-05
x		**Hexane**	5.03E-04	6.28E-04	6.01E-04	I	5.77E-04	6.57E-05
x		**Propionaldehyde**	2.36E-04	2.35E-04	2.17E-04	2.40E-04	2.32E-04	1.01E-05
x		**2-Butanone**	2.41E-04	2.89E-04	2.13E-04	1.63E-04	2.27E-04	5.27E-05
x	z	**1,5-Dimethylnaphthalene**	ND	ND	6.06E-04	I	2.02E-04	3.50E-04
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	I	ND	NA
x	z	**Acenaphthalene**	ND	ND	ND	I	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	NA
		Other VOCs						
		1,2,4-Trimethylbenzene	6.35E-03	5.65E-03	4.79E-03	I	5.60E-03	7.81E-04
		Indene	2.89E-03	2.71E-03	2.62E-03	I	2.74E-03	1.38E-04
		Dodecane	2.52E-03	2.85E-03	1.66E-03	I	2.34E-03	6.16E-04
		1,2,3-Trimethylbenzene	2.55E-03	2.31E-03	1.96E-03	I	2.27E-03	2.97E-04
		2,4-Dimethylphenol	1.34E-03	1.91E-03	1.71E-03	I	1.66E-03	2.87E-04
		3-Ethyltoluene	1.75E-03	1.67E-03	1.37E-03	I	1.60E-03	1.99E-04

Test Plan FR Individual Emission Test Results – Lb/Ton Metal cont.

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FR001	FR002	FR003	FR004	Average	STDEV
		Test Dates	**1/15/04**	**1/15/04**	**1/16/04**	**1/16/04**		
		Other VOCs						
		1,3-Diethylbenzene	2.42E-03	2.11E-03	ND	I	1.51E-03	1.32E-03
		Undecane	1.16E-03	1.64E-03	1.29E-03	I	1.36E-03	2.52E-04
		2-Ethyltoluene	1.22E-03	1.28E-03	1.22E-03	I	1.24E-03	3.66E-05
		n-Propylbenzene	8.81E-04	1.20E-03	8.81E-04	I	9.86E-04	1.81E-04
		Tetradecane	7.27E-04	9.50E-04	1.08E-03	I	9.19E-04	1.79E-04
		Butyraldehyde/Methacrolein	5.61E-04	4.35E-04	3.43E-04	3.95E-04	4.34E-04	9.31E-05
		Benzaldehyde	2.98E-04	2.62E-04	1.88E-04	2.08E-04	2.39E-04	5.01E-05
		Heptane	ND	6.89E-04	ND	I	2.30E-04	3.98E-04
		1,3,5-Trimethylbenzene	ND	ND	ND	I	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	I	ND	NA
		Cyclohexane	ND	ND	ND	I	ND	NA
		Decane	ND	ND	ND	I	ND	NA
		Indan	ND	ND	ND	I	ND	NA
		Nonane	ND	ND	ND	I	ND	NA
		Octane	ND	ND	ND	I	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	NA
		Pentanal	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	NA
		Other Analytes						
		Carbon Dioxide	1.82E+01	NA	1.94E+01	1.80E+01	1.85E+01	7.38E-01
		Methane	2.16E-02	NA	3.83E-02	3.50E-02	3.16E-02	8.87E-03
		Carbon Monoxide	ND	NA	ND	ND	ND	NA
		Ethane	ND	NA	ND	ND	ND	NA
		Propane	ND	NA	ND	ND	ND	NA
		Isobutane	ND	NA	ND	ND	ND	NA
		Butane	ND	NA	ND	ND	ND	NA
		Neopentane	ND	NA	ND	ND	ND	NA
		Isopentane	ND	NA	ND	ND	ND	NA
		Pentane	ND	NA	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

All "Other Analytes" are not included in the Sum of VOCs or HAPs.

Test FR Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	1.87E-05
1,2,4-Trimethylbenzene	1.87E-05
1,3,5-Trimethylbenzene	1.87E-05
1,3-Dimethylnaphthalene	1.87E-05
1-Methylnaphthalene	1.87E-05
2-Ethyltoluene	1.87E-05
2-Methylnaphthalene	1.87E-05
Benzene	1.87E-05
Ethylbenzene	1.87E-05
Hexane	1.87E-05
m,p-Xylene	1.87E-05
Naphthalene	1.87E-05
o-Xylene	1.87E-05
Styrene	1.87E-05
Toluene	1.87E-05
Undecane	1.87E-05
1,2-Dimethylnaphthalene	9.33E-05
1,3-Diethylbenzene	9.33E-05
1,5-Dimethylnaphthalene	9.33E-05
1,6-Dimethylnaphthalene	9.33E-05
1,8-Dimethylnaphthalene	9.33E-05
2,3,5-Trimethylnaphthalene	9.33E-05
2,3-Dimethylnaphthalene	9.33E-05
2,4-Dimethylphenol	9.33E-05

Analytes	Lb/Lb Binder
2,6-Dimethylnaphthalene	9.33E-05
2,6-Dimethylphenol	9.33E-05
2,7- Dimethylnaphthalene	9.33E-05
3-Ethyltoluene	9.33E-05
Acenaphthalene	9.33E-05
Biphenyl	9.33E-05
Cyclohexane	9.33E-05
Decane	9.33E-05
Dodecane	9.33E-05
Heptane	9.33E-05
Indan	9.33E-05
Indene	9.33E-05
m,p-Cresol	9.33E-05
Nonane	9.33E-05
o-Cresol	9.33E-05
Octane	9.33E-05
Phenol	9.33E-05
Propylbenzene	9.33E-05
Tetradecane	9.33E-05
HC as Hexane	5.65E-04
2-Butanone (MEK)	1.67E-05
Acetaldehyde	1.67E-05
Acetone	1.67E-05
Acrolein	1.67E-05

Analytes	Lb/Lb Binder
Benzaldehyde	1.67E-05
Butyraldehyde	1.67E-05
Crotonaldehyde	1.67E-05
Formaldehyde	1.67E-05
Hexaldehyde	1.67E-05
Butyraldehyde/Methacrolein	2.78E-05
o,m,p-Tolualdehyde	4.45E-05
Pentanal (Valeraldehyde)	1.67E-05
Propionaldehyde (Propanal)	1.67E-05
Aniline	1.12E-04
Dimethylaniline	1.12E-04
Carbon Monoxide	4.40E-02
Methane	2.51E-03
Carbon Dioxide	6.91E-02
Ethane	4.71E-02
Propane	6.91E-02
Isobutane	9.11E-02
Butane	9.11E-02
Neopentane	1.13E-01
Isopentane	1.13E-01
Pentane	1.13E-01

Test FR Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.17E-04
1,2,4-Trimethylbenzene	1.17E-04
1,3,5-Trimethylbenzene	1.17E-04
1,3-Dimethylnaphthalene	1.17E-04
1-Methylnaphthalene	1.17E-04
2-Ethyltoluene	1.17E-04
2-Methylnaphthalene	1.17E-04
Benzene	1.17E-04
Ethylbenzene	1.17E-04
Hexane	1.17E-04
m,p-Xylene	1.17E-04
Naphthalene	1.17E-04
o-Xylene	1.17E-04
Styrene	1.17E-04
Toluene	1.17E-04
Undecane	1.17E-04
1,2-Dimethylnaphthalene	5.85E-04
1,3-Diethylbenzene	5.85E-04
1,5-Dimethylnaphthalene	5.85E-04
1,6-Dimethylnaphthalene	5.85E-04
1,8-Dimethylnaphthalene	5.85E-04
2,3,5-Trimethylnaphthalene	5.85E-04
2,3-Dimethylnaphthalene	5.85E-04
2,4-Dimethylphenol	5.85E-04

Analytes	Lb/Tn Metal
2,6-Dimethylnaphthalene	5.85E-04
2,6-Dimethylphenol	5.85E-04
2,7- Dimethylnaphthalene	5.85E-04
3-Ethyltoluene	5.85E-04
Acenaphthalene	5.85E-04
Biphenyl	5.85E-04
Cyclohexane	5.85E-04
Decane	5.85E-04
Dodecane	5.85E-04
Heptane	5.85E-04
Indan	5.85E-04
Indene	5.85E-04
m,p-Cresol	5.85E-04
Nonane	5.85E-04
o-Cresol	5.85E-04
Octane	5.85E-04
Phenol	5.85E-04
Propylbenzene	5.85E-04
Tetradecane	5.85E-04
HC as Hexane	3.54E-03
2-Butanone (MEK)	1.05E-04
Acetaldehyde	1.05E-04
Acetone	1.05E-04
Acrolein	1.05E-04

Analytes	Lb/Tn Metal
Benzaldehyde	1.05E-04
Butyraldehyde	1.05E-04
Crotonaldehyde	1.05E-04
Formaldehyde	1.05E-04
Hexaldehyde	1.05E-04
Butyraldehyde/Methacrolein	1.74E-04
o,m,p-Tolualdehyde	2.79E-04
Pentanal (Valeraldehyde)	1.05E-04
Propionaldehyde (Propanal)	1.05E-04
Aniline	7.04E-04
Dimethylaniline	7.04E-04
Carbon Monoxide	2.76E-01
Methane	1.58E-02
Carbon Dioxide	4.33E-01
Ethane	4.18E-02
Propane	4.33E-01
Isobutane	5.71E-01
Butane	5.71E-01
Neopentane	7.09E-01
Isopentane	7.09E-01
Pentane	7.09E-01

Test Plan GJ Individual Emission Test Results – Lb/Lb Binder

COMPOUND / SAMPLE NUMBER	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Test Dates	3-Feb-05	3-Feb-05	3-Feb-05	7-Feb-05	7-Feb-05	7-Feb-05	8-Feb-05	8-Feb-05	8-Feb-05	—	—
Emission Indicators											
TGOC as Propane	1.87E-02	1.93E-02	I	2.27E-02	2.31E-02	2.42E-02	2.49E-02	1.85E-02	2.37E-02	2.19E-02	2.45E-03
HC as Hexane	2.24E-03	2.79E-03	3.33E-03	3.13E-03	4.27E-03	2.64E-03	4.03E-03	2.34E-03	4.86E-03	3.29E-03	8.63E-04
Sum of Target VOCs	1.75E-03	3.50E-03	4.06E-03	3.41E-03	3.84E-03	3.92E-03	4.43E-03	3.80E-03	4.33E-03	3.88E-03	7.50E-04
Sum of Target HAPs	1.75E-03	3.50E-03	4.06E-03	3.41E-03	3.84E-03	3.92E-03	4.43E-03	3.80E-03	4.33E-03	3.88E-03	7.50E-04
Sum of Target POMs	6.53E-05	8.43E-05	7.79E-05	7.27E-05	6.86E-05	6.33E-05	1.10E-04	5.73E-05	6.90E-05	7.42E-05	1.46E-05
Individual Target HAPs											
Propionaldehyde (Propanal)	3.83E-05	3.54E-05	3.21E-05	3.01E-05	3.81E-05	3.91E-05	3.81E-05	3.33E-05	4.28E-05	3.64E-05	3.99E-06
Xylene, o-	3.43E-05	3.60E-05	3.40E-05	2.78E-05	5.06E-05	4.16E-05	4.98E-05	4.50E-05	5.57E-05	4.16E-05	9.31E-06
Formaldehyde	5.36E-05	4.89E-05	3.15E-05	4.47E-05	4.95E-05	3.42E-05	3.92E-05	4.81E-05	4.10E-05	4.34E-05	7.45E-06
Naphthalene	6.53E-05	8.43E-05	7.79E-05	7.27E-05	6.86E-05	6.33E-05	1.10E-04	5.73E-05	6.90E-05	7.42E-05	1.55E-05
2-Butanone (MEK)	7.90E-05	8.84E-05	9.06E-05	8.97E-05	9.32E-05	8.81E-05	1.16E-04	8.77E-05	1.05E-04	9.31E-05	1.10E-05
Xylene, mp-	9.43E-05	1.01E-04	1.03E-04	7.54E-05	1.37E-04	1.17E-04	1.27E-04	1.09E-04	1.58E-04	1.14E-04	2.45E-05
Toluene	2.71E-04	3.25E-04	3.75E-04	3.10E-04	3.73E-04	3.52E-04	4.11E-04	3.51E-04	4.18E-04	3.54E-04	4.72E-05
Acetaldehyde	5.39E-04	5.18E-04	5.22E-04	5.22E-04	5.50E-04	5.15E-04	5.67E-04	5.05E-04	5.67E-04	5.34E-04	2.30E-05
Phenol	5.27E-04	5.28E-04	9.47E-04	4.02E-04	5.68E-04	8.53E-04	8.95E-04	7.09E-04	8.32E-04	6.96E-04	1.96E-04
Benzene	I	1.69E-03	1.79E-03	1.79E-03	1.86E-03	1.76E-03	2.01E-03	1.80E-03	1.97E-03	1.83E-03	1.06E-04
Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methylnaphthalene, 2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methylnaphthalene, 1-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan GJ Individual Emission Test Results – Lb/Lb Binder

COMPOUND / SAMPLE NUMBER	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Cresol, o-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cresol, mp-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Hexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Other Target VOCs											
Butyraldehyde/Methacrolein	2.01E-05	2.04E-05	2.17E-05	1.89E-05	2.30E-05	2.29E-05	2.57E-05	1.96E-05	2.65E-05	2.21E-05	2.70E-06
Benzaldehyde	1.60E-05	1.68E-05	1.93E-05	1.81E-05	1.76E-05	1.78E-05	2.24E-05	1.74E-05	2.07E-05	1.85E-05	2.00E-06
Hexaldehyde	ND	9.29E-06	9.95E-06	8.68E-06	4.59E-06	1.12E-05	1.18E-05	9.67E-06	1.23E-05	8.61E-06	3.94E-06
Pentanal (Valeraldehyde)	1.67E-05	ND	ND	ND	4.00E-06	8.16E-06	9.93E-06	8.43E-06	1.05E-05	6.42E-06	5.83E-06
Dimethylphenol, 2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylbenzene, 1,2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Octane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Propylbenzene, n-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Decane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethyltoluene, 3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylphenol, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Diethylbenzene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan GJ Individual Emission Test Results – Lb/Lb Binder

COMPOUND / SAMPLE NUMBER	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Furfural	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Furfuryl Alcohol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Criteria Pollutants, Greenhouse Gases and Other Analytes											
Carbon Dioxide	3.72E-01	2.40E-01	2.96E-01	2.29E-01	2.47E-01	2.72E-01	2.72E-01	2.90E-01	3.19E-01	2.82E-01	4.45E-02
Carbon Monoxide	1.07E-01	1.30E-01	1.36E-01	1.35E-01	1.26E-01	1.35E-01	1.49E-01	1.38E-01	1.43E-01	1.33E-01	1.18E-02
Sulfur Dioxide	ND	ND	ND	ND	1.06E-03	1.18E-03	ND	1.20E-03	ND	3.83E-04	5.76E-04
Nitrogen Oxides	I	I	3.61E-04	2.68E-04	2.73E-04	3.48E-04	3.55E-04	3.55E-04	3.08E-04	3.24E-04	4.05E-05
Hydrogen Cyanide	1.78E-04	3.04E-04	ND	ND	ND	2.40E-04	3.36E-04	1.65E-04	2.16E-04	2.40E-04	6.85E-05

Test Plan GJ Individual Emission Test Results – Lb/Tn Metal

COMPOUND	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Test Dates	3-Feb-05	3-Feb-05	3-Feb-05	7-Feb-05	7-Feb-05	7-Feb-05	8-Feb-05	8-Feb-05	8-Feb-05	—	—
Emission Indicators											
TGOC as Propane	2.95E-01	3.00E-01	I	3.49E-01	3.58E-01	3.66E-01	3.74E-01	2.83E-01	3.59E-01	3.36E-01	3.65E-02
HC as Hexane	3.53E-02	4.33E-02	5.09E-02	4.81E-02	6.61E-02	4.00E-02	6.04E-02	3.58E-02	7.38E-02	5.04E-02	1.37E-02
Sum of Target VOCs	2.76E-02	5.45E-02	6.21E-02	5.24E-02	5.93E-02	5.94E-02	6.64E-02	5.81E-02	6.56E-02	5.93E-02	1.17E-02
Sum of HAPs	2.68E-02	5.38E-02	6.13E-02	5.17E-02	5.85E-02	5.85E-02	6.54E-02	5.72E-02	6.46E-02	5.84E-02	1.16E-02
Sum of POMs	1.03E-03	1.31E-03	1.19E-03	1.12E-03	1.06E-03	9.58E-04	1.64E-03	8.76E-04	1.05E-03	1.14E-03	2.28E-04
Individual Target HAPs											
Benzene	I	2.63E-02	2.74E-02	2.75E-02	2.88E-02	2.67E-02	3.01E-02	2.75E-02	2.99E-02	2.80E-02	1.40E-03
Phenol	8.28E-03	8.22E-03	1.45E-02	6.18E-03	8.78E-03	1.29E-02	1.34E-02	1.08E-02	1.26E-02	1.06E-02	2.88E-03
Acetaldehyde	8.48E-03	8.05E-03	7.98E-03	8.02E-03	8.50E-03	7.81E-03	8.50E-03	7.71E-03	8.60E-03	8.18E-03	3.38E-04
Toluene	4.27E-03	5.06E-03	5.73E-03	4.77E-03	5.76E-03	5.32E-03	6.17E-03	5.36E-03	6.34E-03	5.42E-03	6.64E-04
Xylene, mp-	1.48E-03	1.58E-03	1.58E-03	1.16E-03	2.12E-03	1.77E-03	1.90E-03	1.67E-03	2.39E-03	1.74E-03	3.64E-04
2-Butanone (MEK)	1.24E-03	1.38E-03	1.39E-03	1.38E-03	1.44E-03	1.33E-03	1.74E-03	1.34E-03	1.59E-03	1.43E-03	1.52E-04
Naphthalene	1.03E-03	1.31E-03	1.19E-03	1.12E-03	1.06E-03	9.58E-04	1.64E-03	8.76E-04	1.05E-03	1.14E-03	2.28E-04
Formaldehyde	8.44E-04	7.61E-04	4.83E-04	6.87E-04	7.65E-04	5.18E-04	5.88E-04	7.35E-04	6.22E-04	6.67E-04	1.22E-04
Xylene, o-	5.39E-04	5.60E-04	5.20E-04	4.27E-04	7.82E-04	6.30E-04	7.47E-04	6.87E-04	8.46E-04	6.38E-04	1.38E-04
Propionaldehyde (Propanal)	6.03E-04	5.50E-04	4.90E-04	4.62E-04	5.89E-04	5.92E-04	5.72E-04	5.09E-04	6.49E-04	5.57E-04	6.01E-05
Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methylnaphthalene, 2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,7-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylnaphthalene, 2,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methylnaphthalene, 1-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,8-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylnaphthalene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan GJ Individual Emission Test Results – Lb/Tn Metal

COMPOUND	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Dimethylnaphthalene, 1,2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cresol, o-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Hexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cresol, mp-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Other Target VOCs											
Butyraldehyde/Methacrolein	3.16E-04	3.17E-04	3.32E-04	2.91E-04	3.56E-04	3.46E-04	3.86E-04	2.99E-04	4.03E-04	3.38E-04	3.81E-05
Benzaldehyde	2.52E-04	2.62E-04	2.95E-04	2.78E-04	2.72E-04	2.70E-04	3.36E-04	2.66E-04	3.14E-04	2.83E-04	2.72E-05
Hexaldehyde	ND	1.44E-04	1.52E-04	1.33E-04	7.10E-05	1.69E-04	1.77E-04	1.48E-04	1.87E-04	1.31E-04	5.96E-05
Pentanal (Valeraldehyde)	2.63E-04	ND	ND	ND	6.18E-05	1.24E-04	1.49E-04	1.29E-04	1.60E-04	9.85E-05	9.04E-05
Dimethylphenol, 2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylbenzene, 1,2,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Octane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Propylbenzene, n-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Indan	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Decane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethyltoluene, 3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Ethyltoluene, 2-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dimethylphenol, 2,6-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Diethylbenzene, 1,3-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Test Plan GJ Individual Emission Test Results – Lb/Tn Metal

COMPOUND	GJ001	GJ002	GJ003	GJ004	GJ005	GJ006	GJ007	GJ008	GJ009	Average	stdev
Trimethylbenzene, 1,3,5-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Trimethylbenzene, 1,2,4-	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Furfural	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Furfuryl Alcohol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
o,m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Criteria Pollutants, Greenhouse Gases and Other Analytes											
Hydrogen Cyanide	2.79E-03	4.73E-03	NT	NT	NT	3.63E-03	5.04E-03	2.52E-03	3.28E-03	3.67E-03	1.02E-03
Carbon Dioxide	5.86E+00	3.73E+00	4.53E+00	3.52E+00	3.82E+00	4.11E+00	4.08E+00	4.43E+00	4.85E+00	4.32E+00	7.10E-01
Nitrogen Oxides	I	I	5.52E-03	4.12E-03	4.23E-03	5.27E-03	5.33E-03	5.43E-03	4.68E-03	4.94E-03	5.90E-04
Carbon Monoxide	1.69E+00	2.02E+00	2.08E+00	2.08E+00	1.95E+00	2.04E+00	2.23E+00	2.12E+00	2.16E+00	2.04E+00	1.56E-01
Sulfur Dioxide	ND	ND	ND	ND	1.64E-02	1.79E-02	ND	1.84E-02	ND	5.85E-03	8.80E-03
Sulfur Dioxide	ND	ND	ND	ND	1.64E-02	1.79E-02	ND	1.84E-02	ND	5.85E-03	8.80E-03

Test GJ Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	1.36E-05
1,2,4-Trimethylbenzene	1.36E-05
1,3,5-Trimethylbenzene	1.36E-05
1,3-Dimethylnaphthalene	1.36E-05
1-Methylnaphthalene	1.36E-05
2-Ethyltoluene	1.36E-05
2-Methylnaphthalene	1.36E-05
Benzene	1.36E-05
Ethylbenzene	1.36E-05
Hexane	1.36E-05
m,p-Xylene	1.36E-05
Naphthalene	1.36E-05
o-Xylene	1.36E-05
Styrene	1.36E-05
Toluene	1.36E-05
Undecane	1.36E-05
1,2-Dimethylnaphthalene	6.82E-05
1,3-Diethylbenzene	6.82E-05
1,5-Dimethylnaphthalene	6.82E-05
1,6-Dimethylnaphthalene	6.82E-05
1,8-Dimethylnaphthalene	6.82E-05

Analytes	Lb/Lb Binder
2,3,5-Trimethylnaphthalene	6.82E-05
2,3-Dimethylnaphthalene	6.82E-05
2,4-Dimethylphenol	6.82E-05
2,6-Dimethylnaphthalene	6.82E-05
2,6-Dimethylphenol	6.82E-05
2,7- Dimethylnaphthalene	6.82E-05
3-Ethyltoluene	6.82E-05
Acenaphthalene	6.82E-05
Biphenyl	6.82E-05
Cyclohexane	6.82E-05
Decane	6.82E-05
Dodecane	6.82E-05
Heptane	6.82E-05
Indan	6.82E-05
Indene	6.82E-05
m,p-Cresol	6.82E-05
Nonane	6.82E-05
o-Cresol	6.82E-05
Octane	6.82E-05
Phenol	6.82E-05
Propylbenzene	6.82E-05

Analytes	Lb/Lb Binder
Tetradecane	6.82E-05
HC as Hexane	9.31E-04
2-Butanone (MEK)	7.75E-06
Acetaldehyde	7.75E-06
Acetone	7.75E-06
Acrolein	7.75E-06
Benzaldehyde	7.75E-06
Butyraldehyde	7.75E-06
Crotonaldehyde	7.75E-06
Formaldehyde	7.75E-06
Hexaldehyde	7.75E-06
Butyraldehyde/Methacrolein	1.29E-05
o,m,p-Tolualdehyde	2.07E-05
Pentanal (Valeraldehyde)	7.75E-06
Propionaldehyde (Propanal)	7.75E-06
Sulfur Dioxide	1.10E-03
Furfural	9.98E-05
Furfuryl Alcohol	7.56E-05
Hydrogen Cyanide	3.94E-07
Carbon Monoxide	1.81E-03
Carbon Dioxide	2.85E-03
Nitrogen Oxides	1.94E-03
TGOC as propane	2.85E-03

Test GJ Quantitation Limits – Lb/Tn Metal

Analytes	lb/tn Metal
1,2,3-Trimethylbenzene	2.10E-04
1,2,4-Trimethylbenzene	2.10E-04
1,3,5-Trimethylbenzene	2.10E-04
1,3-Dimethylnaphthalene	2.10E-04
1-Methylnaphthalene	2.10E-04
2-Ethyltoluene	2.10E-04
2-Methylnaphthalene	2.10E-04
Benzene	2.10E-04
Ethylbenzene	2.10E-04
Hexane	2.10E-04
m,p-Xylene	2.10E-04
Naphthalene	2.10E-04
o-Xylene	2.10E-04
Styrene	2.10E-04
Toluene	2.10E-04
Undecane	2.10E-04
1,2-Dimethylnaphthalene	1.05E-03
1,3-Diethylbenzene	1.05E-03
1,5-Dimethylnaphthalene	1.05E-03
1,6-Dimethylnaphthalene	1.05E-03
1,8-Dimethylnaphthalene	1.05E-03

Analytes	lb/tn Metal
2,3,5-Trimethylnaphthalene	1.05E-03
2,3-Dimethylnaphthalene	1.05E-03
2,4-Dimethylphenol	1.05E-03
2,6-Dimethylnaphthalene	1.05E-03
2,6-Dimethylphenol	1.05E-03
2,7- Dimethylnaphthalene	1.05E-03
3-Ethyltoluene	1.05E-03
Acenaphthalene	1.05E-03
Biphenyl	1.05E-03
Cyclohexane	1.05E-03
Decane	1.05E-03
Dodecane	1.05E-03
Heptane	1.05E-03
Indan	1.05E-03
Indene	1.05E-03
m,p-Cresol	1.05E-03
Nonane	1.05E-03
o-Cresol	1.05E-03
Octane	1.05E-03
Phenol	1.05E-03
Propylbenzene	1.05E-03

Analytes	lb/tn Metal
Tetradecane	1.05E-03
HC as Hexane	1.43E-02
2-Butanone (MEK)	1.19E-04
Acetaldehyde	1.19E-04
Acetone	1.19E-04
Acrolein	1.19E-04
Benzaldehyde	1.19E-04
Butyraldehyde	1.19E-04
Crotonaldehyde	1.19E-04
Formaldehyde	1.19E-04
Hexaldehyde	1.19E-04
Butyraldehyde/Metha	1.99E-04
o,m,p-Tolualdehyde	3.18E-04
Pentanal (Valeraldeh	1.19E-04
Propionaldehyde (Pro	1.19E-04
Sulfur Dioxide	1.70E-02
Furfural	1.54E-03
Furfuryl Alcohol	1.16E-03
Hydrogen Cyanide	7.88E-04
Carbon Monoxide	2.79E-02
Carbon Dioxide	4.38E-02
Nitrogen Oxides	2.99E-02
TGOC as propane	4.38E-02

APPENDIX C TEST FR AND GJ DETAILED PROCESS DATA

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Test FR Detailed Process Data

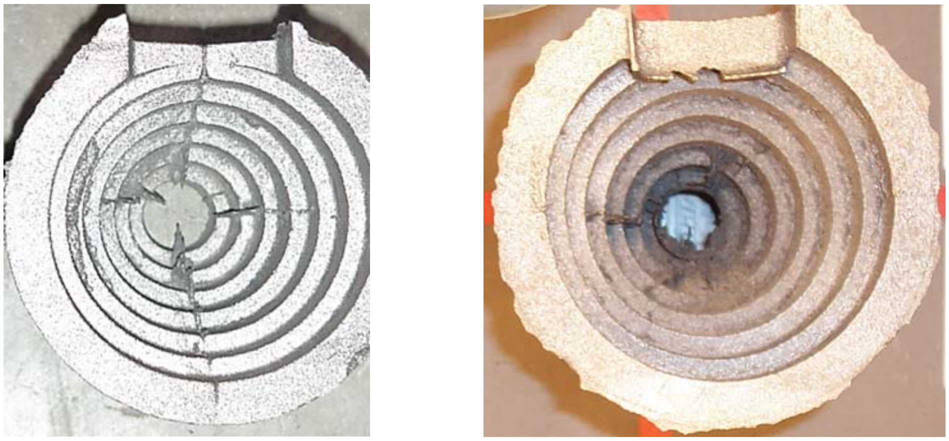
Greensand PCS					
Test Dates	1/15/2004	1/15/2004	1/16/2004	1/16/2004	Averages
Emissions Sample # / Production Sample #	FR 01	FR 02	FR 03	FR 04	
Core Additive	Reference w/o Additive				
Cast Weight (all metal inside mold), Lbs.	110.95	108.35	112.35	112.60	111.1
Pouring Time, sec.	36	26	24	24	28
Pouring Temp ,°F	2636	2632	2630	2631	2632
Pour Hood Process Air Temp at Start of Pour, °F	88	89	85	87	87
Mixer auto dispensed batch weight, Lbs	45.35	45.35	45.35	45.35	45.35
Calibrated auto dispensed binder weight, Lbs	0.633	0.633	0.633	0.633	0.633
Core binder calibrated weight, %BOS	1.39	1.39	1.39	1.39	1.39
Core binder calibrated weight, %	1.38	1.38	1.38	1.38	1.38
Total uncoated core weight in mold, Lbs.	24.70	25.50	25.30	25.50	25.25
Total binder weight in mold, Lbs.	0.340	0.351	0.348	0.351	0.347
Core LOI, %	1.19	1.25	1.37	1.23	1.26
Core dogbone tensile, psi	39.5	39.5	39.5	39.5	39.5
Core age, hrs.	41	55	73	76	61
Muller Batch Weight, Lbs.	900	900	900	900	900
GS Mold Sand Weight, Lbs.	613	622	619	626	620
Mold compactability, %	55	54	57	57	56
Mold Temperature, °F	72	70	67	69	70
Average Green Compression , psi	11.30	12.16	10.44	10.08	11.00
GS Compactability, %	53	47	55	55	53
GS Moisture Content, %	1.86	2.28	2.36	2.56	2.27
GS MB Clay Content, %	5.58	6.20	6.20	6.08	6.02
MB Clay reagent, ml	25.0	26.5	26.5	26.0	26.0
1800°F LOI - Mold Sand, %	0.71	0.68	0.74	0.72	0.71
900°F Volatiles , %	0.20	0.24	0.30	0.20	0.24
Appearance within group B:best, M:median, W: worst	M		B	W	
Overall appearance ranking: 1 = best, 9 = worst	6		4	9	

Test GJ Detailed Process Data

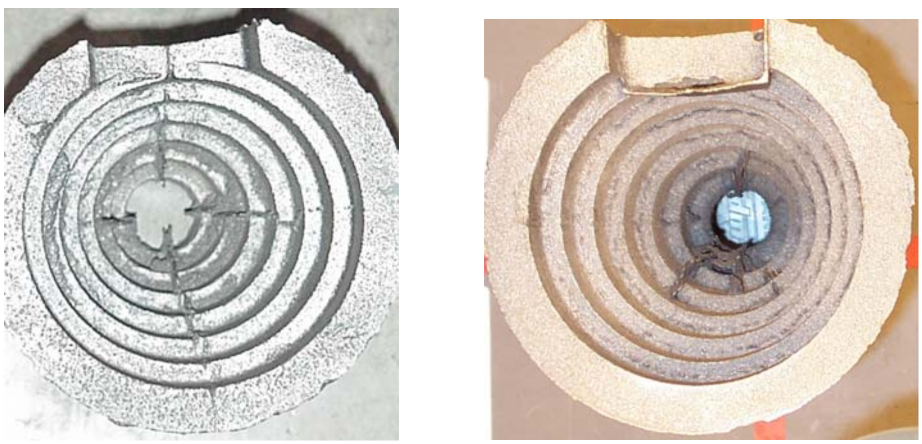
Greensand PCS													
Test Dates	**2/2/05**	**2/2/05**	**2/2/05**	**2/3/05**	**2/3/05**	**2/3/05**	**2/7/05**	**2/7/05**	**2/7/05**	**2/8/05**	**2/8/05**	**2/8/05**	**Averages**
Emissions Sample #	**GJER1**	**GJER2**	**GJER3**	**GJ001**	**GJ002**	**GJ003**	**GJ004**	**GJ005**	**GJ006**	**GJ007**	**GJ008**	**GJ009**	
Production Sample #	**GJ001**	**GJ002**	**GJ003**	**GJ004**	**GJ005**	**GJ006**	**GJ007**	**GJ008**	**GJ009**	**GJ010**	**GJ011**	**GJ012**	
Cast Weight (all metal inside mold), Lbs.	72.45	111.80	112.40	110.60	111.85	113.75	113.20	112.55	114.90	116.00	113.85	114.70	**113.49**
Pouring Time, sec.	16	16	15	18	19	14	14	15	15	14	16	18	**15.89**
Pouring Temp ,°F	2637	2630	2629	2626	2628	2623	2640	2634	2636	2636	2625	2636	**2631.56**
Pour Hood Process Air Temp at Start of Pour, ^{o}F	88	88	88	89	88	86	88	89	89	87	86	86	**87.56**
Total Uncoated Core Weight in Mold, Lbs.	29.00	29.04	29.07	29.12	29.15	29.11	29.13	29.03	29.04	28.95	29.03	29.10	**29.07**
Core Binder Content w/o Catalyst, %BOS	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	**1.43**
Core Binder Calculated Resin Content w/o Catalyst, %	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	**1.41**
Core Binder Resin Weight w/o Calatyst, Lbs	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	**0.41**
Core Binder Catalyst Content, %BOR	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	**23.00**
Silane release agent (%BOR)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.00**
Total Binder Weight in Mold, Lbs.	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	**0.51**
Core LOI	1.27	1.34	1.35	1.35	1.34	1.39	1.36	1.34	1.34	1.36	1.34	1.37	**1.35**
Approximate Core Age, hrs.	335	335	335	360	360	360	450	450	450	475	475	475	**428**
Core box temperature, F	375-410	375-410	375-410	375-410	375-410	375-410	375-410	375-410	375-410	375-410	375-410	375-410	**375-410**
Average heated investment time, Seconds	45-60	45-60	45-60	45-60	45-60	45-60	45-60	45-60	45-60	45-60	45-60	45-60	**45-60**
Muller Batch Weight, Lbs.	1301	900	900	900	900	900	900	900	900	900	900	900	**900**
GS Mold Sand Weight, Lbs.	630	641	636	641	636	636	614	601	634	630	633	634	**629**
Muller Compactability, %	56	55	55	54	55	55	57	54	55	59	52	57	**55**
Mold Temperature, ^{o}F	68	78	78	76	80	81	72	83	82	71	75	75	**77**
Average Green Compression , psi	18.45	20.76	20.02	21.18	23.32	22.69	25.34	27.19	25.67	26.87	22.85	22.81	**24.2**
GS Compactability, %	51	52	39	36	37	35	37	35	27	48	35	35	**36.1**
GS Moisture Content, %	2.08	2.18	1.82	1.76	1.96	2.08	2.28	1.93	2.00	2.18	1.90	2.02	**2.01**
GS MB Clay Content, %	7.40	7.09	6.26	7.92	6.67	7.72	7.82	7.82	7.92	7.72	7.82	7.40	**7.6**
MB Clay Reagent, ml	35.5	34	30	38	32	37	37.5	37.5	38	37	37.5	35.5	**36.7**
1800°F LOI - Mold Sand, %	0.78	0.78	0.84	0.84	0.82	0.85	0.85	1.14	0.80	0.86	0.98	0.87	**0.89**
900°F Volatiles , %	0.30	0.46	0.30	0.32	0.36	0.36	0.40	0.36	0.40	0.38	0.44	0.36	**0.38**
Core Surface Appearance Ranking 1 = Best, 9 = Worst	ND	3a	10	4	9	6	2	3	8	1	5	7	

Note 1: Mold 1 ran out casting incomplete

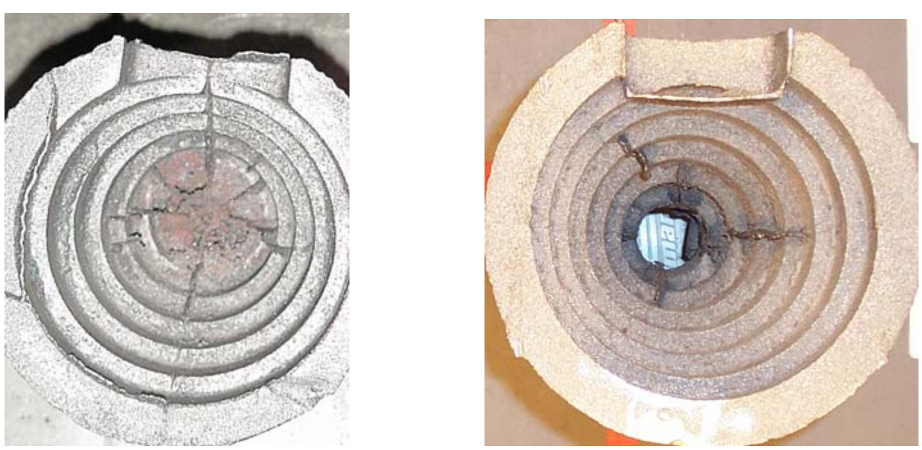
Best Appearing Casting from Mold FR003 & GJ004



Median Appearing from Mold FR001 & GJ002



Worst Appearing Casting from Mold FR004 & GJ008



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APPENDIX D METHOD 25A CHARTS

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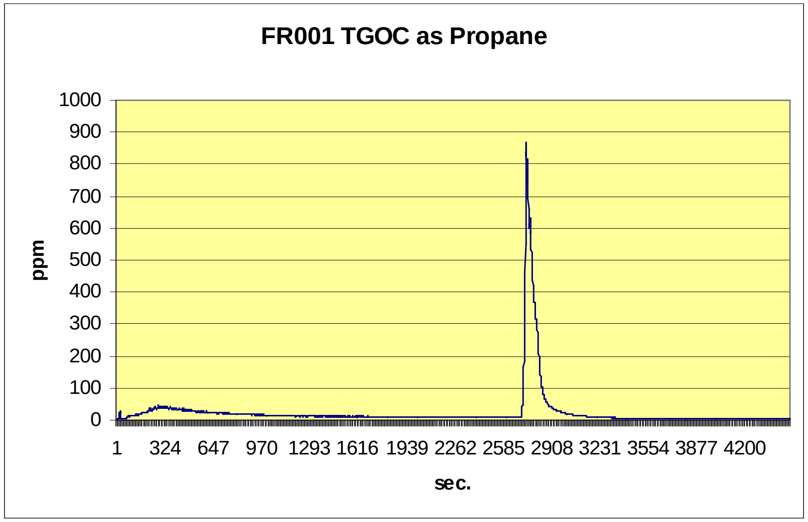
FR001 TGOC as Propane
ppm
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900
800
700
600
500
400
300
200
100
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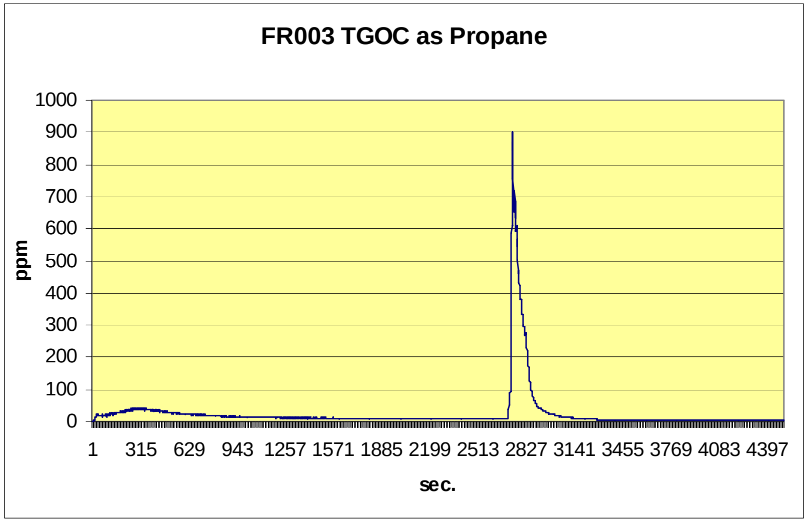
sec.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ppm
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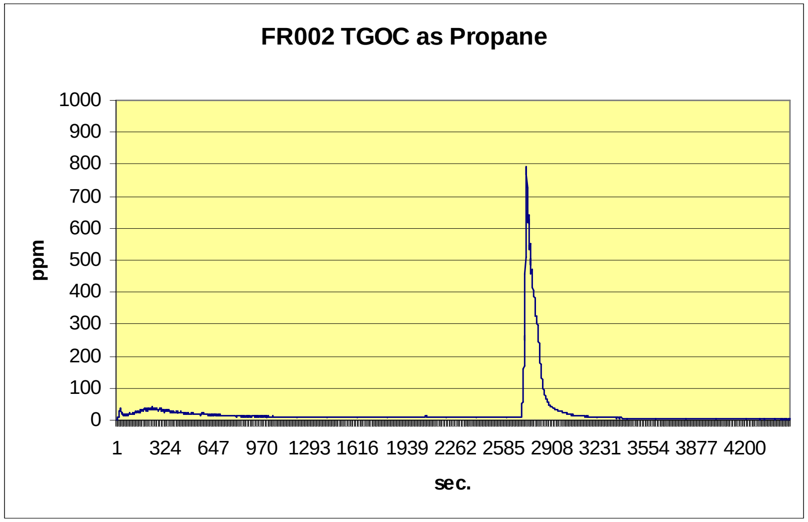
sec.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ppm
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900
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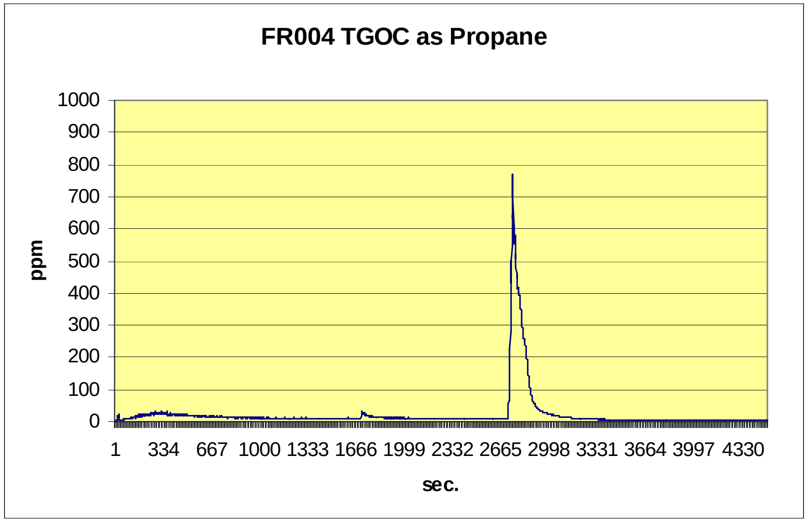
sec.


FR004 TGOC as Propane
ppm
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900
800
700
600
500
400
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200
100
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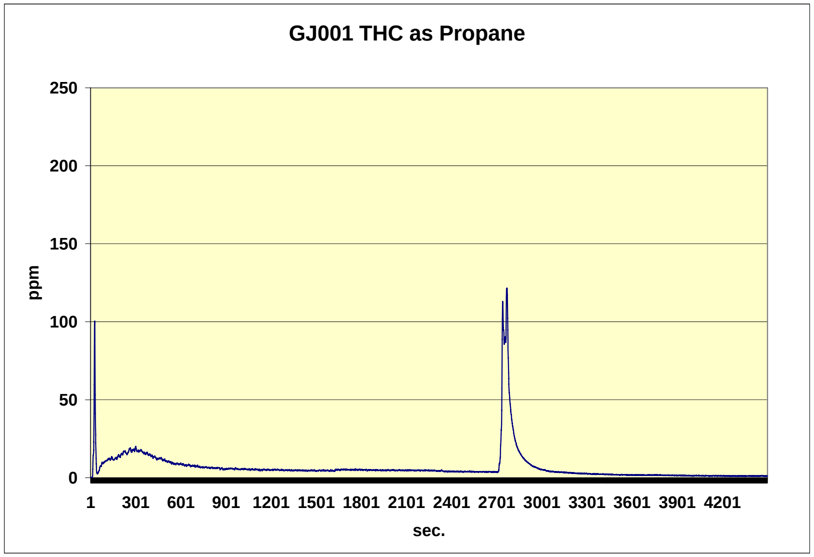
sec.


GJ001 THC as Propane
ppm
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200
150
100
50
0
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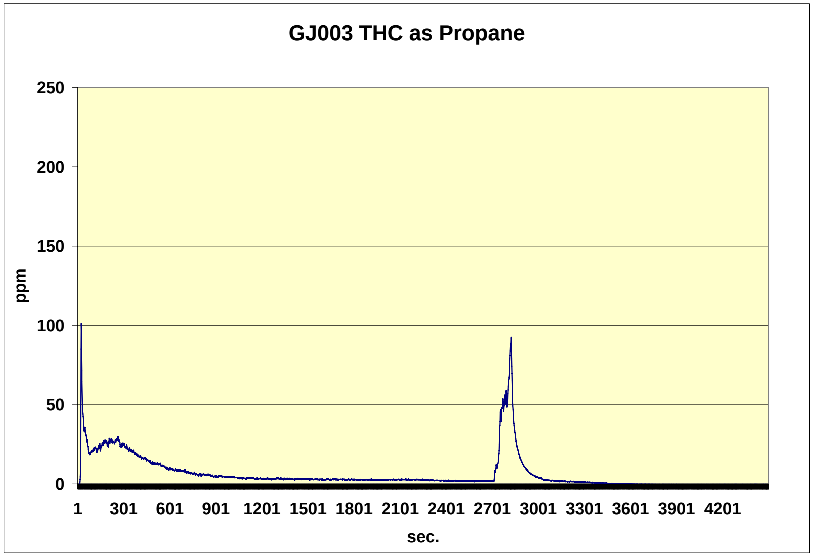
sec.


GJ003 THC as Propane
ppm
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150
100
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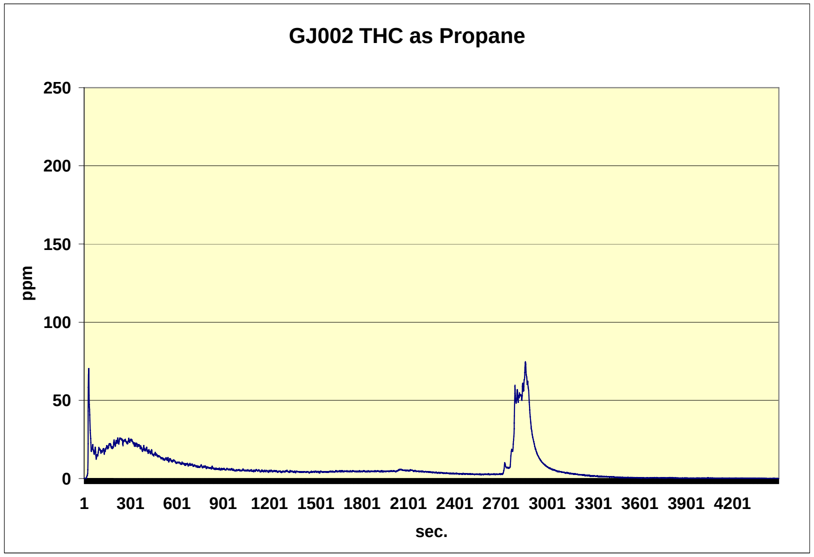
sec.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150
100
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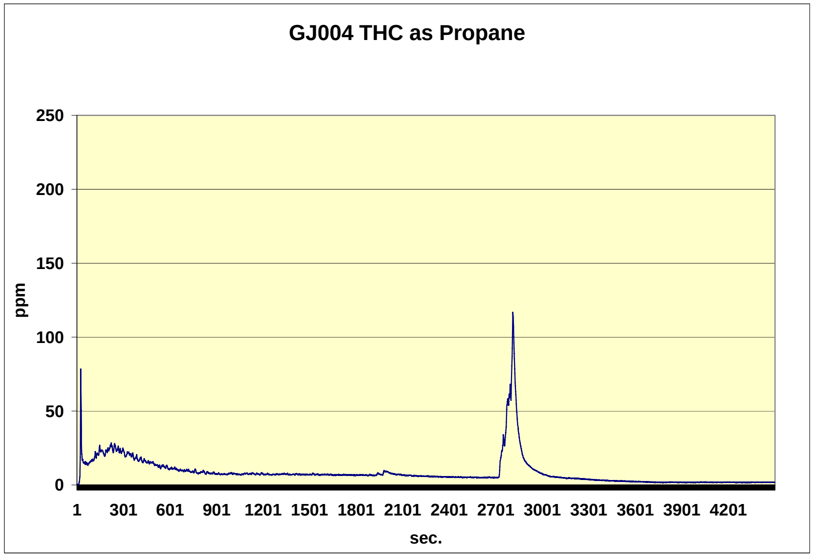
sec.


GJ004 THC as Propane
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150
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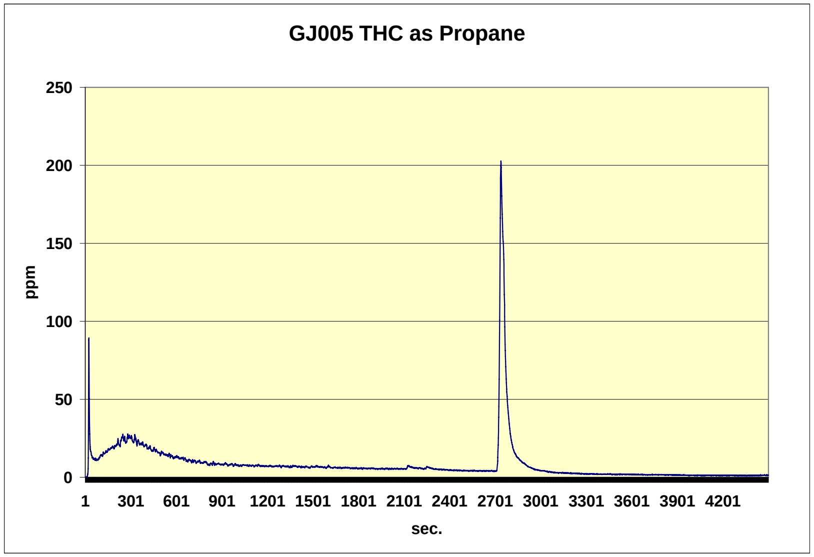
GJ005 THC as Propane
ppm
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200
150
100
50
0
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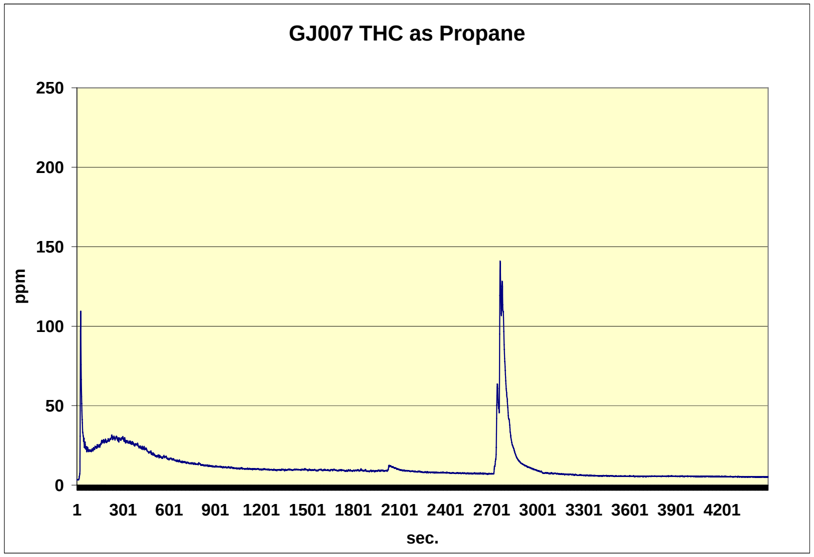
sec.


GJ007 THC as Propane
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150
100
50
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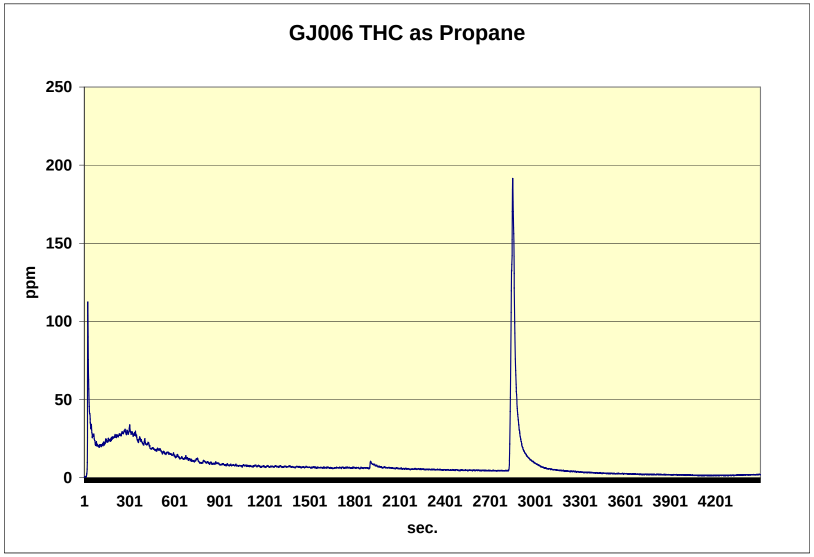
sec.


GJ006 THC as Propane
ppm
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200
150
100
50
0
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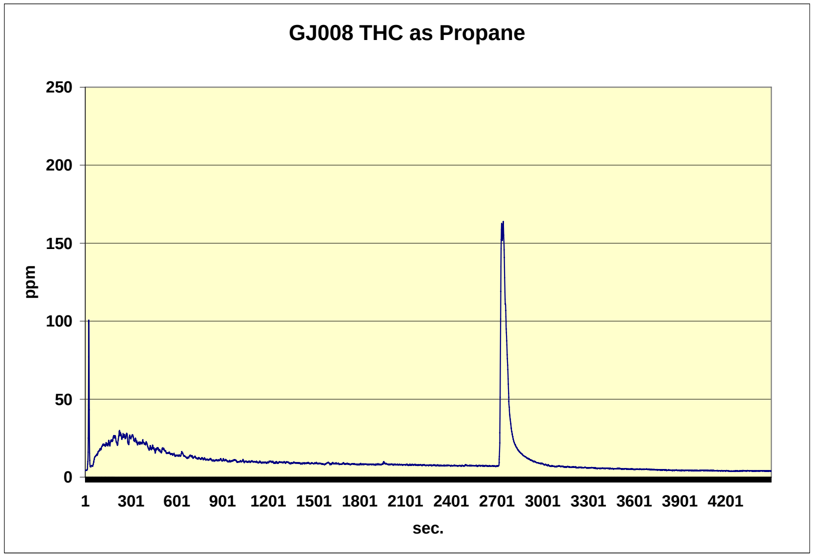
sec.


GJ008 THC as Propane
ppm
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200
150
100
50
0
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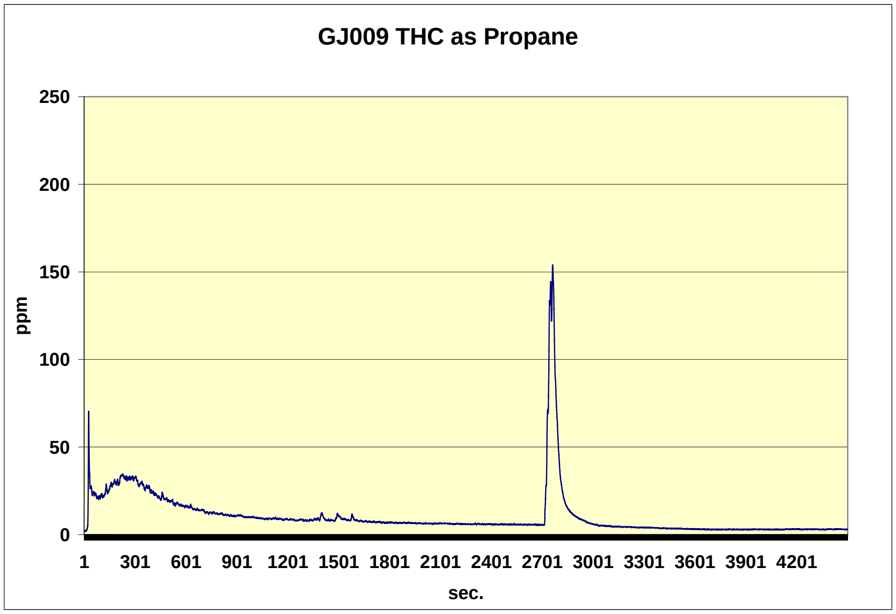
sec.


GJ009 THC as Propane
250
200
150
100
50
0
ppm
1
301
601
901
1201
1501
1801
2101
2401
2701
3001
3301
3601
3901
4201
sec.

APPENDIX E ACRONYMS AND ABBREVIATIONS

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Acronyms and Abbreviations

BO	Based on ( ).
BOS	Based on Sand.
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC as Hexane	Calculated by the summation of all area between elution of Hexane through the elution of Hexadecane. The quantity of HC is performed against a five-point calibration curve of Hexane by dividing the total area count from C6 through C16 to the area of Hexane from the initial calibration curve.
I	Data rejected based on data validation considerations
NA	Not Applicable
ND	Non-Detect
NT	Lab testing was not done
POM	Polycyclic Organic Matter (POM) including Naphthalene and other compounds that contain more than one benzene ring and have a boiling point greater than or equal to 100 degrees Celsius.
TGOC as Propane	Weighted to the detection of more volatile hydrocarbon species, beginning at C1 (methane), with results calibrated against a three-carbon alkane (propane).
VOC	Volatile Organic Compound