CERP
Casting Emission Reduction Program

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Product Test: No-Bake

HA International

TECHNISET® 6066LV/6435/17-727

Technikon # 1410- 113 FP

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(revised for public distribution)

United States Environmental Protection Agency

CISA

AMERICAN FOUNDRY SOCIETY

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH
USCAR
DaimlerChrysler Ford Motor Company General Motors

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

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

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Executive Summary

This report contains the results of testing to evaluate the pouring, cooling and shakeout emissions, and casting surface quality for Test FP, a phenolic urethane No-Bake system poured with iron. These data are compared to results from Test FL, a baseline using a standard No-Bake system. All testing was conducted by Technikon, LLC in its Pre-Production foundry. The emissions results are reported in both pounds per pound (Lbs/Lb) of binder and pounds of analyte per ton (Lbs/Tn) 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 and mold; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack and process material temperature, pressure, volumetric flow rate and moisture content. The test was conducted in the same manner as baseline Test FL. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the test runs. Samples were collected and analyzed for sixty-eight (68) target compounds using procedures based on US EPA Method 18. Continuous monitoring of the Total Gaseous Organic Concentration (TGOC) of the emissions was conducted according to US EPA Method 25A. The casting surface quality was evaluated by visual comparison with castings from baseline Test FL.

The mass emission rate of each parameter or target compound was calculated using the Method 25A data or the laboratory analytical results, the measured source data, and the weight of each casting. Results for structural isomers have been grouped and reported as a single entity. For example, ortho-, meta-, and para-xylene are the three (3) structural isomers of dimethyl benzene. The separate isomer results are available in Appendix B of this report. Other "emissions indicators," in addition to the TGOC as Propane, were also calculated. The HC as Hexane results represent the sum of all organic compounds detected and expressed as Hexane. All of the following sums are sub-groups of this measure. The "Sum of VOCs" is based on the sum of the individual target VOCs measured and includes the selected HAPs and selected Polycyclic Organic Material (POMs) listed in the Clean Air Act Amendments of 1990. The "Sum of HAPs" is the sum of the individual target HAPs measured and includes the selected POMs. Finally, the "Sum of POMs" is the sum of all of the polycyclic organic material measured.

Results for the emission indicators and casting surface quality are shown in the following tables reported as lbs/lb of binder and lbs/tn of metal. The testing was conducted at the Technikon Research Foundry, which is a simple, general purpose manual foundry that was adapted and instrumented to allow the collection of detailed organic emission measurements, using methods based on US EPA air testing protocols. For this test series, the only source of organic matter present in the molds was the binder used to make the mold.

Analytes	TGOC as Propane	HC as Hexane	Sum of VOCs	Sum of HAPs	Sum of POMs
Test FL (Lbs/Lb Binder)	0.2094	0.0670	0.0428	0.0303	0.0007
Test FP (Lbs/Lb Binder)	0.1676	0.0531	0.0319	0.0254	0.0004
Percent Change	-20	-21	-25	-16	-43

Test FL (Lbs/Tn Metal)	12.67	1.043	2.488	1.763	0.0401
Test FP (Lbs/Tn Metal)	10.03	3.147	1.852	1.521	0.0247
Percent Change	-21	-22	-26	-14	-38

This next table demonstrates that when the castings for FP are rank-ordered for quality the spread was much wider than the ranking of the baseline FL and that all the baseline castings were similar to the median of the FP castings.

Relative Casting Quality	
FL Baseline Rank	FP Rank
	1
	2
	3
1, 2, 3	4
3, 4, 5	5
6, 7, 8	6
9	7
	8
	9

It must be noted that the reference and product 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). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes. Other technical partners directly supporting the project include: the American Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US EPA); and the California Air Resources Board (CARB).

1.2 CERP Objectives

The primary objective of CERP is to evaluate the impact of new materials, equipment, and processes on airborne emissions from the production of metal castings. To accomplish this objective, the Technikon facility has been created to evaluate alternate materials and production processes designed to achieve significant airborne emission reductions, especially for organic Hazardous Air Pollutants (HAPs). HAP emissions reduction from the alternative materials, equipment and production processes is expressed as a comparison to similar emissions from a baseline or reference test. The facility has two principal testing arenas: a Pre-Production Foundry designed to measure airborne emissions from individually poured molds, and a Production Foundry designed to measure air emissions in a continuous, full-scale production process. Each of these testing arenas has been specifically designed to facilitate the collection and evaluation of airborne emissions, and associated process data. Candidate materials and/or processes are screened for emission reductions in the Pre-production Foundry and then further evaluated in the Production Foundry. The data collected during the various testing projects are evaluated to determine the impact of the alternate materials and/or processes on airborne emissions as well as on the quality and economics of casting and core manufacture. These alternate materials, equipment, and processes may need to be further adapted and defined so that they will integrate into current commercial green sand casting facilities smoothly and with minimal capital expenditure.

Pre-production testing is conducted in order to evaluate the impact on air emissions from a proposed alternative material, equipment or process. The Pre-Production Foundry is a simple, general-purpose mechanized foundry, which was adapted and instrumented to allow the collection of detailed emission measurements, using methods based on US EPA air testing protocols. Measurements are taken during pouring, casting cooling, and shakeout processes performed on <u>discrete</u> mold and/or core packages under tightly controlled conditions not feasible in a commercial foundry.

Alternative materials, equipment and processes that, during their testing in the Pre-Production Foundry, demonstrate significant air emission reduction potential and preserve casting quality parameters are further evaluated in the Production Foundry. The Production Foundry's design as a basic green sand foundry was deliberately chosen so that whatever is tested in this facility could be easily converted for use in existing mechanized commercial foundries. The Production Foundry emulates an automotive foundry in the type and size of equipment, materials, and processes used. A single cavity automotive I-4 engine block mold is used to further evaluate materials, equipment, and processes in a continuous real-world production-like environment. The Production Foundry provides simultaneous, detailed, individual emission measurements, according to methods based on US EPA air testing protocols, of the melting, pouring, sand preparation, mold making, and core making processes. The Production Foundry is instrumented so that process data on all activities of the metal casting process can be simultaneously and continuously collected in order to complete an economic impact evaluation of the prospective emission reducing strategy. Castings are randomly selected to evaluate the impact of the alternate material, equipment, or process on the quality of the casting.

Test results for a particular process or product may not be the same from both foundries due to differences in the testing process. The Pre-production Foundry is designed to screen new products, processes, or equipment, whereas the Production Foundry is designed to test the effect of the product, process, or equipment in a continuous production-like environment.

The results of the testing conducted at both the Production and Pre-production Foundries are not suitable for use as general emission factors. The specific materials used (gray iron from an electric melt furnace, greensand with seacoal, and a cold box core with a relatively old resin binding system); the specific castings produced the specific production processes employed (a stationary hand-poured mold in the Pre-production Foundry and an impact mold line in the Production Foundry); and the specific testing conditions (relatively low stack velocity, long sampling times, high capture rates, and combined emissions from pouring, cooling and shakeout processes at the Production Foundry) produce emission results unique to the materials, castings, casting processes and measurement conditions used. The data produced are intended to demonstrate the relative emission reductions from the use of alternative materials, equipment and processes, and not the absolute emission levels that would be experienced in commercial foundries. A number of process parameters such as casting surface area, sand to metal ratios, pouring temperatures, stack flow rates, LOI levels, seacoal and resin contents, and the type of foundry (Cope & Drag versus Disa for example) can have a significant impact on actual emission levels.

The Production Foundry provides simultaneous detailed individual emission measurements using methods based on US EPA protocols for the melting, pouring, sand preparation, mold making, and core making processes. The core making area of the Production foundry contains three core blowers, a Georg Fischer for the preparation of automotive block cores, a Redford that is used for the production of step cores, and a second smaller Redford/Carver to produce dogbone tensile test specimens.

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

1.3 Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate the variability of emissions from the No-Bake mold making, pouring, and cooling processes. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, QA/QC procedures, and data management and reduction methods. Section 3 of this report contains the summarized test results and Section 4 contains a discussion of the results. Detailed emissions and process data are included in the Appendices.

The raw data for this test series are included in a data binder that is maintained at the Technikon facility.

1.4 Specific Test Plans and Objectives

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

Table 1-1 Test Plan Summary

Test Plan Number	1410 123 FL	1410 113 FP
Type of Process Tested	Phenolic Urethane No-Bake Baseline	Phenolic Urethane No-Bake Product Test
Binder System	HA Int'l TECHNISET® 6000/6433/17-727	HA Int'l TECHNISET® 6066LV/6435/17-727
Metal Poured	Iron	Iron
Casting Type	4-on Gear	4-on Gear
Number of Molds Poured	9	9
Test Dates	9/17/03 > 9/24/03	11/10/03 > 11/12/03
Emissions Measured	TGOC as Propane, HC as Hexane, 69 Target Analytes	TGOC as Propane, HC as Hexane, 69 Target Analytes
Process Parameters Measured	Total Casting, Mold, and Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate	Total Casting, Mold, and Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate

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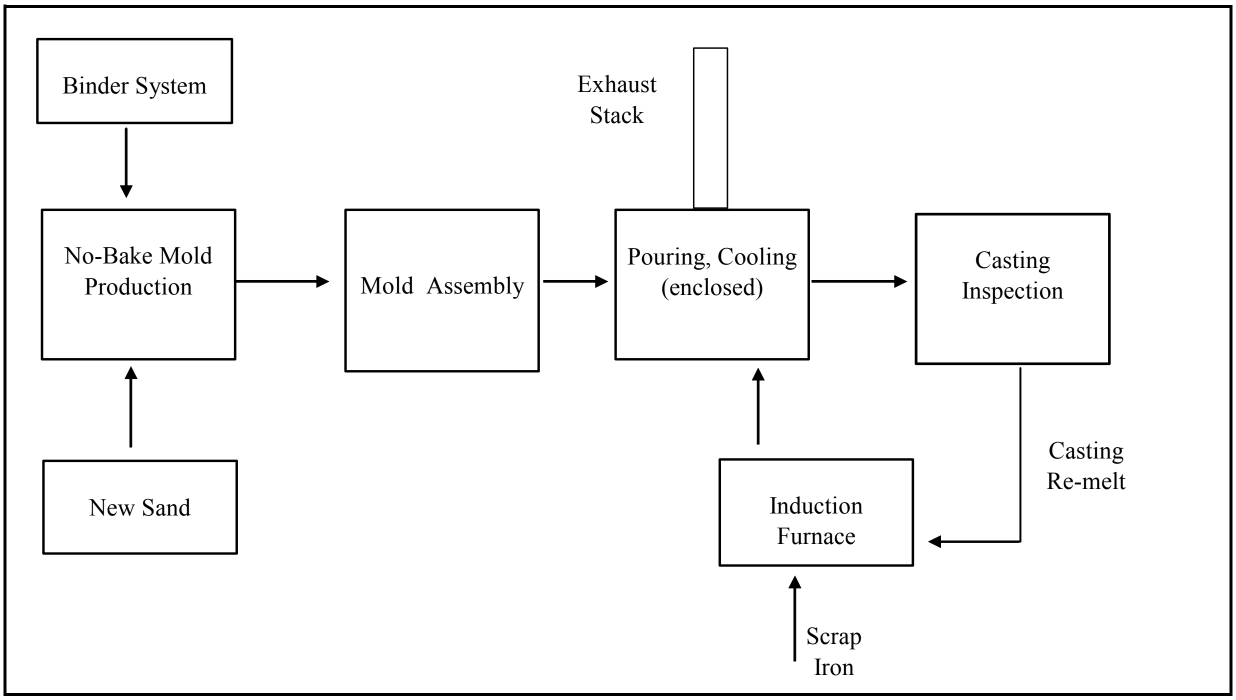
2.0 Test Methodology

2.1 Description of Process and Testing Equipment

Figure 2-1 Pre-Production Foundry No-Bake Process Flowchart



2.2 Description of Testing Program

The process parameters not being evaluated were maintained within prescribed ranges in order to ensure the reproducibility of the tests. Emissions were measured according to US EPA Method 25A, Total Gaseous Organic Concentration, calibrated with propane.

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

1. **<u>Mold Preparation:</u>** The No-Bake mold sand was prepared in a Kloster paddled turbine sand mixer to a calibrated standard composition using Lakesand preheated to 85 to 95 ^{o}F. The sand was placed in 24 x 25 x 5 flasks and vibrated from the time the flasks were half full until 5 seconds after they were full. Sand and binder calibration and mold weight was recorded on the Process Data Summary Sheet.

2. **Metal Preparation:** Iron was melted in a 1000 lb. Ajax induction furnace. The amount of metal was determined from the poured weight of the casting and the number of molds to be poured. The weight of metal poured into each mold was recorded on the Process Data Summary Sheet.

3. **Individual Sampling Events:** The mold packages were placed in an enclosed test stand. The molten metal was poured through an opening in the top of the enclosure. Continuous air sampling was conducted during the seventy-five minute pouring, cooling, and shakeout process at the three stack velocities, and triplicate runs were performed for each flow rate. The weights of the molds were recorded on the Process Data Summary Sheet. In addition, the metal pour temperature and No-Bake sand % LOI were recorded on the Process Data Summary Sheet.

4-on Gear Pattern Castings

The insulated emission hood was supplied with air heated to 85 to 90°F and exhausted through a 6-inch diameter heated duct attached to the top of the hood. Emission samples were drawn from a sampling port located to ensure conformance with US EPA Method 1. The tip of the sample probe was located in the centroid of the stack. Continuous air samples are 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 is seventy-five minutes.

Total Enclosure Test Stand

4. **Test Plan Review and Approval:** The proposed test plan was reviewed by the Technikon staff and the CERP Emissions and Test Design Committees, and approved. Table 2-1 lists

the process parameters that were monitored during each test. The analytical equipment and methods used are also listed.

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Westweigh PP2847 Platform Scale (Gravimetric)
Casting Weight	OHAUS MP-2 Platform Scale (Gravimetric)
LOI% at mold	Denver analytic (AFS procedure 5100-00-S)
Pouring Temperature	Electro-Nite DT 260 (T/C immersion pyrometer)
Carbon/Silicon	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Mettler PJ8000 (Gravimetric)
No-Bake Binder Weight	Mettler PJ8000 (Gravimetric)

5. **Airborne Emissions Analysis:** The specific sampling and analytical methods used in the Pre-production Foundry tests were 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 Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual.

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 2002
VOCs Concentration	EPA Method 18, 25A, TO11, NIOSH 2002, 1500
TGOC as Propane	EPA Method 25A

*These methods were specifically modified to meet the testing objectives of the CERP Program.

6. **Data Reduction, Tabulation and Preliminary Report Preparation:** The analytical results of the emissions tests and average stack flow rate provided the mass emissions for Total Gaseous Organic Concentration as propane emitted during each test run. The mass of emis-

sions is calculated as propane and then divided by both the casting weight and the weight of the binder to provide emissions data in both pounds per ton of metal and pounds per pound of binder. The specific calculation formulas are included in the Technikon Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual. The results of each of the runs and the corresponding process data are included in Section 3 of this report.

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, conclusions 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 emissions data are included in the "Technikon Testing, Quality Control and Quality Assurance, and Data Validation Procedures Manual" In order to ensure the timely review of critical quality control parameters, the following procedures are followed:

- Immediately following the individual runs 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.

- The source (stack) parameters and analytical results are reviewed by the Emission Measurement team to confirm the validity of the data. The Vice President-Measurement Technologies reviews and approves the recommendation, if any, that individual run data should be invalidated. Invalidated data are not used in subsequent calculations.

3.0 Test Results

The average emission results are presented in Tables 3-1 and 3-3 in pounds per pound of binder and pounds per ton of metal poured respectively. The tables include the individual target compounds that comprise at least 95% of the total VOCs measured, along with the corresponding Sum of VOCs, Sum of HAPs, and Sum of POMs. The tables also include the TGOC as propane, HC as hexane, methane, carbon monoxide, and carbon dioxide.

Figures 3-1 to 3-3 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-1 in graphical form. The percentage change in emissions for this test compared to the baseline is shown in Table 3-1.

Figures 3-4 to 3-6 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-3 in graphical form. The percentage change in emissions for this test compared to the baseline is shown in Table 3-3.

The amount of available VOCs for the binder systems was determined using a method based on US EPA Method 24 and found to be 0.48 pounds per pound of binder or 48% of the binder weight for the Baseline Test FL. The amount of available VOCs for Test FP was found to be 0.28 pounds per pound of binder or 28% for test FP. The average emissions results as a percentage of available VOCs expressed as HC as Hexane for both tests are presented in Table 3-2.

Appendix B contains the detailed data including the results for all analytes measured. Table 3-4 includes the averages of the key process parameters. Detailed process data are presented in Appendix C.

Table 3-5 shows the rank order of the casting surface quality for the baseline Test FL. Figures 3-7 to 3-9 present cavity A of the best, median, and worst castings from Test FL.

Table 3-6 shows the rank order of the casting surface quality for Test FP. The best, median, and worst cavity-A castings are shown in Figures 3-10 to 3-12 for Test FP.

Method 25A charts for the tests are included in Appendix D of this report. The charts are presented to show the VOC profile of emissions for each pour.

Table 3-1 Summary of Test Plans FL and FP Average Emissions Results – Lb/Lb Binder

Analytes	Test FL (Lb/Lb Binder)	Test FP (Lb/Lb Binder)	% Change from Test FL
TGOC as Propane	0.2094	0.1676	**-20**
HC as Hexane	0.0670	0.0531	**-21**
Sum of VOCs	0.0428	0.0319	**-25**
Sum of HAPs	0.0303	0.0254	**-16**
Sum of POMs	0.0007	0.0004	**-43**
Individual Organic HAPs			
o,m,p-Cresol	0.0148	0.0103	**-30**
Phenol	0.0088	0.0083	-6
Benzene	0.0044	0.0042	-5
Toluene	0.0010	0.0009	-10
o,m,p-Xylene	0.0008	0.0006	**-25**
Formaldehyde	0.0002	0.0004	**100**
Other VOCs			
Dodecane	0.0064	ND	**NA**
Trimethylbenzenes	0.0033	0.0023	**-30**
1,3-Diethylbenzene	0.0014	0.0011	**-21**
Indan	0.0008	0.0006	**-25**
Dimethylphenols	0.0005	0.0003	-40
Butyraldehyde/Methacrolein	0.0003	0.0004	33
Undecane	ND	0.0005	NA
Propylene Carbonate	NT	0.0012	**NA**
Other Analytes			
Carbon Dioxide	0.5568	0.5947	7
Carbon Monoxide	0.0011	0.0013	18
Methane	0.0010	0.0011	10

ND: Non Detect; NA: Not Applicable; NT: Not Tested

Individual results constitute >95% of mass of all detected VOCs.

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

"Percent Change from Test FL" values in bold have a 95% probability that the differences in the average values were not from test variability.

Table 3-2 Percent Available Solvent

Analyte	Test FL	Test FP
HC as Hexane	14	19

Table 3-3 Summary of Test Plans FL and FP Average Emissions Results – Lb/Tn Metal

Analytes	Test FL (Lb/Tn Metal)	Test FP (Lb/Tn Metal)	% Change from Test FL
TGOC as Propane	12.67	10.03	**-21**
HC as Hexane	4.043	3.147	**-22**
Sum of VOCs	2.488	1.852	**-26**
Sum of HAPs	1.763	1.521	**-14**
Sum of POMs	0.0401	0.0247	**-38**
Individual Organic HAPs			
o,m,p-Cresol	0.8654	0.6154	**-29**
Phenol	0.5106	0.4965	-3
Benzene	0.2521	0.2487	-1
Toluene	0.0575	0.0519	**-10**
o,m,p-Xylene	0.0453	0.0350	**-23**
Formaldehyde	0.0128	0.0221	**73**
Other VOCs			
Dodecane	0.3726	ND	**NA**
Trimethylbenzenes	0.1911	0.1365	**-29**
1,3-Diethylbenzene	0.0822	0.0661	**-20**
Indan	0.0476	0.0349	**-27**
Dimethylphenols	0.0265	0.0181	-32
Butyraldehyde/Methacrolein	0.0208	0.0215	3
Undecane	ND	0.0284	**NA**
Propylene Carbonate	NT	0.0746	**NA**
Other Analytes			
Carbon Dioxide	33.67	35.47	5
Carbon Monoxide	0.0683	0.0796	17
Methane	0.0628	0.0008	**-99**

ND: Non Detect; NA: Not Applicable; NT: Not Tested

Individual results constitute >95% of mass of all detected VOCs.

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

"Percent Change from Test FL" values in bold have a 95% probability that the differences in the average values were not from test variability.

Figure 3-1 Test FL and FP Emissions Indicators– Lb/Lb Binder

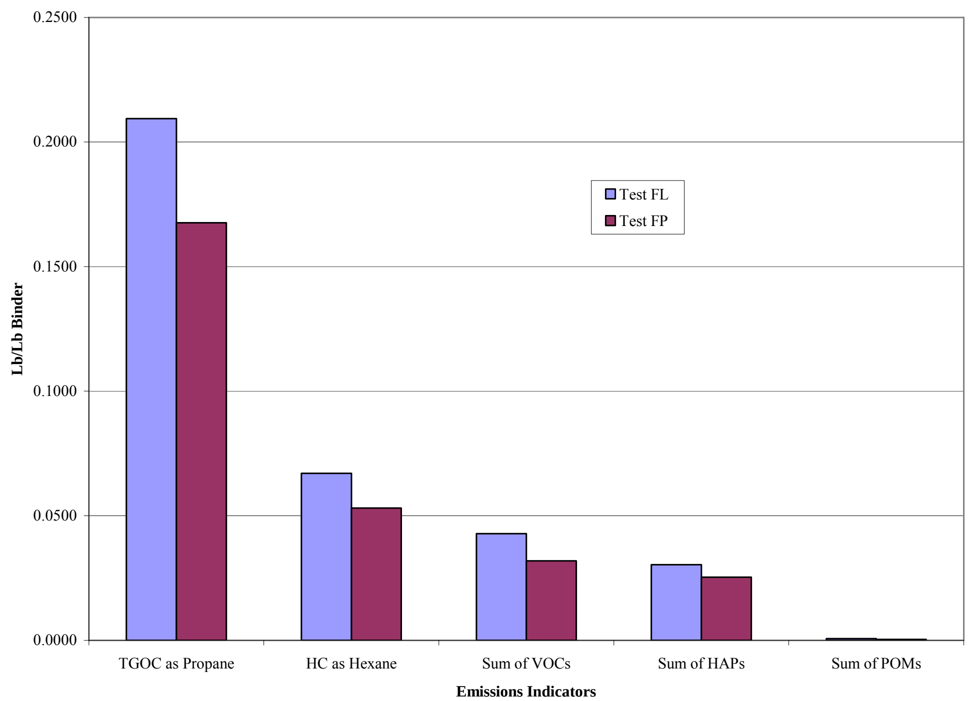


Figure 3-2 Test FL and FP Selected HAPs – Lb/Lb Binder

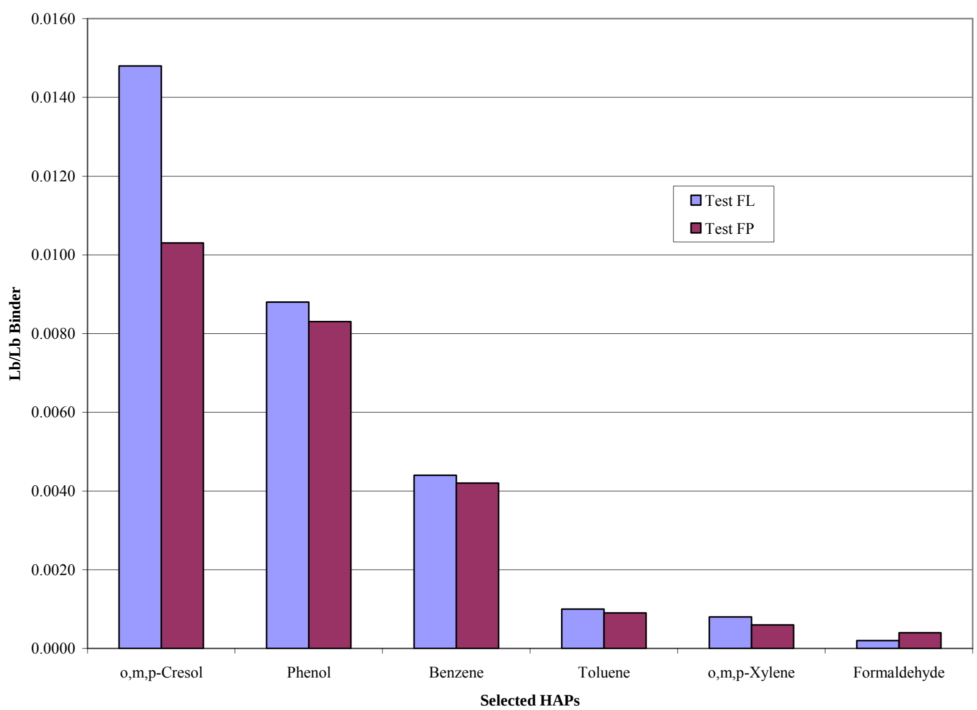


Figure 3-3 Test FL and FP Selected VOCs – Lb/Lb Binder

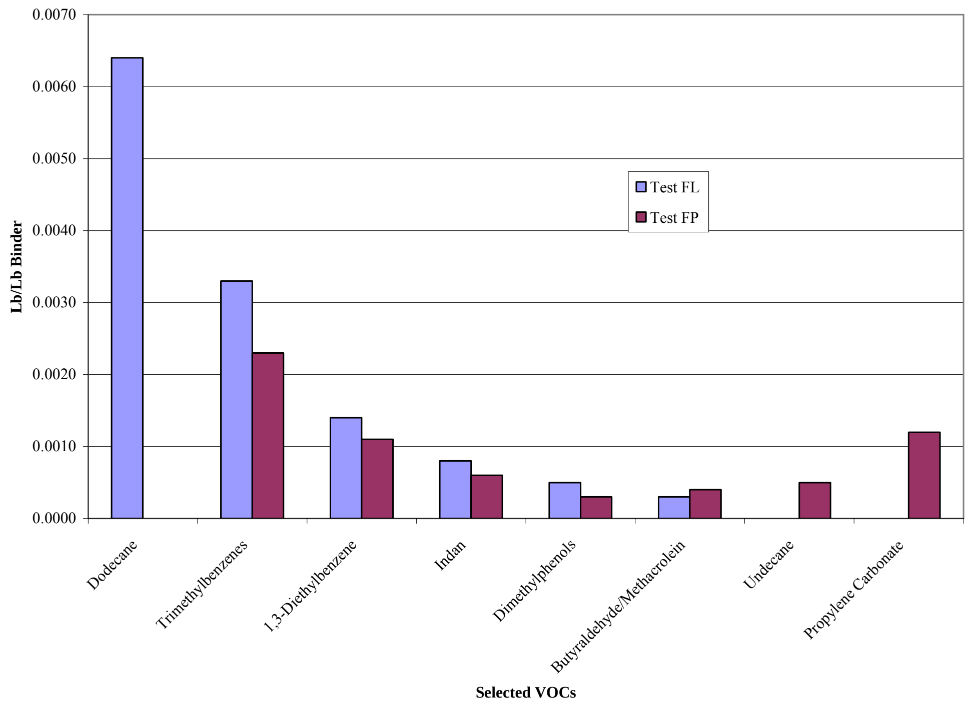


Figure 3-4 Test Series FL and FP Emissions Indicators – Lb/Tn Metal

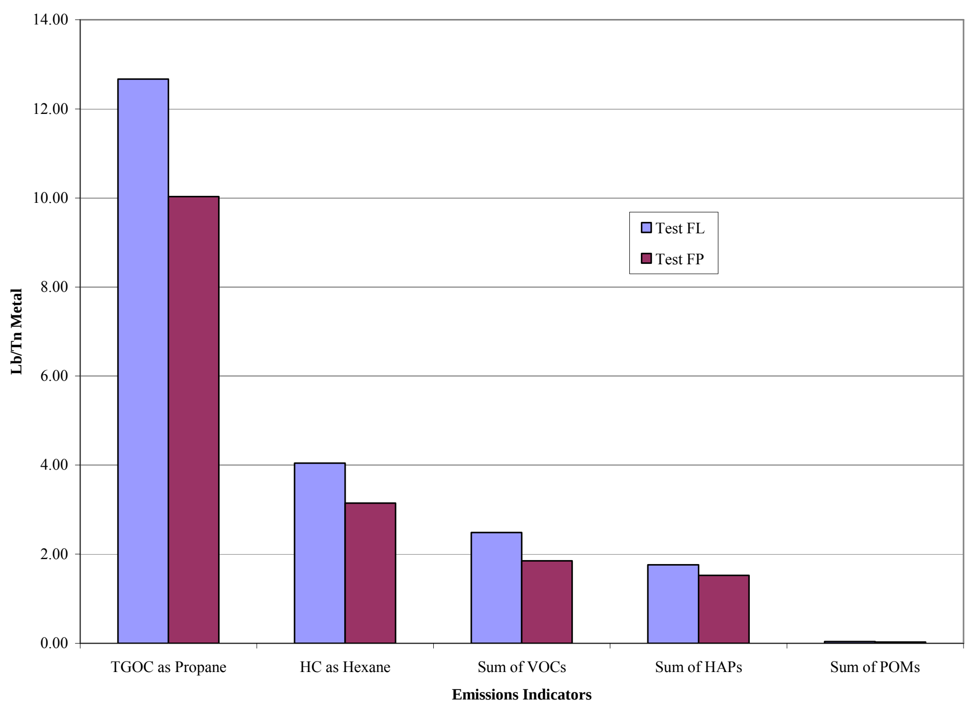


Figure 3-5 Test FL and FP Selected HAPs – Lb/Tn Metal

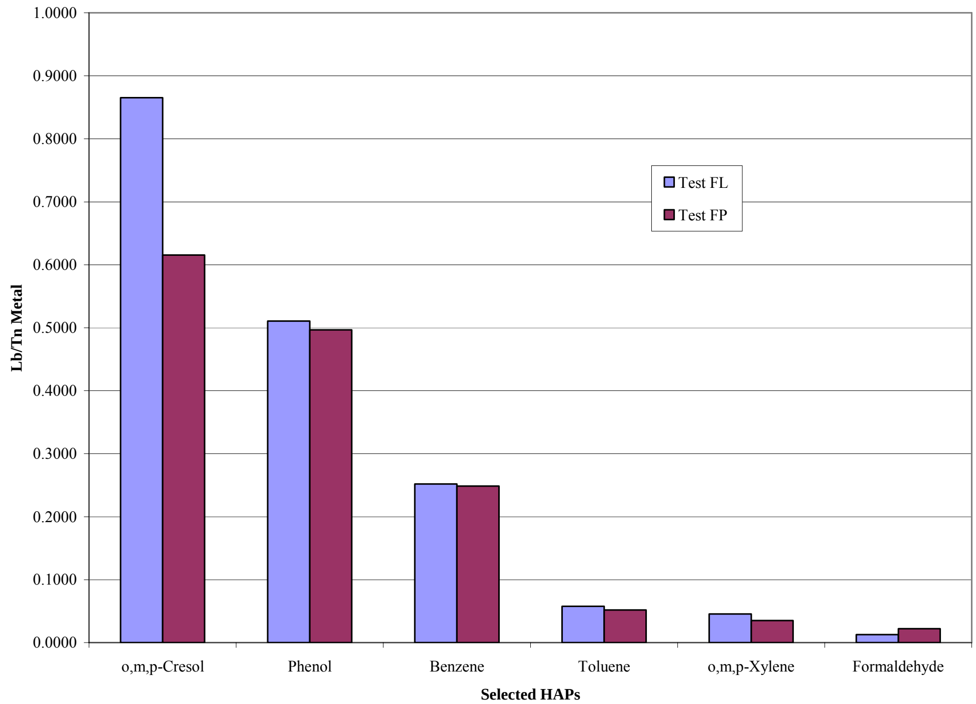


Figure 3-6 Test FL and FP Selected VOCs – Lb/Tn Metal

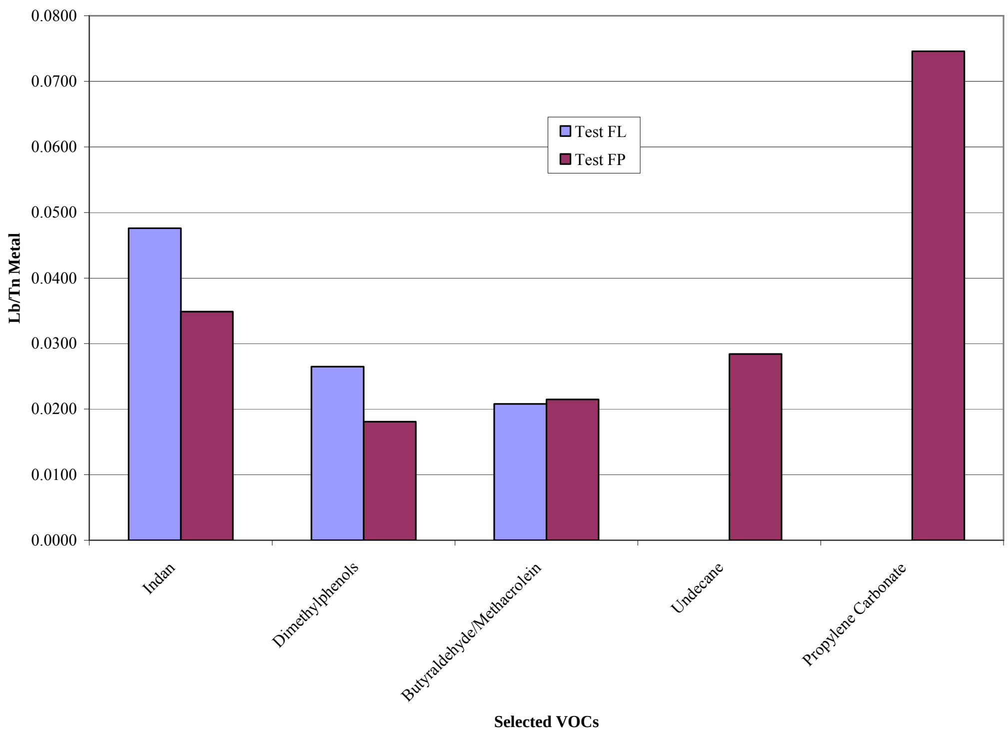


Table 3-4 Average Process Data for Test Series FL and FP

No-Bake Mix/Make/Cure		
Test Dates	9/17/03 > 9/24/03	11/10/2003 - 11/12/2003
Summary	**Test FL**	**Test FP**
Sand Dispensing Rate, lbs/15 sec	30	30
Binder Part1 + Part3 Dispensing Rate, gms/15 sec	84.9	84.5
Binder Part 2 Dispensing Rate, gms/15 sec	63.5	65.3
Calculated Standard % Binder	1.08	1.09
Calculated % Binder (BOS)	1.09	1.10
Mold Weight, lbs	331.1	329.1
Calculated Total Binder Weight, lbs	3.57	3.58
1800F LOI, % (Note 1)	1.10	1.06
Sand Temperature, deg F	82	81
Dogbone Core 2 hr. Tensile Strength, psi	42	89

No-Bake PCS		
Test Dates	9/17/03 > 9/24/03	11/11/2003 - 11/13/2003
Summary	**Test FL**	**Test FP**
Pouring Temp, deg F	2632	2633
Pouring Time, sec.	33	37
Cast Weight (all metal inside mold), Lbs.	117.9	119.6
Process Air Temperature in Hood, deg F (Note 2)	87	87
Mold Temperature when placed in hood, deg F	79	73
Ambient Temperature, deg F	75	66
Mold Age When Poured, hr	23.8	22.5
Test Length, hr	75.0	75.0

Table 3-5 Casting Quality Rank by Mold and Cavity Number for Test FL

Cavity	Best				Median				Worst
a	**2**	**3**	**8**	**9**	**4**	**5**	**6**	**1**	**7**
b	1	3	4	5	9	8	2	7	6
c	1	4	2	3	7	8	9	6	5
d	1	2	3	4	8	9	6	7	5
Rank	1	2	3	4	5	6	7	8	9

Figure 3-7 Best Appearing Casting from Test FL002

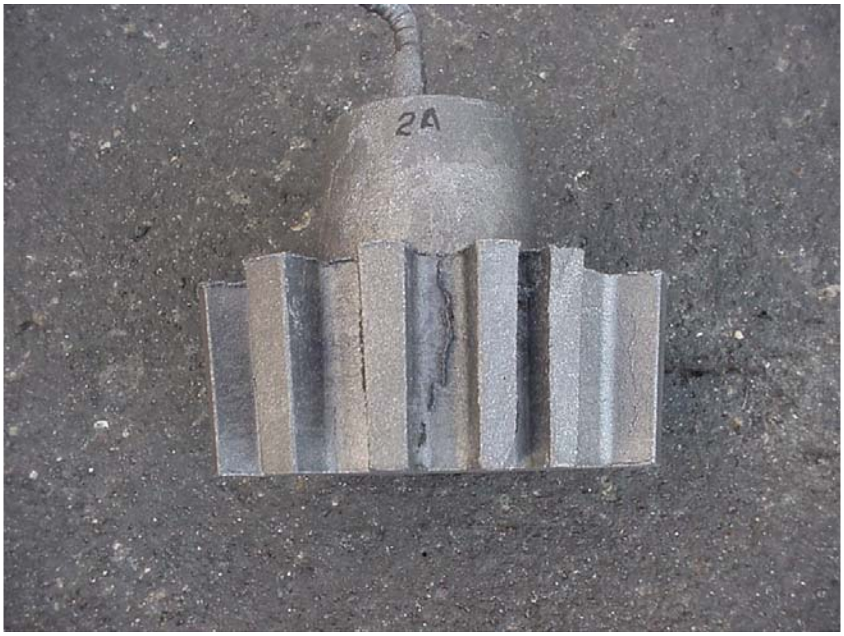


Figure 3-8 Median Appearing Casting from Test FL004

Figure 3-9 Worst Appearing Casting from Test FL007

Table 3-6 Casting Rank for Test FP

Cavity	Best				Median				Worst
a	**8**	**7**	**6**	**4**	**9**	**5**	**3**	**2**	**1**
b									
c									
d									
Rank	1	2	3	4	5	6	7	8	9

Figure 3-10 Best Appearing Casting from Test FP008

Figure 3-11 Median Appearing Casting from Test FP009

Figure 3-12 Worst Appearing Casting from Test FP001

4.0 Discussion of Results

The sampling and analytical methodologies were the same for Test Plans FL and FP.

Observation of measured process parameters indicates that the tests were run within an acceptable range. In Table 3-1, the "% Change from Test FL" emissions values presented in **bold** letters indicate a greater than 95% probability that the differences in the average values were not the result of variability in the test protocol as determined from T-Statistic calculations. Tables showing the T-Statistics calculated are found in Appendix B.

The results of the tests performed for the comparison of Test FL to test FP show a **21%** reduction in TGOC as propane, a **21%** reduction in HC as hexane, a **25%** reduction in Sum of VOCs, a **16%** reduction in Sum of HAPs, and a **43%** reduction in Sum of POMs when expressed in pounds per ton of metal. O,m,p-Cresol was found to be the largest contributor to the total HAPs and VOCs for both Tests FL and FP followed by phenol and benzene.

An independent test for volatile matter content based on EPA Method 24 was performed to determine the amount of available VOCs in the binder system used for this test. The HC as Hexane represents the sum of all compounds that elute from a gas chromatograph between the retention times of hexane and hexadecane. Certain analytes selected for this test may not be represented in the HC as Hexane: formaldehyde, phenol, and cresols, but may be represented in the Method 24 results. Approximately 14% of the available VOCs were recovered for Test FL and 19% for Test FP (Table 3-2).

Carbon dioxide, carbon monoxide, and methane were detected in the ambient (blank) samples for both Tests FL and FP.

Two methods were employed to measure undifferentiated hydrocarbon emissions, TGOC (THC) as propane, performed in accordance with EPA Method 25A, and HC as hexane. EPA Method 25A, TGOC (as propane), is weighted to the detection of more volatile hydrocarbon species, beginning at C1 (methane), with results calibrated against a three-carbon alkane (propane). HC as hexane is weighted to the detection of relatively less volatile compounds. This method detects hydrocarbon compounds in the alkane range between C6 and C16, with results calibrated against a six-carbon alkane (hexane).

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

The casting surface quality of the baseline (FL) casting was clustered near the center of the casting surface quality of the comparative casting (FP). The rankings were based upon the number and severity of veins present and the area of metal penetration into the sand. The FP castings clearly had a wide range of surface quality that generally improved with maturation of the sand.

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APPENDIX A APPROVED TEST PLANS FOR TEST SERIES FL AND FP

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TECHNIKON TEST PLAN

- > **CONTRACT NUMBER:** 1410 **TASK NUMBER:** 1.2.3 **Series:** FL
- > **SITE**: Pre-production No-bake molding and pour, cool, shakeout enclosure.
- > **TEST TYPE:** Baseline: Iron no-bake pouring, cooling, & shakeout.
- > **METAL TYPE:** Class 30 gray-iron.
- > **MOLD TYPE:** 4-on no-bake gear; HA 6000, 6433, 17-727 binder
- > **NUMBER OF MOLDS:** 9
- > **CORE TYPE:** None
- > **SAMPLE Runs:** 9
- > **TEST DATE:** **START:** 29 Sep 2003
  FINISHED: 11 Oct 2003

TEST OBJECTIVES:

Measure selected HAP and VOC emissions using absorption tubes and TGOC using THC for pouring, cooling, and shakeout for a total of 75 minutes to update the iron no-bake baseline in the revised facility. Measure the emissions for the standard iron phenolic urethane no-bake HA 6000/6433/17-727 binder system.

VARIABLES:

The pattern shall be the 4-on gear. The mold shall be made with Wexford W450 sand. The no-bake mold binder will be 1.1% total binder (BOS) in 55/45 ratio of part I/part II and the activator is 10% of part 1. Molds will be poured with iron at 2630 +/- 10^{o}F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout, or until no more material remains to be shaken out. The emission sampling shall be a total of 75 minutes.

BRIEF OVERVIEW:

The emission collection procedure has been updated with a new emission collection system that provides independence from reasonable daily and seasonal ambient temperature changes with improved exhaust homogenization and real time data collection.

SPECIAL CONDITIONS:

The initial sand temperature into the emission collection hood shall be maintained at 80-90^{o}F. The initial process air temperature shall be 85-90^{o}F.

Series FL

Iron No-bake Baseline 2003

Process Instructions

A. Experiment: Measure emissions from an Iron No-Bake Phenolic Urethane binder to update the iron no-bake baseline in the revised facilities.

B. Materials:

1. No-bake molds: Wexford W450 Lakesand and Casting cleaning
2. % HA International Techniset ® No-bake Phenolic-Urethane core binder composed of 6000 part I resin, 6433 part II co-reactant, & 17-727 part III activator. This binder is designed for iron applications.
3. Metal: Class-30 Gray cast iron.

C. Spin blast set up.

1. Load the spin blast shot storage bin with 460 steel shot.
2. Turn on the spin blast bag house.
3. Turn on the spin blast machine.
4. Increase the magnetic feeder so that the motor amperage just turns to 12 amps from 11 amps.
5. Record the shot flow and the motor amperage for each wheel
6. Cleaning castings.
7. Place the four (4) castings from a single mold on one (1) casting basket.
8. Process each rotating basket for eight (8) minutes.
9. Remove and remark casting ID on each casting.

D. 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. Separate castings by cavity number.
4. For each cavity:
5. Place each casting initially in sequential mold number order.
6. Beginning with casting from mold FH001 compares it to castings from mold FH002.
7. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
8. Repeat this procedure with FH001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than FH001 and the next casting farther down the line is inferior.

9. Repeat this comparison to next neighbors for each casting number.
10. 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.
11. Repeat this comparison until all concur with the ranking order.
    a. Record mold number by rank-order series for each cavity.

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

E. Mold requirements

1. Make nine (9) molds according standards determined in test series CW & CP capability studies.

2. Phenolic Urethane No-bake Core Sand preparation:

    a. Load the Kloster core sand mixer with 80-90^{0}F Wexford sand.
    b. The phenolic urethane no-bake sand shall be 1.1% total resin (BOS), Part I/Part II ratio 55/45, Part III at 5% of Part I.
    c. Calibrate the Kloster no-bake sand mixer to dispense 240 pounds of sand /min more or less.
    d. Calibrate the resin pumps:

        (1) Premix Part I resin and Part III activator in a 20:1 weight ratio.
        (2) Part I +Part III: Based on the actual measured sand dispensing rate calibrate the Part I + Part III resin to be 57.14% of 1.1% (.629% BOS) total binder.
        (3) Part II: Based on the actual measured sand dispensing rate calibrate the
        (4) Part II co-reactant to be 42.86% of 1.1% (.471% BOS) total binder.
        (5) All calibrations to have a tolerance of +/- 1% of the calculated value.

3. Run an 1800^{o}F core LOI on three (3) samples from each mold. Report the average value for each mold.

F. Dog bones:

1. Make 12 dogbones for each mold according to the protocol establish in capability study CW.
2. Place the core box on the vibrating compaction table.
3. Start the Kloster mixer and waste a few pounds of sand.
4. Flood the core box with sand then stop the mixer.
5. Strike off the core box to ½ inch deep
6. Turn on the vibrating compaction table for 15 seconds.
7. Screed off most of the excess sand.

8. Screed the core box a second time moving very slowly in a back and forth manner to remove **all** excess sand.

Note: It is important to neither gouge the sand nor leave excess sand in center neck portion of the dogbone or the test results will be affected

9. Set aside for about 6-7 minutes or until hard to the touch.
10. Carefully remove the cores from the core box by separating the corebox components.
11. Perform tensile tests on 12 bones at 2 hours after dogbone manufacture
12. Report the average and standard deviation for each set of twelve (12) for each mold.
13. Weigh each dogbone and record the weight to the nearest 0.1 grams using the PJ 4000 electronic scale at the time it is tensile tested.

Note: Maintain the correlation between the reported weight of a dogbone and its tensile strength and scratch hardness.

14. Run an 1800^{o}F core LOI on three (3) of the tensile test dogbones. Report the average value for each mold.

G. No-bake mold making: 4 on gear core box.

1. Inspect the box for cracks and other damage. Repair before use.
2. Prepare the core box halves with a light coating of Ashland Zipslip® IP 78. Allow to fully dry.
3. Place the drag core box on the vibrating compaction table.
4. Begin filling the box.
5. When the box is about half full start the table vibration.
6. Manually spread the sand around the box as it is filling.
7. Strike off the box until it is full.
8. Allow the vibrator to run an additional 10 seconds after the box is full.
9. Strike off the core box so that the core mold is 5-1/2 inches thick.
10. Set the core box aside for 5 to 6 minutes or until it is hard to the touch.
11. Invert the box and place on a transport pallet.
12. Remove the pivot-hole pins.
13. Remove the core mold half by tapping lightly on the box with a soft hammer.
14. Set the drag core box aside.
15. Immediately roll the drag mold half parting line up and return to the transport pallet.
16. Place the cope core box on the vibrating compaction table.
17. Follow steps F3-F13 except that the cope mold is 5 inches thick.
18. Rotate the unboxed core to set it on edge.
19. Drill vent-holes as per template.
20. Blow out both mold halves.
21. Apply a 1/4-3/8 inch glue bead of Foseco Core Fix 8 one inch (1) in from the outer edge of the mold.
22. Immediately close cope onto drag. Visually check for closure.

23. Install two (2) steel straps, one on either side of the pouring cup, with 4 metal corner protectors each to hold the mold tightly closed.
24. Glue a pouring basin over the sprue hole with Foseco CoreFix 8 or equivalent no emission water base refractory adhesive
25. Weigh and record the weight of the closed mold.
26. Store the mold for next day use at 80-90^{o}F.

H. Emission hood:

1. Loading.

a. Hoist the mold onto the shakeout deck fixture within the emission hood with the pouring cup side toward the furnace.
b. Install a half inch re-rod casting hanger through the cope into each of the four riser cavities and suspend them over the horizontal mold retaining bars.
c. Close and seal the emission hood and lock the ducts together.
d. Attach the heated ambient air duct to plenum.
e. Wait to pour until the process air thermocouple is in the range 85-90^{o}F.
f. Record the ambient & process ambient air temperature.

2. Shakeout.

a. After 45 minutes of cooling time has elapsed, turn on the shakeout unit and run for 15 minutes as prescribed in the emission test plan.
b. Turn off the shakeout. The emission sampling will continue for an additional 15 minutes or a total of 75 minutes.
c. Wait for the emission team to signal that they are finished sampling.
d. Open the hood, remove the castings.
e. Clean core sand out of the waste sand box, off the shakeout, and the floor.
f. Weigh and record cast metal weight adjusted for the re-rod hanger weight.

I. Melting:

1. Initial charge:

a. Charge the furnace according to the Generic Start-Up Charge for Pre-production heat recipe bearing effectivity date 18 Mar 1999.
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^{o}F.
f. Slag the furnace and add the balance of the alloys.

- **g.** Raise the temperature of the melt to 2,700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2,200-2,350°F.
- **h.** Hold the furnace at 2,500-2,550°F until near ready to tap.
- **i.** When ready to tap raise the temperature to 2,700°F and slag the furnace.
- **j.** Record all metallic and alloy additions to the furnace & tap temperature. Record all furnace activities with an associated time. Record Data Cast TPL, TPS, CE, C, & Si.

2. Back charging.

- **a.** If additional iron is desired back charge according to the Generic Pre-production Last Melt heat recipe bearing effectivity date 18 Mar 1999.
- **b.** Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.
- **c.** Follow the above steps beginning with H.1.e

3. Emptying the furnace.

- **a.** Pig the extra metal only after the last 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 2,700°F metal into the cold ladle.
- **b.** Casually pour the metal back to the furnace.
- **c.** Cover the ladle.
- **d.** Reheat the metal to 2,780 +/- 20°F.
- **e.** Tap 450 pounds more or less 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, open the emission hood pour door and wait until the metal temperature reaches 2,630 +/- 10°F.
- **h.** Commence pouring keeping the sprue full.
- **i.** Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.
- **j.** Record Pouring temperature and pour duration.

K. Casting cleaning

1. Spin blast set up.

- **a.** Load the spin blast shot storage bin with 460 steel shot.
- **b.** Turn on the spin blast bag house.
- **c.** Turn on the spin blast machine.

d. Increase the magnetic feeder so that the motor amperage just turns to 12 amps from 11 amps.
e. Record the shot flow and the motor amperage for each wheel

2. Cleaning castings.

a. Place the four (4) castings from a single mold on one (1) casting basket.
b. Process each rotating basket for eight (8) minutes.
c. Remove and remark casting ID on each casting.

L. 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. Separate castings by cavity number.
4. For each cavity:

a. Place each casting initially in sequential mold number order.
b. Beginning with casting from mold FL001, compare it to castings from mold FL002.
c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
d. Repeat this procedure with FL001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than FL001 and the next casting farther down the line is inferior.
e. Repeat this comparison to next neighbors for each casting number.

5. 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.
6. Repeat this comparison until all concur with the ranking order.
7. Record mold number by rank-order series for each cavity.
8. Save one cavity set of casting as the baseline reference set.

Steven Knight
Mgr. Process Engineering

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/7/2003											
RUN 1											
THC	FL001	X									TOTAL
M-18	FL00101		1						30	1	Carbopak charcoal
M-18 MS	FL00102		1						30	2	Carbopak charcoal
M-18 MS	FL00103			1					30	3	Carbopak charcoal
Gas, CO, CO2	FL00104		1						60	4	Tedlar Bag
Gas, CO, CO2	FL00105				1				0		Tedlar Bag
NIOSH 1500	FL00106		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FL00107				1				0		100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00108		1						200	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FL00109				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00110		1						675	9	DNPH Silica Gel (SKC 226-119)
TO11	FL00111				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/7/2003											
RUN 2											
THC	FL002	X									TOTAL
M-18	FL00201		1						30	1	Carbopak charcoal
M-18	FL00202			1					30	2	Carbopak charcoal
M-18	FL00203				1				0		Carbopak charcoal
	Excess								30	3	Excess
Gas, CO, CO2	FL00204		1						60	4	Tedlar Bag
NIOSH 1500	FL00205		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FL00206			1					200	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00207		1						200	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	8	Excess
TO11	FL00208		1						675	9	DNPH Silica Gel (SKC 226-119)
TO11	FL00209			1					675	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/7/2003											
RUN 3											
THC	FL003	X									TOTAL
M-18	FL00301		1						30	1	Carbopak charcoal
M-18	FL00302					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00303		1						60	4	Tedlar Bag
NIOSH 1500	FL00304		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00305		1						200	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FL00306			1					200	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	8	Excess
TO11	FL00307		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/8/2003											
RUN 4											
THC	FL004	X									TOTAL
M-18	FL00401		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00402		1						60	4	Tedlar Bag
NIOSH 1500	FL00403		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00404		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00405		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/8/2003											
RUN 5											
THC	FL005	X									TOTAL
M-18	FL00501		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00502		1						60	4	Tedlar Bag
NIOSH 1500	FL00503		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00504		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00505		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/8/2003											
RUN 6											
THC	FL006	X									TOTAL
M-18	FL00601		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00602		1						60	4	Tedlar Bag
NIOSH 1500	FL00603		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00604		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00605		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/9/2003											
RUN 7											
THC	FL007	X									TOTAL
M-18	FL00701		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00702		1						60	4	Tedlar Bag
NIOSH 1500	FL00703		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00704		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00705		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/9/2003											
RUN 8											
THC	FL008	X									TOTAL
M-18	FL00801		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00802		1						60	4	Tedlar Bag
NIOSH 1500	FL00803		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00804		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00805		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FL - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
10/9/2003											
RUN 9											
THC	FL009	X									TOTAL
M-18	FL00901		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FL00902		1						60	4	Tedlar Bag
NIOSH 1500	FL00903		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FL00904		1						200	6	100/50 mg Silica Gel (SKC 226-10)
	Excess								200	7	Excess
	Excess								200	8	Excess
TO11	FL00905		1						675	9	DNPH Silica Gel (SKC 226-119)
	Excess								675	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

TECHNIKON TEST PLAN

> **CONTRACT NUMBER:** 1410 **TASK NUMBER:** 1.1.3 **Series:** FP
> **SITE:** Pre-production No-Bake molding and pour, cool, shakeout enclosure.
> **TEST TYPE:** Product Test: Iron No-Bake pouring, cooling, & shakeout.
> **METAL TYPE:** Class 30 gray-iron.
> **MOLD TYPE:** 4-on No-Bake gear; HA 6066LV, 6435, 17-727 binder
> **NUMBER OF MOLDS:** 9
> **CORE TYPE:** None
> **SAMPLE Runs:** 9
> **TEST DATE:** **START:** 04 Nov 2003
> **FINISHED:** 12 Dec 2003

TEST OBJECTIVES:

Measure selected HAP and VOC emissions using absorption tubes and TGOC using THC for pouring, cooling, and shakeout for a total of 75 minutes. Compare to No-Bake baseline test FL

VARIABLES:

The pattern shall be the 4-on gear. The mold shall be made with Wexford W450 sand. The No-Bake mold binder will be 1.1% total binder (BOS) in 55/45 ratio of part I/part II and the activator is 5% of part 1. Molds will be poured with iron at 2630 +/- 10^{o}F. Mold cooling will be 45 minutes followed by 15 minutes of shakeout. The emission sampling shall be a total of 75 minutes.

BRIEF OVERVIEW:

The emission collection procedure has been updated with a new emission collection system that provides independence from reasonable daily and seasonal ambient temperature changes, improved stack homogenization, and real time data collection.

SPECIAL CONDITIONS:

The initial sand temperature into the emission collection hood shall be maintained at 80-90^{o}F. The initial process air temperature shall be 85-90^{o}F.

Series FP

PCS Iron No-bake

Process Instructions

A. Experiment:

1. Measure airborne pouring, cooling, & shakeout emissions from the 4-on gear mold made from HA International Techniset ® 6066LV/6435/17-727 iron No-Bake phenolic urethane binder and compare to Iron No-Bake PCS Baseline Test FL.

B. Materials:

1. No-bake molds:

a. Wexford W450 Lakesand and 1.1% HA International Techniset ® No-bake Phenolic-Urethane core binder composed of HA 6066LV part I resin, HA 6435 part II co-reactant, & HA 17-727 part III activator. This binder is designed for iron applications.

2. Metal: Class

a. 30-Gray cast iron.

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

C. Mold requirements

1. Make nine (9) molds according to standards determined in test series CW & CP capability studies.

D. Phenolic Urethane No-bake Core Sand preparation:

1. Load the Kloster core sand mixer with 80-90^{0}F Wexford W450 sand.

a. The phenolic urethane no-bake sand shall be 1.1 % total resin (BOS), Part I/Part II ratio 55/45, Part III at 5% of Part I.

2. Calibrate the Kloster no-bake sand mixer to dispense 240 pounds of sand /min more or less.

3. Calibrate the resin pumps:

a. Premix Part I resin and Part III activator in a 20:1 weight ratio.

(1) Part I +Part III: Based on the actual measured sand dispensing rate calibrate the Part I + Part III resin to be 56.20% of 1.1% (.618% BOS) total binder.

- **b.** Part II: Based on the actual measured sand dispensing rate calibrate the Part II co-reactant to be 43.80% of 1.1% (.482% BOS) total binder.
- **c.** All calibrations to have a tolerance of +/- 1% of the calculated value.

4. Run a 1,800°F core LOI on at least three (3) samples from each mold. Report the average value for each mold.

E. Dog bones:

1. Make 12 dogbones for each mold according to the protocol establish in capability study CW.
2. Place the core box on the vibrating compaction table.
3. Start the Kloster mixer and waste a few pounds of sand.
4. Flood the core box with sand then stop the mixer.
5. Strike off the core box to ½ inch deep
6. Turn on the vibrating compaction table for 5 seconds.
7. Screed off most of the excess sand.
8. Screed the core box a second time moving very slowly in a back and forth manner to remove **all** excess sand.

Note: It is important to neither gouge the sand nor leave excess sand in center neck portion of the dogbone or the test results will be affected

9. Set aside for about 6-7 minutes or until hard to the touch.
10. Carefully remove the cores from the core box by separating the corebox components.
11. Perform tensile tests on 12 bones at 2 hours after dogbone manufacture
12. Report the average and standard deviation for each set of twelve (12) for each mold.
13. Weigh each dogbone and record the weight to the nearest 0.1 grams using the PJ 4000 electronic scale at the time it is tensile tested.

Note: Maintain the correlation between the reported weight of a dogbone and its tensile strength.

14. Run a 1,800°F core LOI on three (3) of the tensile test dogbones. Report the average value for each mold.

F. No-bake mold making: 4 on gear core box.

1. Inspect the box for cracks and other damage. Repair before use.
2. Prepare the core box halves with a light coating of Ashland Zipslip® IP 78. Allow to fully dry.
3. Place the drag core box on the vibrating compaction table.
4. Begin filling the box.
5. Manually spread the sand around the box as it is filling.
6. When the box is about full start the table vibration.
7. Allow the vibrator to run an additional 10 seconds after the box is full.
8. Strike off the core box so that the core mold is 5-1/2 inches thick.

9. Set the core box aside for 5 to 6 minutes or until it is hard to the touch.
10. Invert the box and place on a transport pallet.
11. Remove the pivot-hole pins.
12. Remove the core mold half by tapping lightly on the box with a soft hammer.
13. Set the drag core box aside.
14. Immediately roll the drag mold half parting line up and return to the transport pallet.
15. Place the cope core box on the vibrating compaction table.
16. Follow steps F3-F12 except that the cope mold is 5 inches thick.
17. Rotate the unboxed core to set it on edge.
18. Drill $^{9}/_{16}$ inch vent holes as per template. Re-rod is 0.520 in. rib diameter.
19. Blow out both mold halves.
20. Apply a ¼ - ⅜ inch glue bead of water based Foseco Core Fix eight (8) one (1) inch in from the outer edge of the mold.
21. Immediately close cope onto drag. Visually check for closure.
22. Install two (2) steel straps, one on either side of the pouring cup location, with 4 metal corner protectors each to hold the mold tightly closed.
23. Glue a pouring basin over the sprue hole with Foseco CoreFix 8 or equivalent no emission water based refractory adhesive
24. Weigh and record the weight of the closed mold.
25. Store the mold for next day use at 80-90^{o}F.

G. Emission hood:

1. Loading.

   a. Hoist the mold onto the shakeout deck fixture within the emission hood with the pouring cup side toward the furnace.
   b. Install a half inch re-rod casting hanger through the cope into each of the four riser cavities and suspend them over the horizontal mold restraining bars.
   c. Close and seal the emission hood and lock the ducts together.
   d. Attach the heated ambient air duct to plenum
   e. Wait to pour until the process air thermocouple is in the range 85-90^{o}F.
   f. Record the ambient & process ambient air temperature.

2. Shakeout.

   a. After 45 minutes of cooling time has elapsed turn on the shakeout unit and run for 15 minutes, as prescribed in the emission test-plan.
   b. Turn off the shakeout. The emission sampling will continue for an additional 15 minutes or a total of 75 minutes
   c. Wait for the emission team to signal that they are finished sampling.
   d. Open the hood, remove the castings
   e. Clean core sand out of the waste sand box, off the shakeout, and the floor.
   f. Weigh and record cast metal weight adjusted for the re-rod hanger weight.
   g. Dispose of the used No-Bake sand.

H. Melting:

1. Initial charge:

a. Charge the furnace according to the **Generic Start-Up Charge for Pre-Production** heat recipe bearing effectivity date 18 Mar 1999.
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 2,600 to 2,700°F.
f. Slag the furnace and add the balance of the alloys.
g. Raise the temperature of the melt to 2,700°F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2,200-2,350°F.
h. Hold the furnace at 2,500-2,550°F until near ready to tap.
i. When ready to tap raise the temperature to 2,700°F and slag the furnace.
j. Record all metallic and alloy additions to the furnace & tap temperature. Record all furnace activities with an associated time. Record Data Cast TPL, TPS, CE, C, & Si.

2. Back charging.

a. If additional iron is desired back charge according to the **Generic Pre-Production Last Melt** heat recipe bearing effectivity date 18 Mar 1999.
b. Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.
c. Follow the above steps beginning with H.1.e

3. Emptying the furnace.

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

I. Pouring:

1. Preheat the ladle.

a. Tap 400 pounds more or less of 2,700°F metal into the cold ladle.

2. Casually pour the metal back to the furnace.
3. Cover the ladle.

4. Reheat the metal to 2,780 +/- 20°F.
5. Tap 450 pounds more or less of iron into the ladle while pouring inoculating alloys onto the metal stream near its base.
6. Cover the ladle to conserve heat.
7. Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 2630 +/- 10°F.
8. Commence pouring keeping the sprue full.
9. Upon completion close the hood door, return the extra metal to the furnace, and cover the ladle.
10. Record Pouring temperature and pour duration.

J. Casting cleaning

1. Spin blast set up.
2. Load the spin blast shot storage bin with 460 steel shot.
3. Turn on the spin blast bag house.
4. Turn on the spin blast machine.
5. Increase the magnetic feeder so that the motor amperage just turns to 12 amps from 11 amps.
6. Record the shot flow and the motor amperage for each wheel
7. 2. Cleaning castings.
8. Place the four (4) castings from a single mold on one (1) casting basket.
9. Process each rotating basket for eight (8) minutes.
10. Remove and remark casting ID on each casting.
11. Weigh & report the aggregate cast weight of the four castings from each mold; the aggregate gating, sprue, and pour basin for each mold; and any splash metal on the outside of the mold.
12. Separate the cavity 3 casting from each mold for Rank-Order evaluation

K. Rank order evaluation.

1. The supervisor shall select a group of four or five persons to make a collective subjective judgment of the casting's relative surface appearance.
2. Review the general appearance of the castings and select specific casting features to compare. Generally for the gear mold the material related casting features should be metal penetration, veining, expansion defects and texture (tactile feel). Defects arising from loose sand, slag, broken molds, double striking, and shrinkage should be disregarded.
3. Separate cavity 3 castings by cavity number.
4. For each cavity 3 casting:

   a. Place each casting initially in sequential mold number order.
   b. Beginning with casting from cavity 3, mold FP001, compare it to castings from cavity 3 mold FP002.
   c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.

d. Repeat this procedure with cavity 3 mold FP001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than cavity-3 mold FP001 and the next casting farther down the line is inferior.
e. Repeat this comparison to next neighbors for each cavity 3 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 evaluators concur with the ranking order.
h. Record cavity 3 mold number by rank-order series.
i. Save the best, median, and worst castings of Cavity 3 for photographing and archiving.

Steven Knight
Mgr. Process Engineering

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 1											
THC	FP001	X									TOTAL
M-18	FP00101		1						30	1	Carbopak charcoal
M-18 MS	FP00102		1						30	2	Carbopak charcoal
M-18 MS	FP00103			1					30	3	Carbopak charcoal
Gas, CO, CO2	FP00104		1						60	4	Tedlar Bag
Gas, CO, CO2	FP00105				1				0		Tedlar Bag
NIOSH 1500	FP00106		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FP00107				1				0		100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00108		1						200	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FP00109				1				0		100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00110		1						200	7	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	FP00111				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00112		1						675	10	DNPH Silica Gel (SKC 226-119)
TO11	FP00113				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 2											
THC	FP002	X									TOTAL
M-18	FP00201		1						30	1	Carbopak charcoal
M-18	FP00202			1					30	2	Carbopak charcoal
M-18	FP00203				1				0		Carbopak charcoal
	Excess								30	3	Excess
Gas, CO, CO2	FP00204		1						60	4	Tedlar Bag
NIOSH 1500	FP00205		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FP00206			1					200	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00207		1						200	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FP00208			1					200	8	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00209		1						200	9	100/50 mg Charcoal (SKC 226-01)
TO11	FP00210		1						675	10	DNPH Silica Gel (SKC 226-119)
TO11	FP00211			1					675	11	DNPH Silica Gel (SKC 226-119)
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 3											
THC	FP003	X									TOTAL
M-18	FP00301		1						30	1	Carbopak charcoal
M-18	FP00302					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00303		1						60	4	Tedlar Bag
NIOSH 1500	FP00304		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00305		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00306		1						200	7	100/50 mg Charcoal (SKC 226-01)
Modified NIOSH 1500	FP00307			1					200	8	100/50 mg Charcoal (SKC 226-01)
	Excess								200	9	Excess
TO11	FP00308		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 4											
THC	FP004	X									TOTAL
M-18	FP00401		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00402		1						60	4	Tedlar Bag
NIOSH 1500	FP00403		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00404		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00405		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00406		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 5											
THC	FP005	X									TOTAL
M-18	FP00501		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00502		1						60	4	Tedlar Bag
NIOSH 1500	FP00503		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00504		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00505		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00506		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 6											
THC	FP006	X									TOTAL
M-18	FP00601		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00602		1						60	4	Tedlar Bag
NIOSH 1500	FP00603		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00604		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00605		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00606		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 7											
THC	FP007	X									TOTAL
M-18	FP00701		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00702		1						60	4	Tedlar Bag
NIOSH 1500	FP00703		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00704		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00705		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00706		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 8											
THC	FP008	X									TOTAL
M-18	FP00801		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00802		1						60	4	Tedlar Bag
NIOSH 1500	FP00803		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00804		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00805		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00806		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FP - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
RUN 9											
THC	FP009	X									TOTAL
M-18	FP00901		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
Gas, CO, CO2	FP00902		1						60	4	Tedlar Bag
NIOSH 1500	FP00903		1						200	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FP00904		1						200	6	100/50 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	FP00905		1						200	7	100/50 mg Charcoal (SKC 226-01)
	Excess								200	8	Excess
	Excess								200	9	Excess
TO11	FP00906		1						675	10	DNPH Silica Gel (SKC 226-119)
	Excess								675	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

APPENDIX B DETAILED EMISSIONS DATA

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Test Plan FL Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	**10/06/03**	**10/06/03**	**10/06/03**	**10/07/03**	**10/07/03**	**10/07/03**	**10/08/03**	**10/08/03**	**10/08/03**		
		TGOC as Propane	2.17E-01	2.24E-01	2.14E-01	2.08E-01	2.12E-01	2.07E-01	1.93E-01	2.06E-01	2.04E-01	2.09E-01	8.58E-03
		HC as Hexane	I	8.22E-02	6.80E-02	6.35E-02	6.44E-02	I	5.87E-02	6.39E-02	6.85E-02	6.70E-02	7.45E-03
		Sum of VOCs	I	4.67E-02	4.34E-02	3.85E-02	5.73E-02	3.63E-02	3.94E-02	3.90E-02	4.14E-02	4.28E-02	6.69E-03
		Sum of HAPs	I	3.23E-02	3.05E-02	2.71E-02	4.04E-02	2.41E-02	2.74E-02	3.20E-02	2.87E-02	3.03E-02	4.92E-03
		Sum of POMs	I	8.10E-04	6.89E-04	5.82E-04	8.51E-04	5.85E-04	6.43E-04	7.94E-04	6.48E-04	7.00E-04	1.05E-04
		Individual Organic HAPs											
x		**m,p-Cresol**	I	1.50E-02	1.43E-02	1.24E-02	1.87E-02	1.33E-02	1.26E-02	1.47E-02	1.35E-02	1.43E-02	2.02E-03
x		**Phenol**	I	9.22E-03	8.59E-03	7.65E-03	1.19E-02	8.03E-03	7.55E-03	9.38E-03	8.00E-03	8.78E-03	1.42E-03
x		**Benzene**	4.32E-03	4.30E-03	4.23E-03	3.94E-03	5.61E-03	I	4.09E-03	4.35E-03	4.05E-03	4.36E-03	5.25E-04
x		**Toluene**	8.88E-04	9.84E-04	9.50E-04	9.37E-04	1.27E-03	8.64E-04	9.31E-04	1.00E-03	9.59E-04	9.76E-04	1.18E-04
x		**m,p-Xylene**	I	5.92E-04	5.76E-04	5.63E-04	7.72E-04	5.30E-04	5.58E-04	6.11E-04	5.80E-04	5.98E-04	7.45E-05
x		**o-Cresol**	I	6.91E-04	5.01E-04	4.95E-04	6.77E-04	4.40E-04	5.09E-04	4.97E-04	5.00E-04	5.39E-04	9.24E-05
x	z	**Naphthalene**	I	4.31E-04	3.84E-04	3.22E-04	4.83E-04	3.34E-04	3.46E-04	4.22E-04	3.60E-04	3.85E-04	5.59E-05
x		**Formaldehyde**	1.89E-04	2.87E-04	2.44E-04	2.06E-04	1.98E-04	I	1.76E-04	2.30E-04	1.76E-04	2.13E-04	3.84E-05
x	z	**2-Methylnaphthalene**	8.63E-05	2.32E-04	1.89E-04	1.61E-04	2.28E-04	1.56E-04	1.86E-04	2.28E-04	1.78E-04	1.83E-04	4.63E-05
x		**o-Xylene**	I	1.79E-04	1.75E-04	1.67E-04	2.35E-04	1.64E-04	1.67E-04	1.84E-04	1.73E-04	1.80E-04	2.29E-05
x		**Styrene**	I	1.00E-04	9.73E-05	9.08E-05	1.40E-04	9.86E-05	9.37E-05	1.10E-04	9.02E-05	1.03E-04	1.64E-05
x	z	**1-Methylnaphthalene**	4.49E-05	1.04E-04	8.56E-05	7.22E-05	1.02E-04	7.03E-05	7.98E-05	1.03E-04	8.06E-05	8.25E-05	1.92E-05
x		**Acetaldehyde**	4.54E-05	6.48E-05	5.66E-05	4.76E-05	4.29E-05	I	4.32E-05	5.07E-05	4.39E-05	4.94E-05	7.74E-06
x		**Ethylbenzene**	3.76E-05	4.15E-05	4.03E-05	4.00E-05	5.44E-05	3.89E-05	4.09E-05	4.61E-05	3.92E-05	4.21E-05	5.18E-06
x	z	**1,3-Dimethylnaphthalene**	1.90E-05	4.23E-05	3.08E-05	2.73E-05	3.74E-05	2.50E-05	3.16E-05	4.18E-05	2.97E-05	3.16E-05	7.72E-06
x		**Acrolein**	6.59E-06	1.43E-05	1.11E-05	9.14E-06	8.16E-06	I	8.70E-06	1.13E-05	9.99E-06	9.90E-06	2.34E-06
x		**2-Butanone**	6.48E-06	7.59E-06	7.37E-06	6.55E-06	5.75E-06	I	ND	5.42E-06	ND	4.89E-06	3.11E-06
x		**Propionaldehyde**	ND	5.65E-06	4.92E-06	ND	ND	I	ND	ND	ND	1.32E-06	2.45E-06
x	z	**Acenaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Biphenyl**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Hexane**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan FL Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	**10/06/03**	**10/06/03**	**10/06/03**	**10/07/03**	**10/07/03**	**10/07/03**	**10/08/03**	**10/08/03**	**10/08/03**		
			Other VOCs										
		Dodecane	3.26E-03	7.45E-03	6.57E-03	5.40E-03	8.07E-03	5.62E-03	5.82E-03	I	6.09E-03	6.04E-03	1.45E-03
		1,2,3-Trimethylbenzene	I	2.17E-03	2.10E-03	1.84E-03	2.77E-03	1.99E-03	1.84E-03	2.12E-03	1.98E-03	2.10E-03	2.95E-04
		1,3-Diethylbenzene	I	1.42E-03	1.35E-03	1.30E-03	1.78E-03	1.35E-03	1.35E-03	1.35E-03	1.37E-03	1.41E-03	1.53E-04
		1,2,4-Trimethylbenzene	I	1.20E-03	1.18E-03	1.03E-03	1.53E-03	1.12E-03	1.04E-03	1.23E-03	1.12E-03	1.18E-03	1.57E-04
		Indan	I	8.56E-04	8.20E-04	7.16E-04	1.09E-03	7.68E-04	7.08E-04	8.24E-04	7.62E-04	8.17E-04	1.21E-04
		2,4-Dimethylphenol	1.98E-04	3.31E-04	I	3.94E-04	7.64E-04	5.62E-04	5.25E-04	5.88E-04	5.07E-04	4.84E-04	1.73E-04
		Butyraldehyde/Methacrolein	2.75E-04	4.38E-04	3.69E-04	2.94E-04	2.57E-04	4.59E-04	3.14E-04	3.59E-04	3.34E-04	3.44E-04	6.96E-05
		3-Ethyltoluene	I	8.29E-05	8.04E-05	7.09E-05	1.02E-04	7.74E-05	7.18E-05	8.37E-05	7.39E-05	8.04E-05	9.93E-06
		Indene	I	5.95E-05	1.85E-04	1.08E-04	1.86E-04	1.26E-04	1.23E-04	1.97E-04	1.58E-04	1.43E-04	4.73E-05
		2-Ethyltoluene	I	8.00E-05	7.58E-05	6.51E-05	1.02E-04	7.39E-05	6.52E-05	7.84E-05	6.76E-05	7.60E-05	1.21E-05
		Tetradecane	I	7.53E-05	6.64E-05	5.24E-05	7.20E-05	5.11E-05	5.85E-05	7.52E-05	5.48E-05	6.32E-05	1.02E-05
		Decane	I	4.85E-05	4.72E-05	4.07E-05	6.08E-05	4.37E-05	3.89E-05	4.58E-05	4.30E-05	4.61E-05	6.77E-06
		Benzaldehyde	3.24E-05	5.03E-05	4.07E-05	3.00E-05	2.79E-05	I	3.27E-05	3.72E-05	3.43E-05	3.57E-05	7.10E-06
		o,m,p-Tolualdehyde	3.00E-05	4.50E-05	4.70E-05	2.96E-05	2.48E-05	I	2.97E-05	3.50E-05	3.37E-05	3.43E-05	7.82E-06
		Pentanal	2.85E-05	4.46E-05	3.51E-05	2.83E-05	2.43E-05	I	3.13E-05	3.26E-05	3.51E-05	3.25E-05	6.12E-06
		Hexaldehyde	I	1.87E-05	1.83E-05	1.11E-05	9.05E-06	2.50E-05	1.13E-05	1.44E-05	1.25E-05	1.50E-05	5.28E-06
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	I	ND	NA
		Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Octane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Undecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan FL Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	**10/06/03**	**10/06/03**	**10/06/03**	**10/07/03**	**10/07/03**	**10/07/03**	**10/08/03**	**10/08/03**	**10/08/03**		
		Other Analytes											
		Acetone	4.33E-05	3.93E-05	4.48E-05	3.35E-05	3.32E-05	4.08E-05	4.93E-05	3.04E-05	3.36E-05	3.87E-05	6.41E-06
		Carbon Dioxide	6.20E-01	5.53E-01	5.76E-01	5.52E-01	5.41E-01	5.29E-01	5.63E-01	5.38E-01	5.39E-01	5.57E-01	2.77E-02
		Carbon Monoxide	1.03E-02	ND	ND	ND	ND	ND	ND	ND	ND	1.15E-03	3.45E-03
		Methane	1.29E-03	1.01E-03	1.15E-03	1.05E-03	1.01E-03	9.86E-04	1.02E-03	9.03E-04	9.31E-04	1.04E-03	1.17E-04
		Ethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Propane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Isobutane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Butane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Neopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Isopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Pentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

Test Plan FL Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	**10/06/03**	**10/06/03**	**10/06/03**	**10/07/03**	**10/07/03**	**10/07/03**	**10/08/03**	**10/08/03**	**10/08/03**		
		TGOC as Propane	1.29E+01	1.30E+01	1.30E+01	1.30E+01	1.26E+01	1.29E+01	1.17E+01	1.25E+01	1.25E+01	1.27E+01	4.19E-01
		HC as Hexane	I	4.78E+00	4.12E+00	3.95E+00	3.84E+00	I	3.55E+00	3.87E+00	4.18E+00	4.04E+00	3.85E-01
		Sum of VOCs	I	2.71E+00	2.63E+00	2.40E+00	2.62E+00	2.26E+00	2.39E+00	2.36E+00	2.53E+00	2.49E+00	1.57E-01
		Sum of HAPs	I	1.87E+00	1.85E+00	1.69E+00	1.85E+00	1.50E+00	1.66E+00	1.93E+00	1.76E+00	1.76E+00	1.42E-01
		Sum of POMs	I	4.09E-02	4.18E-02	3.63E-02	3.87E-02	3.64E-02	3.89E-02	4.81E-02	3.96E-02	4.01E-02	3.77E-03
		Individual Organic HAPs											
x		**m,p-Cresol**	I	8.71E-01	8.66E-01	7.72E-01	8.52E-01	8.28E-01	7.60E-01	8.90E-01	8.22E-01	8.33E-01	4.67E-02
x		**Phenol**	I	5.36E-01	5.21E-01	4.76E-01	5.40E-01	4.99E-01	4.57E-01	5.68E-01	4.89E-01	5.11E-01	3.69E-02
x		**Benzene**	I	2.50E-01	2.56E-01	2.45E-01	2.55E-01	I	2.47E-01	2.63E-01	2.47E-01	2.52E-01	6.36E-03
x		**Toluene**	I	5.72E-02	5.76E-02	5.84E-02	5.77E-02	5.37E-02	5.63E-02	6.05E-02	5.86E-02	5.75E-02	1.97E-03
x		**o-Cresol**	I	4.10E-02	3.19E-02	3.15E-02	3.25E-02	2.84E-02	3.17E-02	3.15E-02	3.25E-02	3.26E-02	3.63E-03
x		**m,p-Xylene**	I	3.44E-02	3.49E-02	3.51E-02	3.51E-02	3.29E-02	3.38E-02	3.70E-02	3.55E-02	3.48E-02	1.20E-03
x	z	**Naphthalene**	I	2.51E-02	2.33E-02	2.00E-02	2.20E-02	2.08E-02	2.09E-02	2.55E-02	2.20E-02	2.24E-02	2.01E-03
x		**Formaldehyde**	1.13E-02	1.67E-02	1.48E-02	1.28E-02	1.18E-02	I	1.06E-02	1.39E-02	1.08E-02	1.28E-02	2.15E-03
x	z	**2-Methylnaphthalene**	I	9.93E-03	1.15E-02	1.00E-02	1.04E-02	9.70E-03	1.13E-02	1.38E-02	1.09E-02	1.09E-02	1.33E-03
x		**o-Xylene**	I	1.04E-02	1.06E-02	1.04E-02	1.07E-02	1.02E-02	1.01E-02	1.11E-02	1.06E-02	1.05E-02	3.19E-04
x		**Styrene**	I	5.84E-03	5.90E-03	5.66E-03	6.38E-03	6.13E-03	5.67E-03	6.67E-03	5.51E-03	5.97E-03	3.95E-04
x	z	**1-Methylnaphthalene**	I	4.41E-03	5.19E-03	4.50E-03	4.65E-03	4.37E-03	4.83E-03	6.23E-03	4.93E-03	4.89E-03	6.09E-04
x		**Acetaldehyde**	2.70E-03	3.76E-03	3.43E-03	2.97E-03	2.56E-03	I	2.61E-03	3.07E-03	2.68E-03	2.97E-03	4.31E-04
x		**Ethylbenzene**	I	2.41E-03	2.45E-03	2.49E-03	2.47E-03	2.41E-03	2.47E-03	I	2.40E-03	2.44E-03	3.77E-05
x	z	**1,3-Dimethylnaphthalene**	I	1.55E-03	1.87E-03	1.70E-03	1.70E-03	1.55E-03	1.91E-03	2.53E-03	1.81E-03	1.83E-03	3.14E-04
x		**Acrolein**	3.92E-04	8.29E-04	6.72E-04	5.69E-04	4.87E-04	I	5.27E-04	6.82E-04	6.10E-04	5.96E-04	1.35E-04
x		**2-Butanone**	3.86E-04	4.41E-04	4.47E-04	4.08E-04	3.43E-04	I	ND	3.28E-04	ND	2.94E-04	1.86E-04
x		**Propionaldehyde**	ND	3.28E-04	2.98E-04	ND	ND	I	ND	ND	ND	7.83E-05	1.45E-04
x	z	**1,2-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x	z	**Acenaphthalene**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Biphenyl**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Hexane**	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**Aniline**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

Test Plan FL Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	10/06/03	10/06/03	10/06/03	10/07/03	10/07/03	10/07/03	10/08/03	10/08/03	10/08/03		
		Other VOCs											
		Dodecane	1.94E-01	4.33E-01	3.98E-01	3.37E-01	3.67E-01	3.49E-01	3.52E-01	I	3.72E-01	3.50E-01	7.02E-02
		1,2,3-Trimethylbenzene	I	1.26E-01	1.27E-01	1.15E-01	1.26E-01	1.24E-01	1.11E-01	1.28E-01	1.21E-01	1.22E-01	6.17E-03
		1,3-Diethylbenzene	I	8.23E-02	8.20E-02	8.09E-02	8.09E-02	8.38E-02	8.19E-02	8.17E-02	8.38E-02	8.22E-02	1.13E-03
		1,2,4-Trimethylbenzene	I	6.99E-02	7.18E-02	6.45E-02	6.97E-02	6.99E-02	6.32E-02	7.42E-02	6.82E-02	6.89E-02	3.62E-03
		Indan	I	4.97E-02	4.97E-02	4.46E-02	4.95E-02	4.77E-02	4.29E-02	4.98E-02	4.66E-02	4.76E-02	2.68E-03
		2,4-Dimethylphenol	I	1.93E-02	I	2.45E-02	3.47E-02	3.49E-02	3.18E-02	3.56E-02	3.10E-02	3.03E-02	6.15E-03
		Butyraldehyde/Methacrolien	1.63E-02	2.55E-02	2.23E-02	1.83E-02	1.53E-02	2.85E-02	1.90E-02	2.17E-02	2.04E-02	2.08E-02	4.24E-03
		Indene	I	3.46E-03	1.12E-02	6.71E-03	8.44E-03	7.82E-03	7.44E-03	1.19E-02	9.66E-03	8.34E-03	2.69E-03
		3-Ethyltoluene	I	4.82E-03	4.87E-03	4.42E-03	4.63E-03	4.81E-03	4.35E-03	5.06E-03	4.52E-03	4.69E-03	2.47E-04
		2-Ethyltoluene	I	4.65E-03	4.59E-03	4.05E-03	4.65E-03	4.59E-03	3.94E-03	4.75E-03	4.13E-03	4.42E-03	3.20E-04
		Tetradecane	I	4.38E-03	4.02E-03	3.26E-03	3.28E-03	3.17E-03	3.54E-03	4.55E-03	3.35E-03	3.69E-03	5.45E-04
		Decane	I	2.82E-03	2.86E-03	2.53E-03	2.77E-03	2.71E-03	2.35E-03	2.77E-03	2.63E-03	2.68E-03	1.68E-04
		Benzaldehyde	1.93E-03	2.92E-03	2.46E-03	1.87E-03	1.67E-03	I	1.98E-03	2.25E-03	2.10E-03	2.15E-03	3.96E-04
		o,m,p-Tolualdehyde	1.79E-03	2.62E-03	2.85E-03	1.84E-03	1.48E-03	I	1.79E-03	2.12E-03	2.06E-03	2.07E-03	4.57E-04
		Pentanal	1.70E-03	2.59E-03	2.13E-03	1.76E-03	1.45E-03	I	1.89E-03	1.97E-03	2.14E-03	1.95E-03	3.45E-04
		Hexaldehyde	I	1.09E-03	1.11E-03	6.92E-04	5.40E-04	1.55E-03	6.81E-04	8.70E-04	7.61E-04	9.11E-04	3.25E-04
		1,3,5-Trimethylbenzene	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Cyclohexane	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Heptane	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Nonane	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		n-Propylbenzene	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Octane	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Undecane	I	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	I	ND	NA

Test Plan FL Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FL001	FL002	FL003	FL004	FL005	FL006	FL007	FL008	FL009	Average	STDEV
		Test Dates	**10/06/03**	**10/06/03**	**10/06/03**	**10/07/03**	**10/07/03**	**10/07/03**	**10/08/03**	**10/08/03**	**10/08/03**		
		Other Analytes											
		Acetone	2.58E-03	2.28E-03	2.71E-03	2.09E-03	1.98E-03	2.53E-03	2.99E-03	1.84E-03	2.05E-03	2.34E-03	3.84E-04
		Carbon Dioxide	3.69E+01	3.21E+01	3.49E+01	3.44E+01	3.23E+01	3.29E+01	3.41E+01	3.26E+01	3.29E+01	3.37E+01	1.55E+00
		Carbon Monoxide	6.15E-01	ND	ND	ND	ND	ND	ND	ND	ND	6.83E-02	2.05E-01
		Methane	7.67E-02	5.85E-02	6.95E-02	6.57E-02	6.02E-02	6.13E-02	6.19E-02	5.46E-02	5.69E-02	6.28E-02	6.85E-03
		Ethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Propane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Isobutane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Butane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Neopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Isopentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
		Pentane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

Test Plan FP Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	**11/10/03**	**11/10/03**	**11/10/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/12/03**	**11/12/03**	**11/12/03**		
		TGOC as Propane	1.61E-01	1.74E-01	1.81E-01	1.64E-01	1.58E-01	1.64E-01	I	1.70E-01	1.69E-01	1.68E-01	7.38E-03
		HC as Hexane	5.02E-02	6.00E-02	5.53E-02	4.93E-02	4.96E-02	I	I	I	5.44E-02	5.31E-02	4.21E-03
		Sum of VOCs	3.19E-02	3.42E-02	3.43E-02	3.24E-02	3.19E-02	3.13E-02	I	2.96E-02	2.92E-02	3.19E-02	1.86E-03
		Sum of HAPs	2.56E-02	2.70E-02	2.70E-02	2.56E-02	2.51E-02	2.57E-02	I	2.45E-02	2.29E-02	2.54E-02	1.34E-03
		Sum of POMs	4.35E-04	4.32E-04	4.37E-04	4.16E-04	3.99E-04	5.08E-04	I	2.78E-04	3.52E-04	4.07E-04	6.79E-05
			Individual Organic HAPs										
x		**m,p-Cresol**	9.85E-03	1.04E-02	1.07E-02	9.80E-03	9.50E-03	1.01E-02	I	9.21E-03	8.90E-03	9.81E-03	5.92E-04
x		**Phenol**	8.23E-03	8.72E-03	9.10E-03	8.46E-03	8.36E-03	8.34E-03	I	7.78E-03	7.40E-03	8.30E-03	5.24E-04
x		**Benzene**	4.48E-03	4.52E-03	4.17E-03	4.21E-03	4.03E-03	3.84E-03	I	4.13E-03	3.87E-03	4.16E-03	2.49E-04
x		**Toluene**	8.89E-04	9.11E-04	8.38E-04	8.72E-04	9.50E-04	7.86E-04	I	8.73E-04	8.09E-04	8.66E-04	5.35E-05
x		**o-Cresol**	4.41E-04	6.02E-04	4.57E-04	5.39E-04	5.04E-04	4.03E-04	I	4.54E-04	4.47E-04	4.81E-04	6.40E-05
x		**m,p-Xylene**	4.64E-04	4.85E-04	4.37E-04	4.44E-04	4.94E-04	4.22E-04	I	4.57E-04	4.19E-04	4.53E-04	2.78E-05
x		**Formaldehyde**	2.44E-04	3.27E-04	3.49E-04	2.47E-04	2.93E-04	6.12E-04	I	6.46E-04	2.40E-04	3.70E-04	1.65E-04
x	z	**Naphthalene**	2.46E-04	2.39E-04	2.47E-04	2.40E-04	2.24E-04	2.38E-04	I	2.08E-04	2.08E-04	2.31E-04	1.61E-05
x		**Styrene**	1.71E-04	1.93E-04	1.84E-04	1.69E-04	2.04E-04	1.70E-04	I	1.66E-04	1.59E-04	1.77E-04	1.53E-05
x		**o-Xylene**	1.41E-04	1.41E-04	1.27E-04	1.29E-04	1.42E-04	1.20E-04	I	1.31E-04	1.20E-04	1.31E-04	9.07E-06
x		**Acetaldehyde**	7.76E-05	1.01E-04	1.09E-04	8.19E-05	9.27E-05	1.87E-04	I	I	7.86E-05	1.04E-04	3.83E-05
x	z	**2-Methylnaphthalene**	1.21E-04	9.45E-05	9.82E-05	1.02E-04	9.47E-05	9.48E-05	I	8.86E-05	7.65E-05	9.62E-05	1.26E-05
x		**Propionaldehyde**	5.38E-05	6.46E-05	6.55E-05	5.65E-05	6.13E-05	1.46E-04	I	1.63E-04	5.79E-06	7.70E-05	5.16E-05
x		**Ethylbenzene**	5.86E-05	6.44E-05	5.61E-05	6.37E-05	6.73E-05	5.01E-05	I	5.94E-05	5.06E-05	5.88E-05	6.30E-06
x	z	**1-Methylnaphthalene**	6.32E-05	4.99E-05	4.73E-05	5.45E-05	4.75E-05	5.04E-05	I	4.32E-05	4.03E-05	4.95E-05	7.05E-06
x	z	**1,3-Dimethylnaphthalene**	4.77E-05	4.19E-05	3.36E-05	3.95E-05	3.48E-05	3.23E-05	I	2.72E-05	2.54E-05	3.53E-05	7.46E-06
x		**Acrolein**	9.49E-06	1.58E-05	1.57E-05	1.05E-05	1.19E-05	3.10E-05	I	3.22E-05	9.74E-06	1.71E-05	9.33E-06
x		**Biphenyl**	3.49E-05	1.78E-05	ND	3.49E-05	ND	ND	I	ND	ND	1.10E-05	1.60E-05
x		**Hexane**	1.00E-05	4.54E-06	1.27E-05	8.91E-06	ND	ND	I	6.35E-06	8.40E-06	6.37E-06	4.61E-06
x		**2-Butanone**	7.06E-06	8.41E-06	7.19E-06	6.96E-06	ND	ND	I	ND	ND	3.70E-06	3.98E-06
x	z	**Acenaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Aniline**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Dimethylaniline**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FP Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	**11/10/03**	**11/10/03**	**11/10/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/12/03**	**11/12/03**	**11/12/03**		
			Other VOCs										
		Propylene Carbonate	9.34E-04	1.53E-03	1.51E-03	1.27E-03	1.20E-03	I	I	I	1.05E-03	1.25E-03	2.40E-04
		1,2,3-Trimethylbenzene	1.48E-03	1.58E-03	1.62E-03	1.47E-03	1.46E-03	1.53E-03	I	1.42E-03	1.38E-03	1.49E-03	8.00E-05
		1,3-Diethylbenzene	1.11E-03	1.17E-03	1.19E-03	1.09E-03	1.08E-03	1.13E-03	I	1.06E-03	1.02E-03	1.11E-03	5.71E-05
		1,2,4-Trimethylbenzene	7.94E-04	8.62E-04	8.05E-04	7.48E-04	7.81E-04	7.64E-04	I	7.40E-04	7.03E-04	7.74E-04	4.79E-05
		Indan	5.80E-04	6.25E-04	6.36E-04	5.78E-04	5.63E-04	6.06E-04	I	5.46E-04	5.34E-04	5.83E-04	3.64E-05
		Undecane	4.84E-04	4.99E-04	5.12E-04	4.76E-04	4.78E-04	4.82E-04	I	4.48E-04	4.25E-04	4.76E-04	2.76E-05
		Butyraldehyde/Methacrolein	2.95E-04	3.69E-04	3.64E-04	3.29E-04	3.28E-04	4.53E-04	I	I	3.78E-04	3.60E-04	5.03E-05
		Indene	1.91E-04	1.93E-04	2.40E-04	1.79E-04	1.81E-04	2.55E-04	I	1.61E-04	1.45E-04	1.93E-04	3.74E-05
		2,4-Dimethylphenol*	ND	ND	ND	3.46E-04	3.24E-04	ND	I	3.33E-04	3.44E-04	1.68E-04	1.80E-04
		2,6-Dimethylphenol	1.36E-04	1.32E-04	1.29E-04	1.62E-04	1.27E-04	1.27E-04	I	1.16E-04	1.30E-04	1.32E-04	1.33E-05
		2-Ethyltoluene	6.98E-05	8.03E-05	7.66E-05	I	7.61E-05	6.82E-05	I	6.64E-05	6.68E-05	7.20E-05	5.56E-06
		3-Ethyltoluene	6.75E-05	6.92E-05	6.59E-05	6.69E-05	7.22E-05	6.37E-05	I	6.51E-05	6.28E-05	6.67E-05	3.04E-06
		Tetradecane	5.86E-05	6.39E-05	4.76E-05	5.55E-05	5.56E-05	5.30E-05	I	4.48E-05	4.22E-05	5.26E-05	7.34E-06
		Decane	4.21E-05	4.59E-05	4.60E-05	4.47E-05	4.29E-05	4.57E-05	I	4.19E-05	4.12E-05	4.38E-05	1.97E-06
		Benzaldehyde	2.17E-05	3.02E-05	2.91E-05	2.13E-05	3.12E-05	5.09E-05	I	5.48E-05	2.59E-05	3.31E-05	1.27E-05
		o,m,p-Tolualdehyde	1.52E-05	2.01E-05	1.85E-05	1.33E-05	2.84E-05	3.73E-05	I	4.31E-05	2.26E-05	2.48E-05	1.07E-05
		Pentanal	5.65E-06	6.85E-06	6.72E-06	4.97E-06	5.52E-06	8.47E-06	I	I	4.55E-06	6.11E-06	1.34E-06
		Hexaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Cyclohexane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Dodecane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Heptane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Nonane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Octane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Propylbenzene	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FP Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	Compound/Sample Number	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	**11/10/03**	**11/10/03**	**11/10/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/12/03**	**11/12/03**	**11/12/03**		
			Other Analytes										
		Acetone	7.19E-05	3.93E-05	6.82E-05	7.01E-05	7.01E-05	I	I	7.26E-05	6.24E-05	6.49E-05	1.18E-05
		Carbon Dioxide	6.80E-01	5.45E-01	5.60E-01	6.46E-01	6.27E-01	5.72E-01	I	5.34E-01	I	5.95E-01	5.59E-02
		Carbon Monoxide	ND	ND	ND	ND	ND	9.31E-03	I	ND	I	1.33E-03	3.52E-03
		Methane	1.31E-03	9.15E-04	1.04E-03	1.25E-03	8.93E-04	1.02E-03	I	9.71E-04	I	1.06E-03	1.62E-04
		Ethane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Propane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Isobutane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Butane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Neopentane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Isopentane	ND	ND	ND	ND	ND	ND	I	ND	I	ND	NA
		Pentane	ND	ND	ND	ND	ND	ND	I	ND	I	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 HAPs or VOCs.

*** 2,4-Dimethylphenol was detected inconsistently due to interferences**

Test Plan FP Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	**11/10/03**	**11/10/03**	**11/10/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/12/03**	**11/12/03**	**11/12/03**		
		TGOC as Propane	9.58E+00	1.04E+01	1.08E+01	9.86E+00	9.33E+00	9.85E+00	I	1.02E+01	1.03E+01	1.00E+01	4.92E-01
		HC as Hexane	2.98E+00	3.40E+00	3.29E+00	2.96E+00	2.91E+00	I	I	I	3.33E+00	3.15E+00	2.18E-01
		Sum of VOCs	1.84E+00	1.95E+00	1.95E+00	1.87E+00	1.81E+00	1.88E+00	I	1.79E+00	1.73E+00	1.85E+00	7.77E-02
		Sum of HAPs	1.52E+00	1.61E+00	1.61E+00	1.53E+00	1.48E+00	1.54E+00	I	1.48E+00	1.40E+00	1.52E+00	6.95E-02
		Sum of POMs	2.84E-02	2.53E-02	2.54E-02	2.61E-02	2.36E-02	2.49E-02	I	2.22E-02	2.14E-02	2.47E-02	2.24E-03
			Individual Organic HAPs										
x		**m,p-Cresol**	5.85E-01	6.18E-01	6.35E-01	5.87E-01	5.58E-01	6.07E-01	I	5.57E-01	5.45E-01	5.87E-01	3.21E-02
x		**Phenol**	4.89E-01	5.19E-01	5.42E-01	5.07E-01	4.91E-01	4.99E-01	I	4.71E-01	4.53E-01	4.96E-01	2.76E-02
x		**Benzene**	2.66E-01	2.69E-01	2.49E-01	2.52E-01	2.37E-01	2.30E-01	I	2.50E-01	2.37E-01	2.49E-01	1.39E-02
x		**Toluene**	5.28E-02	5.48E-02	4.99E-02	5.23E-02	5.58E-02	4.71E-02	I	5.29E-02	4.95E-02	5.19E-02	2.89E-03
x		**o-Cresol**	2.62E-02	3.58E-02	2.72E-02	3.23E-02	2.96E-02	2.41E-02	I	2.75E-02	2.73E-02	2.88E-02	3.73E-03
x		**m,p-Xylene**	2.76E-02	2.89E-02	2.60E-02	2.66E-02	2.91E-02	2.52E-02	I	2.77E-02	2.56E-02	2.71E-02	1.45E-03
x		**Formaldehyde**	1.45E-02	1.94E-02	2.08E-02	1.48E-02	1.72E-02	3.66E-02	I	3.91E-02	1.47E-02	2.21E-02	9.98E-03
x	z	**Naphthalene**	1.46E-02	1.42E-02	1.47E-02	1.44E-02	1.32E-02	1.43E-02	I	1.26E-02	1.27E-02	1.38E-02	8.75E-04
x		**Styrene**	1.02E-02	1.15E-02	1.09E-02	1.01E-02	1.20E-02	1.02E-02	I	1.00E-02	9.73E-03	1.06E-02	8.05E-04
x		**o-Xylene**	8.37E-03	8.39E-03	7.58E-03	7.75E-03	8.34E-03	7.17E-03	I	7.94E-03	7.34E-03	7.86E-03	4.79E-04
x		**Acetaldehyde**	4.61E-03	6.02E-03	6.51E-03	4.91E-03	5.45E-03	1.12E-02	I	I	4.81E-03	6.21E-03	2.29E-03
x	z	**2-Methylnaphthalene**	7.20E-03	5.63E-03	5.85E-03	6.09E-03	5.56E-03	5.68E-03	I	5.36E-03	4.68E-03	5.76E-03	7.13E-04
x		**Propionaldehyde**	3.20E-03	3.84E-03	3.90E-03	3.38E-03	3.61E-03	8.73E-03	I	9.84E-03	3.54E-04	4.61E-03	3.12E-03
x		**Ethylbenzene**	3.48E-03	3.83E-03	3.34E-03	3.82E-03	3.96E-03	3.00E-03	I	3.59E-03	3.10E-03	3.52E-03	3.52E-04
x	z	**1-Methylnaphthalene**	3.76E-03	2.97E-03	2.82E-03	3.27E-03	2.79E-03	3.02E-03	I	2.61E-03	2.47E-03	2.96E-03	4.04E-04
x	z	**1,3-Dimethylnaphthalene**	2.84E-03	2.49E-03	2.00E-03	2.37E-03	2.05E-03	1.94E-03	I	1.65E-03	1.56E-03	2.11E-03	4.32E-04
x		**Acrolein**	5.64E-04	9.40E-04	9.36E-04	6.29E-04	7.01E-04	1.86E-03	I	1.95E-03	5.96E-04	1.02E-03	5.63E-04
x		**Biphenyl**	2.07E-03	1.06E-03	ND	2.09E-03	ND	ND	I	ND	ND	6.53E-04	9.56E-04
x		**Hexane**	5.95E-04	2.70E-04	7.58E-04	5.34E-04	ND	ND	I	3.84E-04	5.14E-04	3.82E-04	2.76E-04
x		**2-Butanone**	4.19E-04	5.00E-04	4.29E-04	4.17E-04	ND	ND	I	ND	ND	2.21E-04	2.37E-04
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**Acenaphthalene**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Aniline**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FP Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	11/10/03	11/10/03	11/10/03	11/11/03	11/11/03	11/11/03	11/12/03	11/12/03	11/12/03		
			Other VOCs										
		1,2,3-Trimethylbenzene	8.78E-02	9.43E-02	9.64E-02	8.83E-02	8.57E-02	9.15E-02	I	8.59E-02	8.45E-02	8.93E-02	4.32E-03
		1,3-Diethylbenzene	6.57E-02	6.95E-02	7.09E-02	6.54E-02	6.35E-02	6.78E-02	I	6.42E-02	6.21E-02	6.61E-02	3.04E-03
		1,2,4-Trimethylbenzene	4.71E-02	5.13E-02	4.80E-02	4.48E-02	4.59E-02	4.57E-02	I	4.48E-02	4.30E-02	4.63E-02	2.52E-03
		Indan	3.44E-02	3.72E-02	3.79E-02	3.46E-02	3.31E-02	3.63E-02	I	3.31E-02	3.27E-02	3.49E-02	2.00E-03
		Undecane	2.88E-02	2.97E-02	3.05E-02	2.86E-02	2.81E-02	2.89E-02	I	2.71E-02	2.60E-02	2.84E-02	1.42E-03
		Butyraldehyde/Methacrolien	1.76E-02	2.20E-02	2.17E-02	1.97E-02	1.93E-02	2.71E-02	I	I	2.32E-02	2.15E-02	3.11E-03
		Indene	1.14E-02	1.15E-02	1.43E-02	1.07E-02	1.07E-02	1.53E-02	I	9.72E-03	8.85E-03	1.15E-02	2.19E-03
		2,4-Dimethylphenol*	ND	ND	ND	2.07E-02	1.90E-02	ND	I	2.02E-02	2.10E-02	1.01E-02	1.08E-02
		2,6-Dimethylphenol	8.10E-03	7.88E-03	7.71E-03	9.71E-03	7.46E-03	7.57E-03	I	7.03E-03	7.95E-03	7.93E-03	7.92E-04
		2-Ethyltoluene	4.15E-03	4.78E-03	4.57E-03	I	4.47E-03	4.08E-03	I	4.02E-03	4.09E-03	4.31E-03	2.97E-04
		3-Ethyltoluene	4.01E-03	4.12E-03	3.92E-03	4.01E-03	4.25E-03	3.82E-03	I	3.94E-03	3.84E-03	3.99E-03	1.42E-04
		Tetradecane	3.48E-03	3.03E-03	2.84E-03	3.33E-03	3.27E-03	3.17E-03	I	2.71E-03	2.58E-03	3.05E-03	3.18E-04
		Decane	2.50E-03	2.73E-03	2.74E-03	2.68E-03	2.52E-03	2.73E-03	I	2.54E-03	2.52E-03	2.62E-03	1.09E-04
		Benzaldehyde	1.29E-03	1.80E-03	1.73E-03	1.28E-03	1.84E-03	3.05E-03	I	3.31E-03	1.59E-03	1.99E-03	7.71E-04
		o,m,p-Tolualdehyde	9.01E-04	1.20E-03	1.10E-03	7.96E-04	1.67E-03	2.23E-03	I	2.61E-03	1.38E-03	1.49E-03	6.45E-04
		Pentanal	3.36E-04	4.08E-04	4.01E-04	2.98E-04	3.25E-04	5.07E-04	I	I	2.79E-04	3.65E-04	7.93E-05
		Propylene Carbonate	5.55E-02	9.32E-02	8.83E-02	7.58E-02	7.03E-02	I	I	I	6.42E-02	7.46E-02	1.43E-02
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Cyclohexane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Dodecane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Heptane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Nonane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		n-Propylbenzene	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Octane	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Hexaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FP Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FP001	FP002	FP003	FP004	FP005	FP006	FP007	FP008	FP009	Average	STDEV
		Test Dates	**11/10/03**	**11/10/03**	**11/10/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/12/03**	**11/12/03**	**11/12/03**		
			Other Analytes										
		Acetone	4.27E-03	3.97E-03	4.06E-03	4.20E-03	4.12E-03	I	I	4.39E-03	3.82E-03	4.12E-03	1.91E-04
		Carbon Dioxide	4.04E+01	3.24E+01	3.33E+01	3.87E+01	3.69E+01	3.42E+01	I	3.23E+01	NA	3.55E+01	3.20E+00
		Carbon Monoxide	ND	ND	ND	ND	ND	5.57E-01	I	ND	NA	7.96E-02	2.11E-01
		Methane	1.04E-03	7.26E-04	8.28E-04	9.98E-04	7.00E-04	8.10E-04	I	7.84E-04	NA	8.41E-04	1.30E-04
		Ethane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Propane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Isobutane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Butane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Neopentane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Isopentane	ND	ND	ND	ND	ND	ND	I	ND	NA	ND	NA
		Pentane	ND	ND	ND	ND	ND	ND	I	ND	NA	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 HAPs or VOCs.
*** 2,4-Dimethylphenol was detected inconsistently due to interferences**

Test Plan FL Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	6.77E-06
1,2,4-Trimethylbenzene	6.77E-06
1,3,5-Trimethylbenzene	6.77E-06
1,3-Dimethylnaphthalene	6.77E-06
1-Methylnaphthalene	6.77E-06
2-Ethyltoluene	6.77E-06
2-Methylnaphthalene	6.77E-06
Benzene	6.77E-06
Ethylbenzene	6.77E-06
Hexane	6.77E-06
m,p-Xylene	6.77E-06
Naphthalene	6.77E-06
o-Xylene	6.77E-06
Styrene	6.77E-06
Toluene	6.77E-06
Undecane	6.77E-06
1,2-Dimethylnaphthalene	3.39E-05
1,3-Diethylbenzene	3.39E-05
1,5-Dimethylnaphthalene	3.39E-05
1,6-Dimethylnaphthalene	3.39E-05
1,8-Dimethylnaphthalene	3.39E-05
2,3,5-Trimethylnaphthalene	3.39E-05
2,3-Dimethylnaphthalene	3.39E-05
2,4-Dimethylphenol	3.39E-05
2,6-Dimethylnaphthalene	3.39E-05
2,6-Dimethylphenol	3.39E-05
2,7- Dimethylnaphthalene	3.39E-05
3-Ethyltoluene	3.39E-05
Acenaphthalene	3.39E-05

Analytes	Lb/Lb Binder
Biphenyl	3.39E-05
Cyclohexane	3.39E-05
Decane	3.39E-05
Dodecane	3.39E-05
Heptane	3.39E-05
Indan	3.39E-05
Indene	3.39E-05
m,p-Cresol	3.39E-05
Nonane	3.39E-05
o-Cresol	3.39E-05
Octane	3.39E-05
Phenol	3.39E-05
Propylbenzene	3.39E-05
Tetradecane	3.39E-05
2-Butanone (MEK)	4.80E-06
Acetaldehyde	4.80E-06
Acetone	4.80E-06
Acrolein	4.80E-06
Benzaldehyde	4.80E-06
Butyraldehyde	4.80E-06
Crotonaldehyde	4.80E-06
Formaldehyde	4.80E-06
Hexaldehyde	4.80E-06
Butyraldehyde/Methacrolein	8.00E-06
o,m,p-Tolualdehyde	1.28E-05
Pentanal (Valeraldehyde)	4.80E-06
Propionaldehyde (Propanal)	4.80E-06
HC as Hexane	4.49E-04

Analytes	Lb/Lb Binder
Carbon Monoxide	8.87E-03
Methane	5.07E-04
Carbon Dioxide	1.39E-02
Ethane	9.50E-03
Propane	1.39E-02
Isobutane	1.84E-02
Butane	1.84E-02
Neopentane	2.28E-02
Isopentane	2.28E-02
Pentane	2.28E-02

Test Plan FL Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	4.10E-04
1,2,4-Trimethylbenzene	4.10E-04
1,3,5-Trimethylbenzene	4.10E-04
1,3-Dimethylnaphthalene	4.10E-04
1-Methylnaphthalene	4.10E-04
2-Ethyltoluene	4.10E-04
2-Methylnaphthalene	4.10E-04
Benzene	4.10E-04
Ethylbenzene	4.10E-04
Hexane	4.10E-04
m,p-Xylene	4.10E-04
Naphthalene	4.10E-04
o-Xylene	4.10E-04
Styrene	4.10E-04
Toluene	4.10E-04
Undecane	4.10E-04
1,2-Dimethylnaphthalene	2.05E-03
1,3-Diethylbenzene	2.05E-03
1,5-Dimethylnaphthalene	2.05E-03
1,6-Dimethylnaphthalene	2.05E-03
1,8-Dimethylnaphthalene	2.05E-03
2,3,5-Trimethylnaphthalene	2.05E-03
2,3-Dimethylnaphthalene	2.05E-03
2,4-Dimethylphenol	2.05E-03
2,6-Dimethylnaphthalene	2.05E-03
2,6-Dimethylphenol	2.05E-03
2,7- Dimethylnaphthalene	2.05E-03
3-Ethyltoluene	2.05E-03
Acenaphthalene	2.05E-03

Analytes	Lb/Tn Metal
Biphenyl	2.05E-03
Cyclohexane	2.05E-03
Decane	2.05E-03
Dodecane	2.05E-03
Heptane	2.05E-03
Indan	2.05E-03
Indene	2.05E-03
m,p-Cresol	2.05E-03
Nonane	2.05E-03
o-Cresol	2.05E-03
Octane	2.05E-03
Phenol	2.05E-03
Propylbenzene	2.05E-03
Tetradecane	2.05E-03
Acetaldehyde	2.91E-04
2-Butanone (MEK)	2.91E-04
Acetone	2.91E-04
Acrolein	2.91E-04
Benzaldehyde	2.91E-04
Butyraldehyde	2.91E-04
Crotonaldehyde	2.91E-04
Formaldehyde	2.91E-04
Hexaldehyde	2.91E-04
Butyraldehyde/Methacrolein	4.84E-04
o,m,p-Tolualdehyde	7.75E-04
Pentanal (Valeraldehyde)	2.91E-04
Propionaldehyde (Propanal)	2.91E-04
HC as Hexane	2.72E-02

Analytes	Lb/Tn Metal
Carbon Monoxide	5.37E-01
Methane	3.07E-02
Carbon Dioxide	8.44E-01
Ethane	5.76E-01
Propane	8.44E-01
Isobutane	1.11E+00
Butane	1.11E+00
Neopentane	1.38E+00
Isopentane	1.38E+00
Pentane	1.38E+00

Test Plan FP Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	6.48E-06
1,2,4-Trimethylbenzene	6.48E-06
1,3,5-Trimethylbenzene	6.48E-06
1,3-Dimethylnaphthalene	6.48E-06
1-Methylnaphthalene	6.48E-06
2-Ethyltoluene	6.48E-06
2-Methylnaphthalene	6.48E-06
Benzene	6.48E-06
Ethylbenzene	6.48E-06
Hexane	6.48E-06
m,p-Xylene	6.48E-06
Naphthalene	6.48E-06
o-Xylene	6.48E-06
Styrene	6.48E-06
Toluene	6.48E-06
Undecane	6.48E-06
1,2-Dimethylnaphthalene	3.24E-05
1,3-Diethylbenzene	3.24E-05
1,5-Dimethylnaphthalene	3.24E-05
1,6-Dimethylnaphthalene	3.24E-05
1,8-Dimethylnaphthalene	3.24E-05
2,3,5-Trimethylnaphthalene	3.24E-05
2,3-Dimethylnaphthalene	3.24E-05
2,4-Dimethylphenol	3.24E-05
2,6-Dimethylnaphthalene	3.24E-05
2,6-Dimethylphenol	3.24E-05
2,7- Dimethylnaphthalene	3.24E-05
3-Ethyltoluene	3.24E-05
Acenaphthalene	3.24E-05

Analytes	Lb/Lb Binder
Biphenyl	3.24E-05
Cyclohexane	3.24E-05
Decane	3.24E-05
Dodecane	3.24E-05
Heptane	3.24E-05
Indan	3.24E-05
Indene	3.24E-05
m,p-Cresol	3.24E-05
Nonane	3.24E-05
o-Cresol	3.24E-05
Octane	3.24E-05
Phenol	3.24E-05
Propylbenzene	3.24E-05
Tetradecane	3.24E-05
HC as Hexane	4.40E-04
2-Butanone (MEK)	4.69E-06
Acetaldehyde	4.69E-06
Acetone	4.69E-06
Acrolein	4.69E-06
Benzaldehyde	4.69E-06
Butyraldehyde	4.69E-06
Crotonaldehyde	4.69E-06
Formaldehyde	4.69E-06
Hexaldehyde	4.69E-06
Butyraldehyde/Methacrolein	7.81E-06
o,m,p-Tolualdehyde	1.25E-05
Pentanal (Valeraldehyde)	4.69E-06
Propionaldehyde (Propanal)	4.69E-06

Analytes	Lb/Lb Binder
Carbon Monoxide	4.16E-03
Methane	2.38E-04
Carbon Dioxide	6.54E-03
Ethane	4.46E-03
Propane	6.54E-03
Isobutane	8.62E-03
Butane	8.62E-03
Neopentane	1.07E-02
Isopentane	1.07E-02
Pentane	1.07E-02

Test Plan FL Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	3.97E-04
1,2,4-Trimethylbenzene	3.97E-04
1,3,5-Trimethylbenzene	3.97E-04
1,3-Dimethylnaphthalene	3.97E-04
1-Methylnaphthalene	3.97E-04
2-Ethyltoluene	3.97E-04
2-Methylnaphthalene	3.97E-04
Benzene	3.97E-04
Ethylbenzene	3.97E-04
Hexane	3.97E-04
m,p-Xylene	3.97E-04
Naphthalene	3.97E-04
o-Xylene	3.97E-04
Styrene	3.97E-04
Toluene	3.97E-04
Undecane	3.97E-04
1,2-Dimethylnaphthalene	1.98E-03
1,3-Diethylbenzene	1.98E-03
1,5-Dimethylnaphthalene	1.98E-03
1,6-Dimethylnaphthalene	1.98E-03
1,8-Dimethylnaphthalene	1.98E-03
2,3,5-Trimethylnaphthalene	1.98E-03
2,3-Dimethylnaphthalene	1.98E-03
2,4-Dimethylphenol	1.98E-03
2,6-Dimethylnaphthalene	1.98E-03
2,6-Dimethylphenol	1.98E-03
2,7- Dimethylnaphthalene	1.98E-03
3-Ethyltoluene	1.98E-03
Acenaphthalene	1.98E-03

Analytes	Lb/Tn Metal
Biphenyl	1.98E-03
Cyclohexane	1.98E-03
Decane	1.98E-03
Dodecane	1.98E-03
Heptane	1.98E-03
Indan	1.98E-03
Indene	1.98E-03
m,p-Cresol	1.98E-03
Nonane	1.98E-03
o-Cresol	1.98E-03
Octane	1.98E-03
Phenol	1.98E-03
Propylbenzene	1.98E-03
Tetradecane	1.98E-03
HC as Hexane	2.69E-02
2-Butanone (MEK)	2.87E-04
Acetaldehyde	2.87E-04
Acetone	2.87E-04
Acrolein	2.87E-04
Benzaldehyde	2.87E-04
Butyraldehyde	2.87E-04
Crotonaldehyde	2.87E-04
Formaldehyde	2.87E-04
Hexaldehyde	2.87E-04
Butyraldehyde/Methacrolein	4.78E-04
o,m,p-Tolualdehyde	7.65E-04
Pentanal (Valeraldehyde)	2.87E-04
Propionaldehyde (Propanal)	2.87E-04

Analytes	Lb/Tn Metal
Carbon Monoxide	5.29E-01
Methane	3.03E-02
Carbon Dioxide	8.32E-01
Ethane	5.67E-01
Propane	8.32E-01
Isobutane	1.10E+00
Butane	1.10E+00
Neopentane	1.36E+00
Isopentane	1.36E+00
Pentane	1.36E+00

APPENDIX C DETAILED PROCESS DATA

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Test Series FL Detailed Process Data

No-Bake Mix/Make/Cure										
Test Dates	**10/6/2003**	**10/6/2003**	**10/6/2003**	**10/7/2003**	**10/7/2003**	**10/7/2003**	**10/8/2003**	**10/8/2003**	**10/8/2003**	**Average**
Emissions Sample # / Production Sample #	**FL 001**	**FL 002**	**FL 003**	**FL 004**	**FL 005**	**FL 006**	**FL 007**	**FL 008**	**FL 009**	
Sand Dispensing Rate, lbs/15 sec	30	30	30	30	30	30	30	30	30	**30**
Binder Part1 + Part3 Dispensing Rate, gms/15 sec	83.8	83.8	83.8	85.7	85.7	85.7	85.3	85.3	85.3	**84.9**
Binder Part 2 Dispensing Rate, gms/15 sec	61.6	61.6	61.6	64.7	64.7	64.7	64.1	64.1	64.1	**63.5**
Calculated Standard % Binder	1.06	1.06	1.06	1.09	1.09	1.09	1.09	1.09	1.09	**1.08**
Calculated % Binder (BOS)	1.07	1.07	1.07	1.10	1.10	1.10	1.10	1.10	1.10	**1.09**
Mold Weight, lbs	330.5	328.0	336.5	334.0	328.0	329.0	328.0	331.0	335.0	**331.1**
Calculated Total Binder Weight, lbs	3.49	3.46	3.55	3.65	3.58	3.59	3.56	3.59	3.63	**3.57**
1800F LOI, % (Note 1)	1.04	1.13	1.11	1.02	0.96	1.26	1.02	1.27	1.09	**1.10**
Sand Temperature, deg F	80	80	80	82	83	81	86	81	84	**82**
Dogbone Core 2 hr. Tensile Strength, psi	47	50	55	47	36	38	24	34	51	**42**

No-Bake PCS										
Test Dates	**10/7/2003**	**10/7/2003**	**10/7/2003**	**10/8/2003**	**10/8/2003**	**10/8/2003**	**10/9/2003**	**10/9/2003**	**10/9/2003**	**Average**
Emissions Sample # / Production Sample #	**FL 001**	**FL 002**	**FL 003**	**FL 004**	**FL 005**	**FL 006**	**FL 007**	**FL 008**	**FL 009**	
Pouring Temp, deg F	2624	2629	2628	2640	2630	2637	2636	2628	2635	**2632**
Pouring Time, sec.	34	32	34	35	35	35	30	32	31	**33**
Cast Weight (all metal inside mold), Lbs.	117.30	119.05	117.15	117.15	119.95	115.55	117.65	118.65	118.80	**117.92**
Process Air Temperature in Hood, deg F (Note 2)	86	88	90	86	85	89	85	86	86	**87**
Mold Temperature when placed in hood, deg F	79	79	77	80	80	78	81	80	77	**79**
Ambient Temperature, deg F	73	76	79	73	75	79	69	72	76	**75**
Mold Age When Poured, hr	22.8	24.2	24.5	22.4	23.6	23.7	23.5	24.8	24.6	**23.8**
Test Length, Min	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	**75.0**
Rank order cavity 'A'	8	1	2	5	6	7	9	3	4	

Note 1: 1800F LOI is the net sample weight difference when combusted at 1800F for 2 hours and includes decomposition of carbonates that originate in the source sand.

Note 2: Process air in the hood is ambient air infiltrated under the hood and controlled heated air from an oven blended at the base of the hood and measured at the level of the mold.

Test Series FP Detailed Process Data

No-Bake Mix/Make/Cure										
Test Dates	11/10/2003	11/10/2003	11/10/2003	11/11/2003	11/11/2003	11/11/2003	11/12/2003	11/12/2003	11/12/2003	Average
Emissions Sample # / Production Sample #	FP 001	FP 002	FP 003	FP 004	FP 005	FP 006	FP 007	FP 008	FP 009	
Sand Dispensing Rate, lbs/15 sec	30	30	30	30	30	30	30	30	30	**30**
Binder Part1 + Part3 Dispensing Rate, gms/15 sec	84.2	84.2	84.2	84.6	84.6	84.6	84.6	84.6	84.6	**84.5**
Binder Part 2 Dispensing Rate, gms/15 sec	65.2	65.2	65.2	65.3	65.3	65.3	65.3	65.3	65.3	**65.3**
Calculated Standard % Binder	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	**1.09**
Calculated % Binder (BOS)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	**1.10**
Mold Weight, lbs	329.0	327.5	328.0	328.5	326.5	327.0	329.5	331.0	335.5	**329**
Calculated Total Binder Weight, lbs	3.57	3.55	3.56	3.58	3.55	3.56	3.59	3.60	3.65	**3.58**
1800F LOI, % (Note 1)	0.96	1.02	0.95	0.99	1.27	1.14	1.02	1.05	1.06	**1.06**
Sand Temperature, deg F	82	81	80	81	82	80	82	81	79	**81**
Dogbone Core 2 hr. Tensile Strength, psi	62	87	94	99	103	77	97	93	97	**89**

No-Bake PCS										
Test Dates	11/11/2003	11/11/2003	11/11/2003	11/12/2003	11/12/2003	11/12/2003	11/13/2003	11/13/2003	11/13/2003	Average
Emissions Sample # / Production Sample #	FP 001	FP 002	FP 003	FP 004	FP 005	FP 006	FP 007	FP 008	FP 009	
Pouring Temp, deg F	2639	2620	2639	2633	2637	2632	2638	2632	2635	**2633**
Pouring Time, sec.	43	39	38	38	31	30	32	34	40	**37**
Cast Weight (all metal inside mold), Lbs.	120.20	119.25	119.50	119.45	120.80	118.95	100.90	119.00	119.25	**119.6**
Process Air Temperature in Hood, deg F (Note 2)	86	89	87	88	85	86	86	87	87	**87**
Mold Temperature when placed in hood, deg F	76	72	70	76	72	71	78	----	72	**73**
Ambient Temperature, deg F	63	65	68	63	66	70	65	66	69	**66**
Mold Age When Poured, hr	20.7	21.3	22.7	23.0	24.0	23.0	21.7	21.5	23.5	**22**
Test Length, Min	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	**75.0**
Rank order cavity 'A'	9	8	7	4	6	3	2	1	5	
Rank relative to baseline FL			FL's Worst	FL's Best						

Note 1: 1800F LOI is the net sample weight difference when combusted at 1800F for 2 hours and includes decomposition of carbonates that originate in the source sand.

Note 2: Process air in the hood is ambient air infiltrated under the hood and controlled heated air from an oven blended at the base of the hood and measured at the level of the mold.

Note 3 Run FP007 invalidated because of excessive cast metal weight difference due to a parting line runout

APPENDIX D METHOD 25A CHARTS

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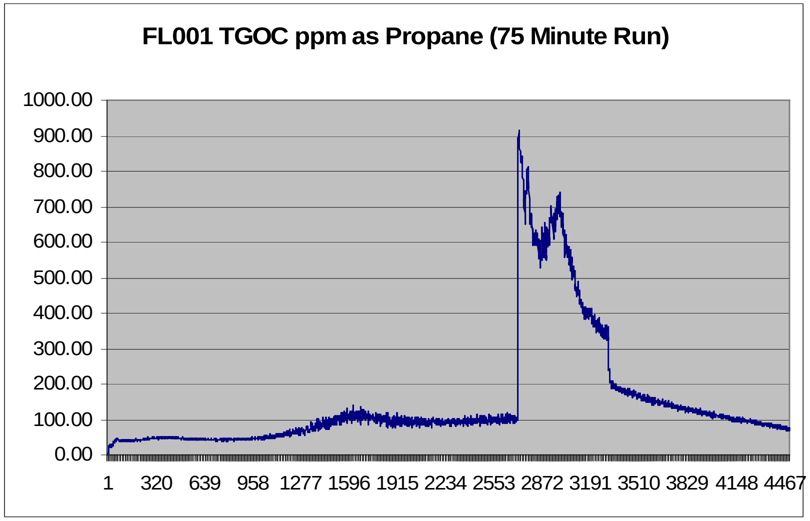
FL001 TGOC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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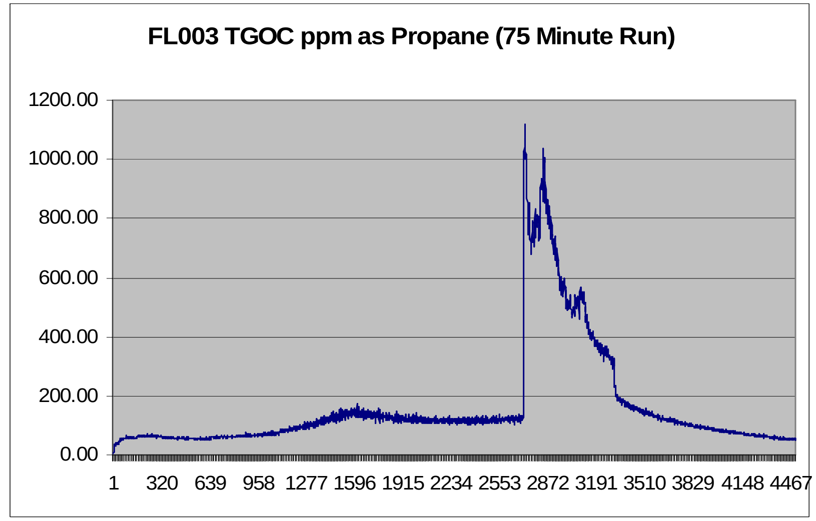
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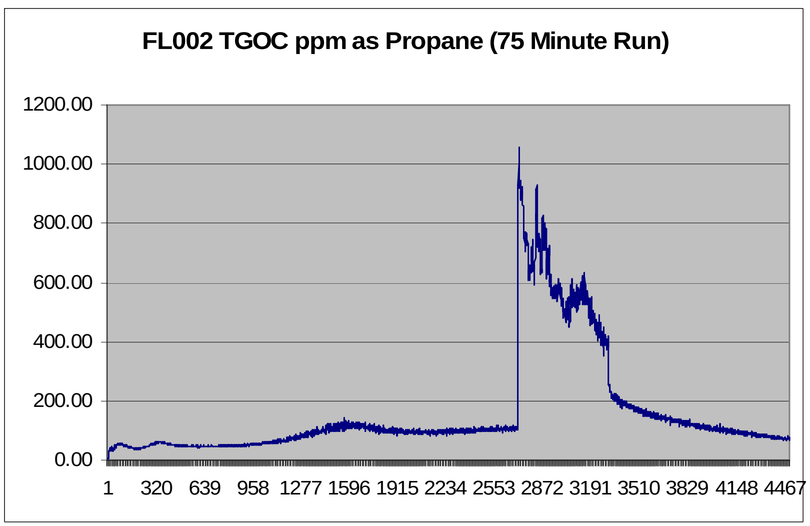
FL002 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
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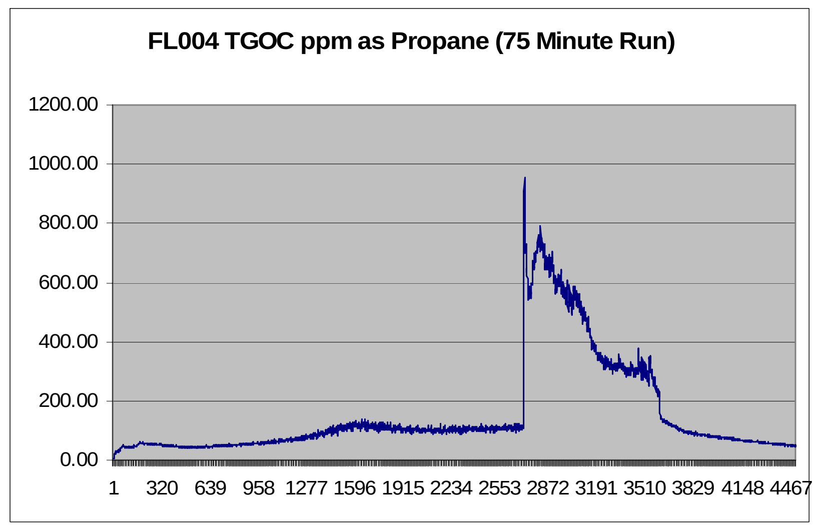
FL004 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
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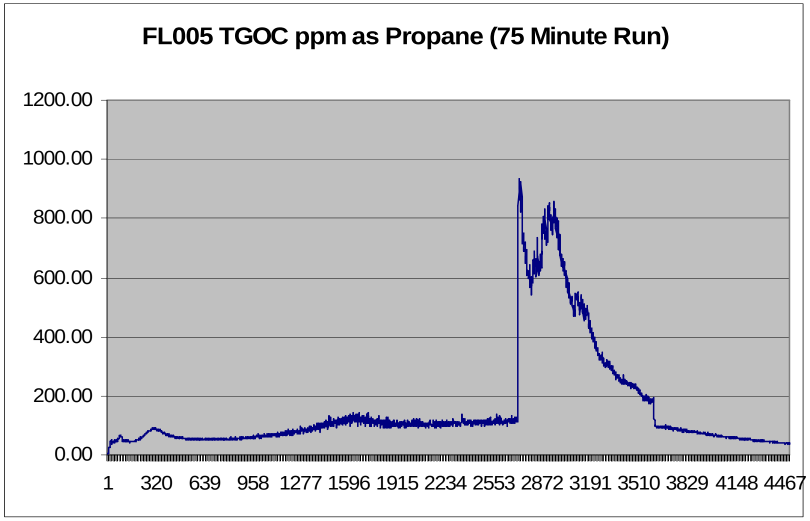
FL005 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
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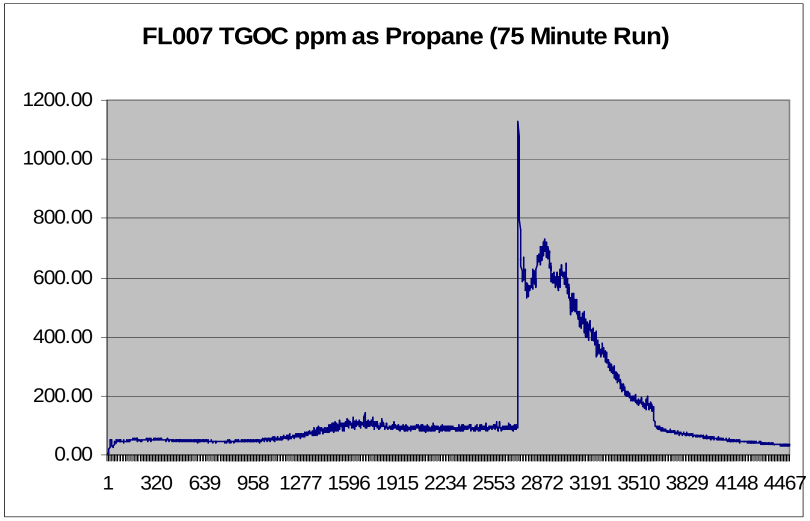
FL007 TGOC ppm as Propane (75 Minute Run)
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800.00
600.00
400.00
200.00
0.00
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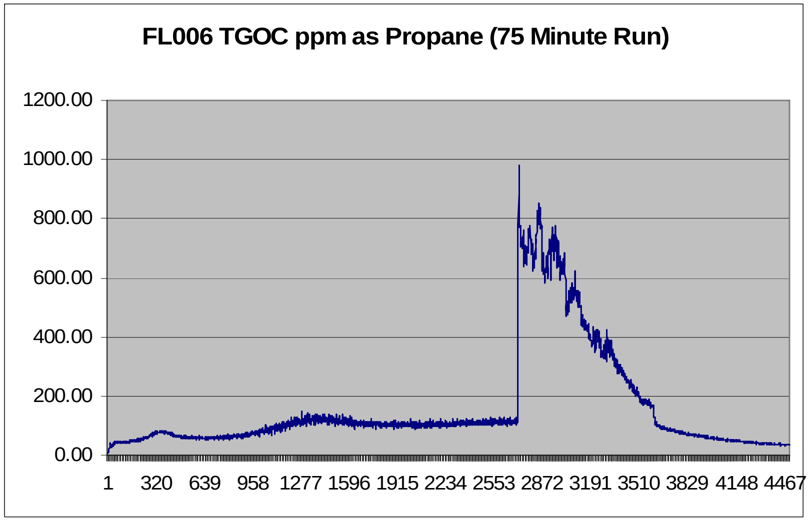
FL006 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
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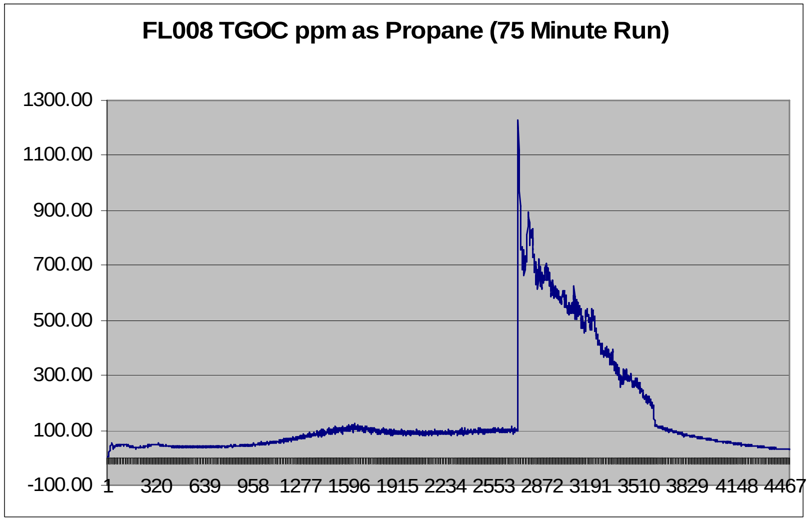
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1300.00
1100.00
900.00
700.00
500.00
300.00
100.00
-100.00
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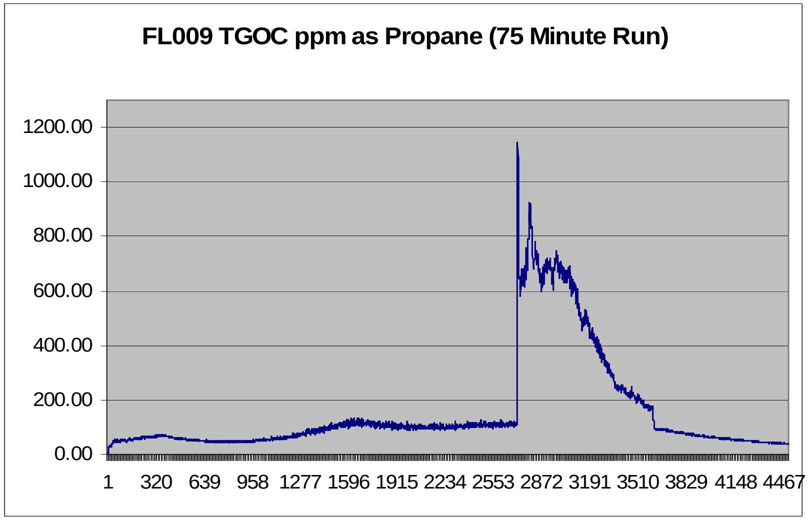
FL009 TGOC ppm as Propane (75 Minute Run)
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600.00
400.00
200.00
0.00
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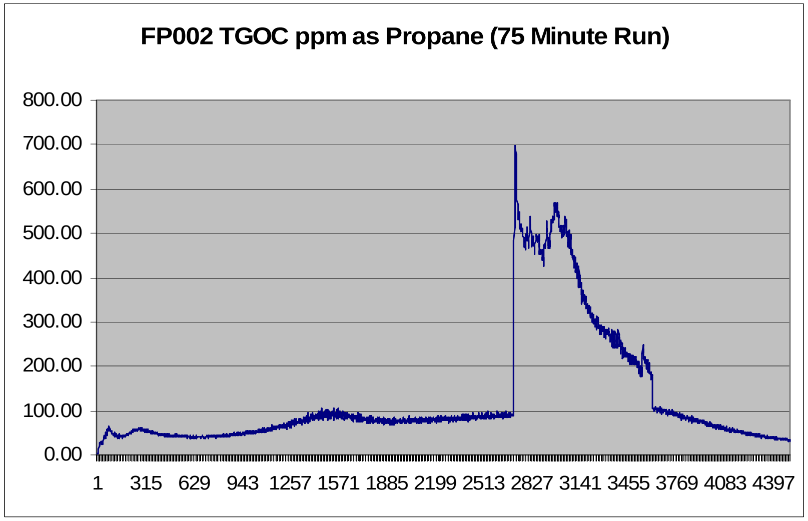
FP002 TGOC ppm as Propane (75 Minute Run)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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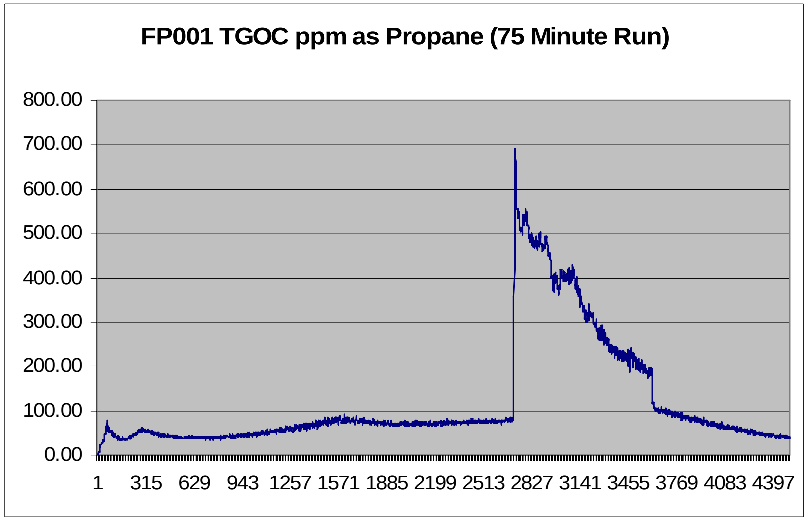
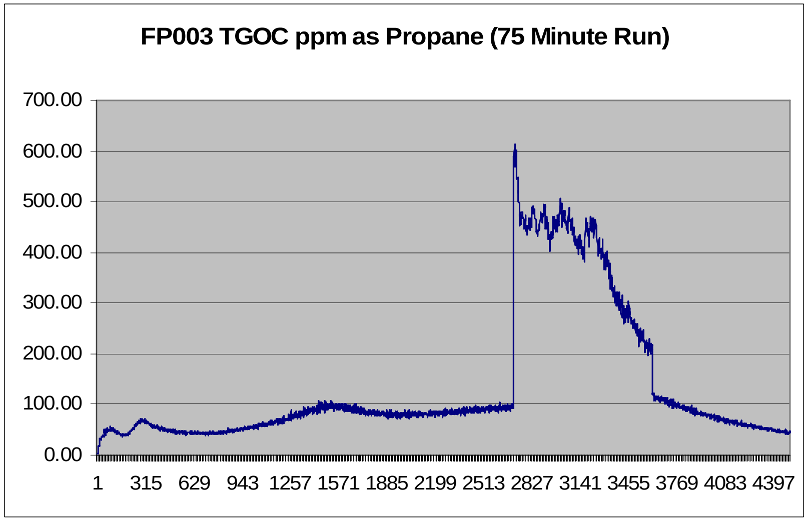
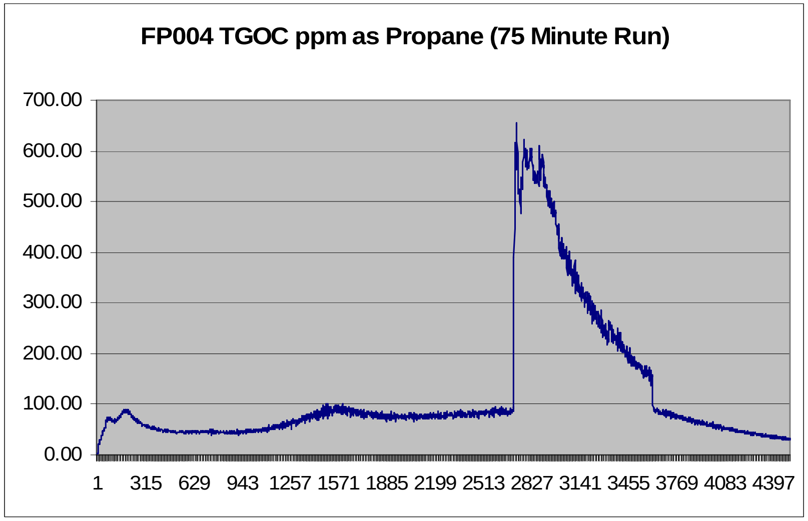

FP001 TGOC ppm as Propane (75 Minute Run)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FP003 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FP004 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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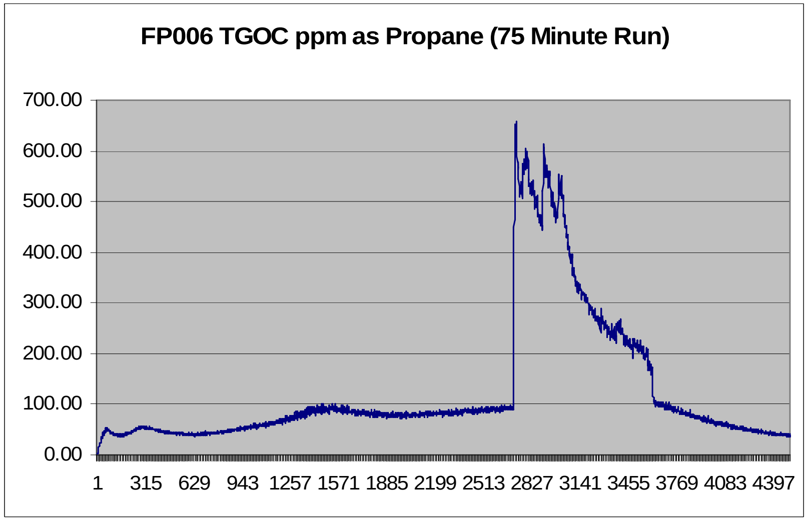
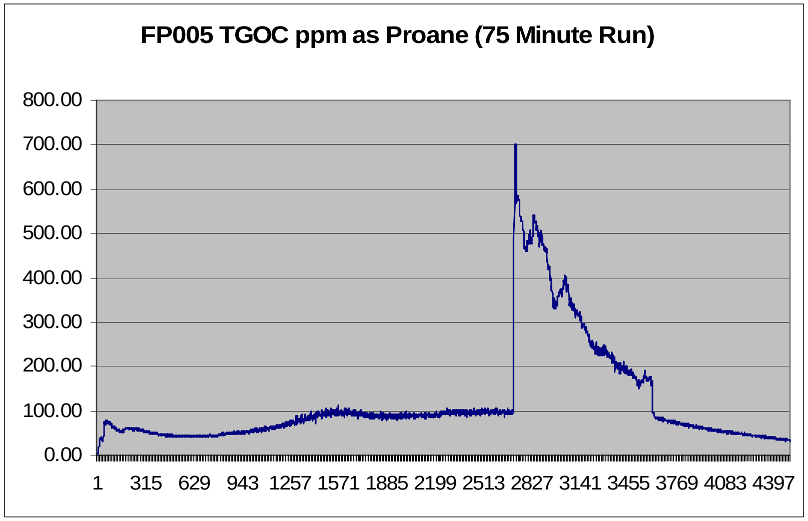
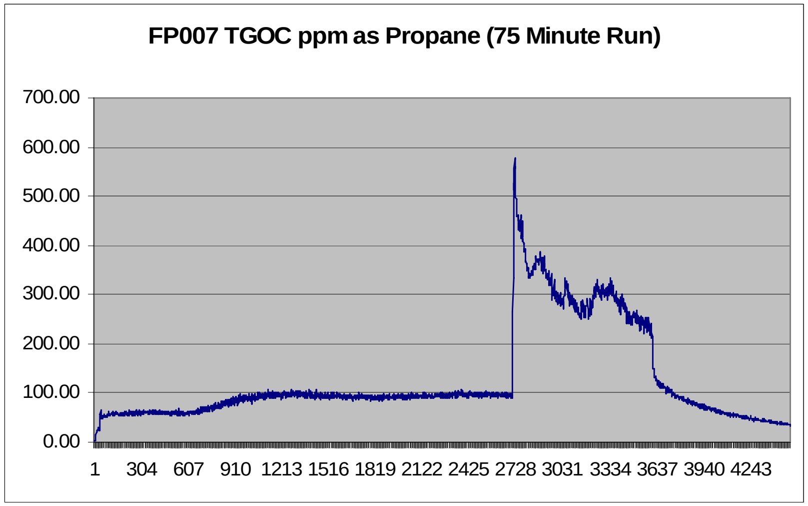

FP006 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FP005 TGOC ppm as Proane (75 Minute Run)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FP007 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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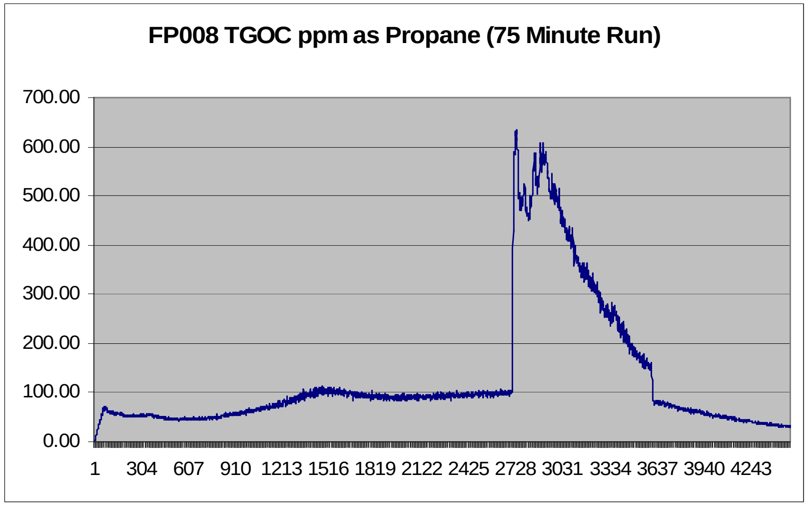
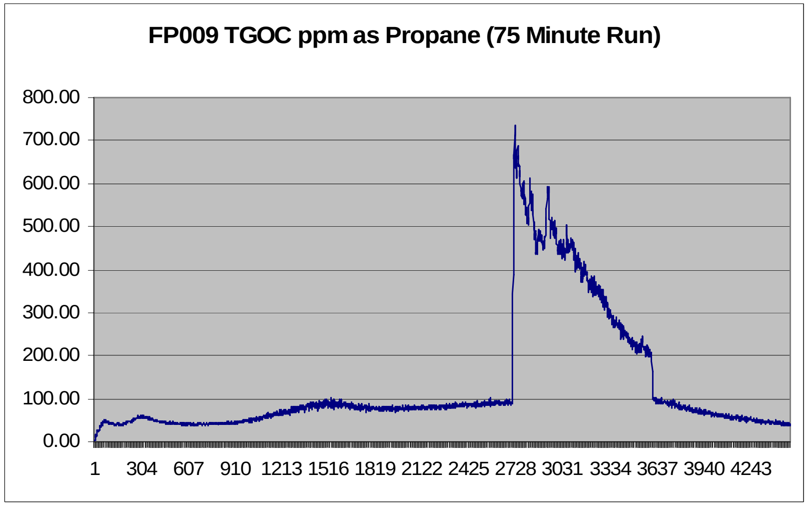

FP008 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 304 607 910 1213 1516 1819 2122 2425 2728 3031 3334 3637 3940 4243


FP009 TGOC ppm as Propane (75 Minute Run)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 304 607 910 1213 1516 1819 2122 2425 2728 3031 3334 3637 3940 4243

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APPENDIX E GLOSSARY

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Glossary

ACFM	Actual Cubic Feet Per Minute
BO	Based on ( ).
BOS	Based on Sand.
FPM	Feet Per Minute
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	Invalid, Data rejected based on data validation considerations
NA	Not Applicable
ND	Non-Detect
NT	Not-Done, 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.
PPMV	Parts Per Million by Volume
SCFM	Standard Cubic Feet per Minute
TGOC	Total Gaseous Organic Carbon
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