Casting Emission Reduction Program

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US Army Contract DAAE30-02-C-1095
FY 2003 Tasks
WBS # 7.1.0

Thin Wall Test: Ashland Light Weight Aggregate

Technikon # 1410-710 FZ

November 2004
(revised for public distribution)

United States Environmental Protection Agency

CISA

AFS

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH
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DAIMLERCHRYSLER Ford Motor Company General Motors

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Thin Wall Test: Ashland Light Weight Aggregate

Technikon Test # 1410-710 FZ

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 FZ, a thin wall casting in an Ashland light weight insulating mold aggregate (ALWA) No-Bake® system poured with iron. This test consisted of twelve test pours, nine (FZ001-FZ009) of which were made using the light weight aggregate and the remaining three (FZ010-FZ012) were made using standard sand. A comparison was made between the two systems. 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 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 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. Carbon monoxide and carbon dioxide were monitored according to US EPA Methods 10 and 3A, respectively. The ALWA casting surface quality was evaluated by visual comparison with the sand baseline castings. The absolute binder content for both mold aggregates was the same. The numerical values of the binder content expressed as % of aggregate are different only because of the different aggregate density.

The mass emission rate of each parameter or target compound was calculated using the continuous monitoring 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 Target Analytes" is based on the sum of the individual Target Analytes 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.

When preparing the sand and ALWA materials it was intended that they both have the same absolute weight of binder per unit of volume in the compacted mold. Owing to the significant differences in the loose and compacted bulk densities and the material compacting characteristics, the absolute weights of binder in the compacted molds of the two materials turned out to be about 8% different from each other. The reader is advised to not confuse the absolute binder content with that same binder content expressed as a % of their respective aggregate mold weights because the different bulk densities will give significantly different results (2.3 % based on sand weight for the mold and 8.1 % based on the ALWA weight for the same mold shape). Results for the emission indicators are shown in the following tables reported as Lbs/Lb of binder and Lbs/ton of metal. The emissions are different by each of the reporting methods partially because the approximately 8% greater binder content in the sand baseline material than in the ALWA material. The emissions when reported as Lb/lb of binder look closer because the binder content differences are normalized in the calculation of the reported values.

Results for the emission indicators are shown in the following tables reported as lbs/lb of binder and lbs/tn of metal.

Test Plan FZ Average Emissions Results – Lb/Lb Binder

Analytes	TGOC as Propane	HC as Hexane	Sum of Target Analytes	Sum of HAPs	Sum of POMs
Test FZ Sand Baseline (Lb/Lb Binder)	0.2415	0.2162	0.0587	0.0465	0.0006
Test FZ ALWA (Lb/Lb Binder)	0.2239	0.1850	0.0564	0.0440	0.0004

Test Plan FZ Average Emissions Results – Lb/Tn Metal

Analytes	TGOC as Propane	HC as Hexane	Sum of Target Analytes	Sum of HAPs	Sum of POMs
Test FZ Sand Baseline (Lb/Tn Metal)	41.49	37.15	10.08	7.970	0.0982
Test FZ ALWA (Lb/Tn Metal)	35.87	29.55	8.997	7.006	0.0724

The surface quality of all the lightweight aggregate castings was inferior to the sand based castings.

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 TECHNIKON OBJECTIVES

The primary objective of Technikon is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions, especially for the 1990 Clean Air Act Amendment. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing arena has been specially designed to facilitate the repeatable collection and evaluation of airborne emissions and associated process data.

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.

1.3 REPORT ORGANIZATION

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate VOC emissions from a No-Bake® system with two types of mold aggregate. 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. Specific data collected during this test are summarized in Section 3 of this report, with detailed data included in Appendix B of this report. Section 4 of this report contains a discussion of the results.

The raw data for this test series data binder is maintained at the Technikon facility.

1.4 SPECIFIC TEST PLAN AND OBJECTIVES

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

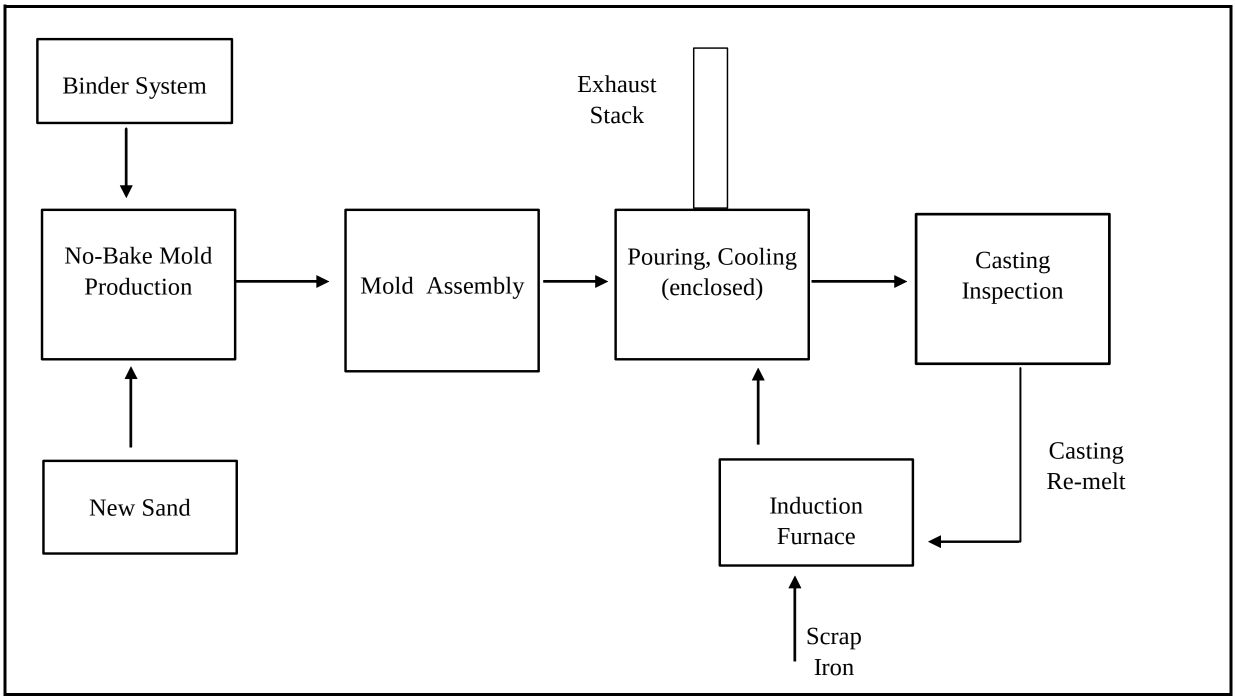
Table 1-1 Test Plan Summary

Test Plan Number	**1410 710 FZ**	**1410 710 FZ**
Type of Process Tested	Phenolic Urethane Thin Wall No-Bake® Baseline	Phenolic Urethane Thin Wall Light Weight Aggregate No-Bake® Test
Aggregate	Wedron 530 Silica Sand	Ashland Exactherm® G220 Light Weight Aggregate
Binder System	Ashland PEPSET® XI-1000/XII-2000/3500	Ashland PEPSET® XI-1000/XII-2000/3500
Metal Poured	Iron	Iron
Casting Type	1-on Star	1-on Star
Number of Molds Poured	3	9
Test Dates	11/10/03 > 11/12/03	11/10/03 > 11/12/03
Emissions Measured	TGOC as Propane, HC as Hexane, 68 Target Analytes	TGOC as Propane, HC as Hexane, 68 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

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. **Mold Preparation:** The No-Bake® mold sand was prepared in a Kloster paddled turbine sand mixer to a calibrated standard composition using Wedron 530 Silica Sand preheated to 85 to 95^{o}F. The sand was placed in 16 x 12 x 6/6 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. 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.

   The insulated emission hood was supplied with air heated to 85 to 90^{o}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.

1-on Star Pattern

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.

Total Enclosure Test Stand

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Cardinal 748E platform scale (Gravimetric)
Casting Weight	Cardinal 748E platform scale (Gravimetric)
Binder Weight	Mettler SB12001 Digital Scale (Gravimetric)
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold	Denver Instruments XE-100 (AFS procedure 5100-00-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C Immersion Pyrometer)
Carbon/Silicon Fusion Temperature	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale (Gravimetric)

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
Target Analytes 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 emissions 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 respectively. The tables include the individual target compounds that comprise at least 95% of the total Target Analytes measured, along with the corresponding Sum of Target Analytes, Sum of HAPs, and Sum of POMs. The tables also include carbon dioxide, carbon monoxide, TGOC as propane, and HC as hexane.

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 based on binder weight.

Figures 3-4 to 3-6 present the five emissions indicators and selected HAP and VOC emissions data from Table 3-3 in graphical form based on metal weight.

The amount of available Target Analytes for the binder systems was determined using a method based on US EPA Method 24 and found to be 0.54 pounds per pound of binder or 54% of the binder weight for the baseline segment. The amount of available Target Analytes for the ALWA segment was found to be 0.46 pounds per pound of binder or 46%. The average emissions results as a percentage of available Target Analytes expressed as HC as hexane for both tests are presented in Table 3-2.

Appendix B contains the detailed emissions 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.

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 FZ Average Emissions Results – Lb/Lb Binder

Analytes	Test FZ Baseline (Lb/Lb Binder)	Test FZ ALWA (Lb/Lb Binder)	% Change from Baseline
TGOC as Propane	0.2415	0.2239	**-7**
HC as Hexane	0.2162	0.1850	**-14**
Sum of Target Analytes	0.0587	0.0564	-4
Sum of HAPs	0.0465	0.0440	-5
Sum of POMs	0.0006	0.0004	**-33**
Individual Organic HAPs			
o,m,p-Cresol	0.0194	0.0168	-13
Phenol	0.0173	0.0183	6
Benzene	0.0059	0.0055	-7
Toluene	0.0015	0.0014	-7
o,m,p-Xylene	0.0012	0.0008	**-33**
Other VOCs			
Trimethylbenzenes	0.0059	0.0056	-5
1,3-Diethylbenzene	0.0016	0.0016	0
Dodecane	0.0012	0.0014	17
Dimethylphenols	0.0011	0.0010	-9
Ethyltoluenes	0.0009	0.0013	**44**
Other Analytes			
Carbon Dioxide	0.1492	0.4054	**172**
Carbon Monoxide	0.0203	0.1150	**467**

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

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

Table 3-2 Percent Available Solvent

Analyte	Test FZ Baseline	Test FZ ALWA
HC as Hexane	54	46

Table 3-3 Summary of Test Plans FZ Average Emissions Results – Lb/Tn Metal

Analytes	Test FZ Baseline (Lb/Tn Metal)	Test FZ ALWA (Lb/Tn Metal)	% Change from Baseline
TGOC as Propane	41.49	35.87	**-14**
HC as Hexane	37.15	29.55	**-20**
Sum of Target Analytes	10.08	8.997	**-11**
Sum of HAPs	7.970	7.006	**-12**
Sum of POMs	0.0982	0.0724	**-26**
Individual Organic HAPs			
o,m,p-Cresol	3.322	2.677	**-19**
Phenol	2.962	2.911	-2
Benzene	1.011	0.8743	-14
Toluene	0.2497	0.2158	**-14**
o,m,p-Xylene	0.1984	0.1332	**-33**
Other VOCs			
Trimethylbenzenes	1.015	0.8879	**-13**
1,3-Diethylbenzene	0.2801	0.2570	**-8**
Dodecane	0.2119	0.2161	**2**
Dimethylphenols	0.1889	0.1591	**-16**
Ethyltoluenes	0.1469	0.2043	**39**
Butyraldehyde/Methacrolein	0.1238	0.1118	-10
Other Analytes			
Carbon Dioxide	25.61	64.57	**152**
Carbon Monoxide	3.499	18.36	**425**

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 Baseline" values in bold have a 95% probability that the differences in the average values were not from test variability.

Figure 3-1 Test FZ Emissions Indicators– Lb/Lb Binder

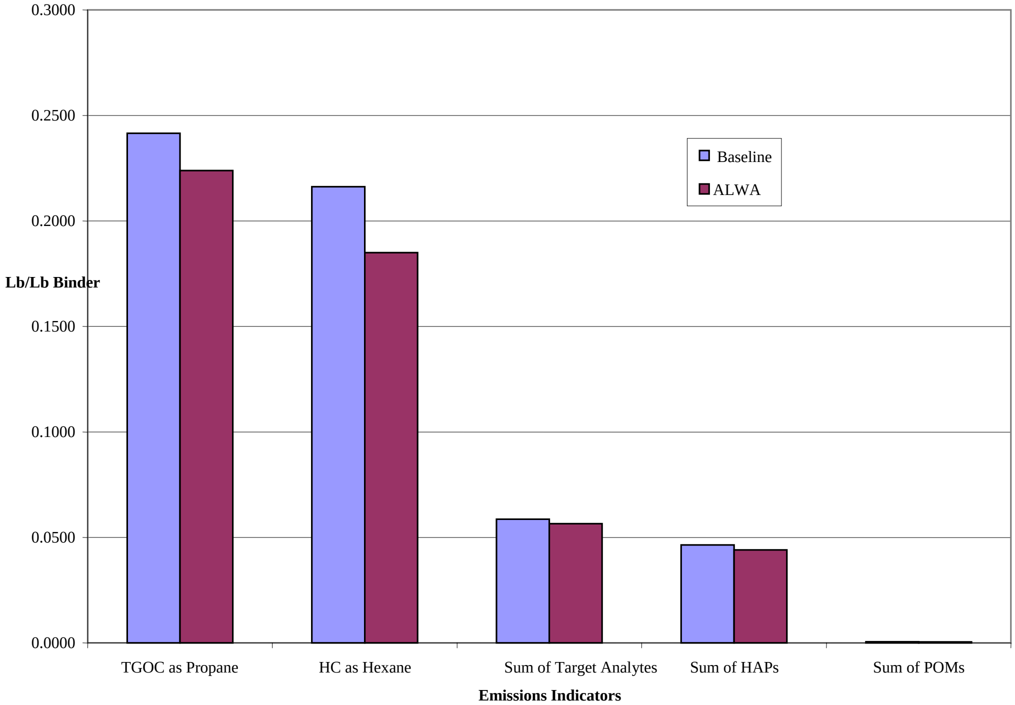


Figure 3-2 Test FZ Selected HAPs – Lb/Lb Binder

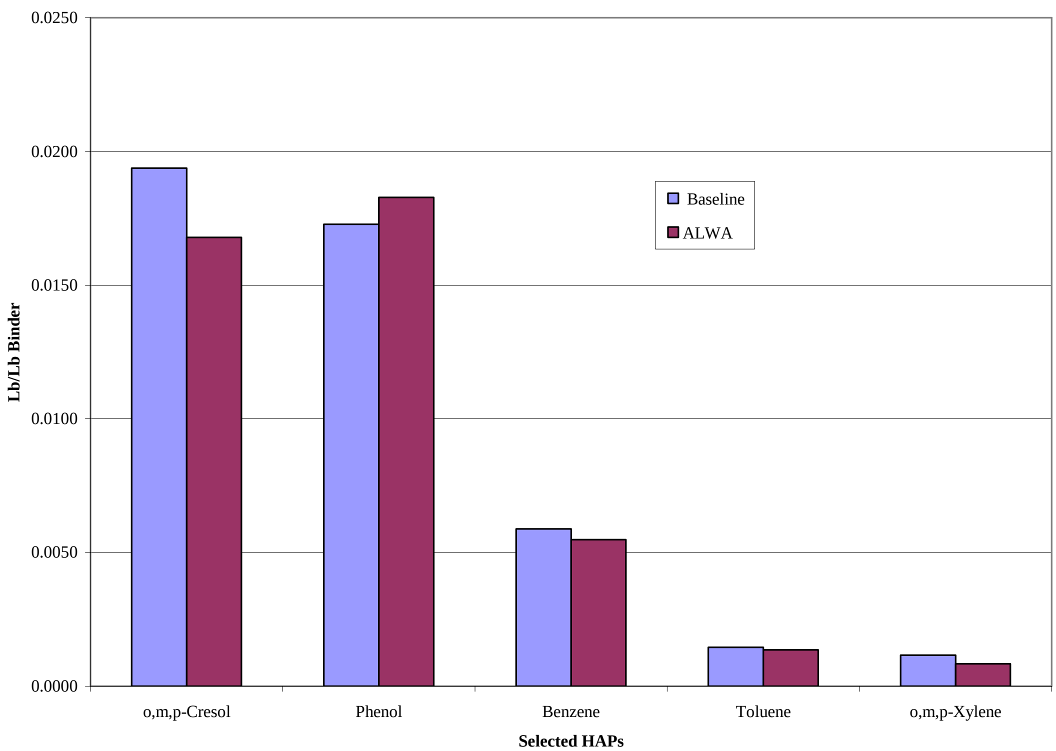


Figure 3-3 Test FZ Selected VOCs – Lb/Lb Binder

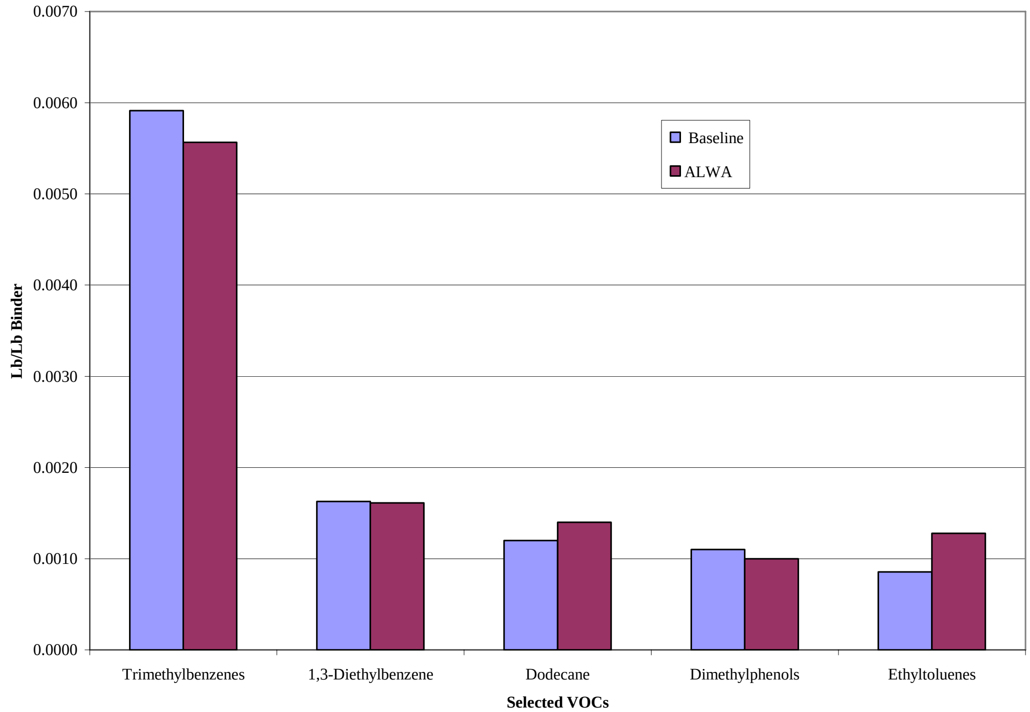


Figure 3-4 Test Series FZ Emissions Indicators – Lb/Tn Metal

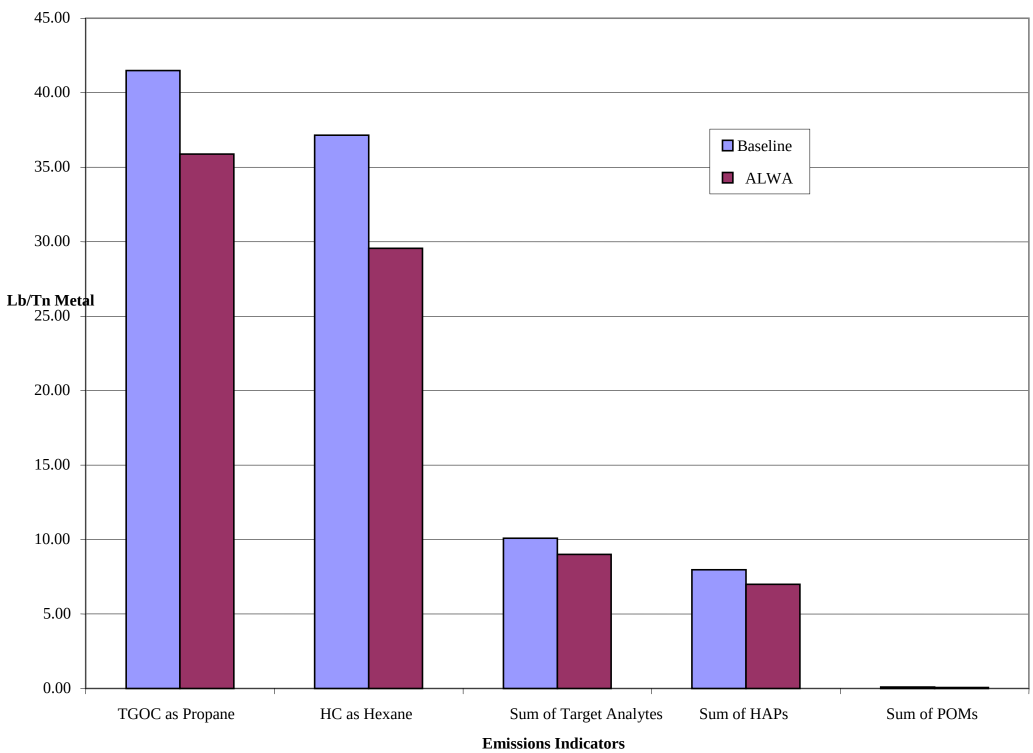


Figure 3-5 Test FZ Selected HAPs – Lb/Tn Metal

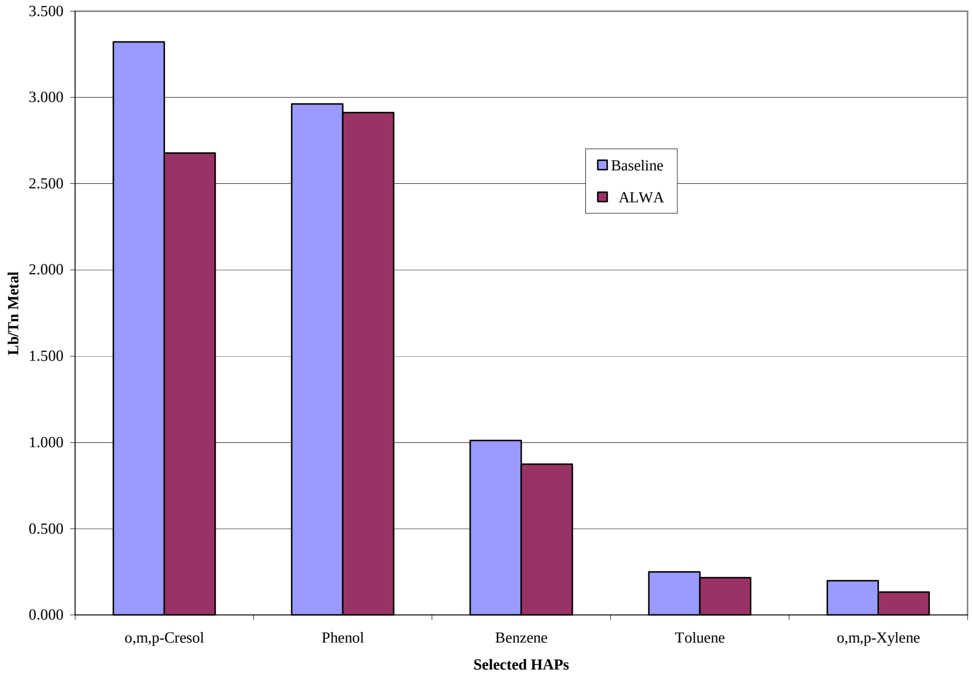


Figure 3-6 Test FZ Selected VOCs – Lb/Tn Metal

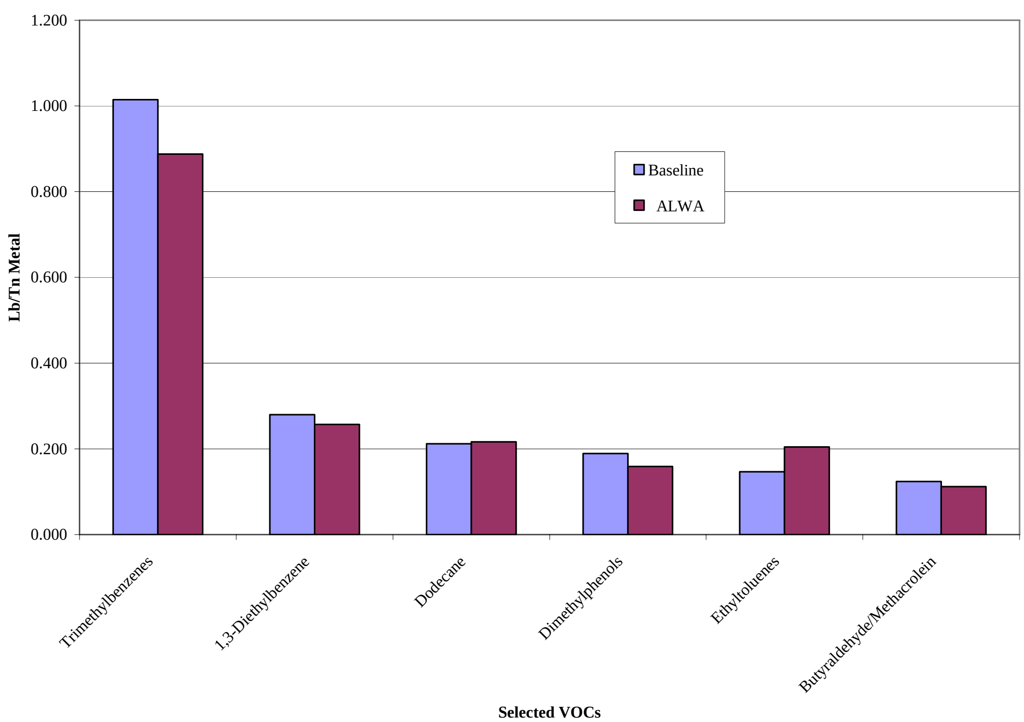


Table 3-4 Average Process Data for Test Series FZ

No-Bake Mix/Make/Cure		
Test Dates	6/16-6/18-04	6/16-6/18-04
Summary	**ALWA**	**Sand**
Calculated Standard % Binder	7.5	2.2
Calculated % Binder (BOA)	8.1	2.3
Mold Weight, lbs	31.4	113.1
Calculated Total Binder Weight, lbs	2.4	2.5
1800F LOI, %	6.5	1.8
Sand Temperature, deg F	82.6	82.7
Dogbone Core 2 hr. Tensile Strength, psi	81.1	169.7

No-Bake PCS			
Pouring Temp, deg F		2677	2682
Pouring Time, sec.		15	15
Cast Weight (all metal inside mold), Lbs.		29.63	29.55
Process Air Temperature in Hood, deg F (Note 2)		88	86
Mold Temperature when placed in hood, deg F		ND	78
Mold Age When Poured, hr		27	25
Test Length, Min		75	75
Rank order mold Number 1= best , 12 = worst	1		**10**
	2		**11**
	3		**12**
	4	**6**	
	5	**4**	
	6	**2**	
	7	**5**	
	8	**8**	
	9	**1**	
	10	**9**	
	11	**7**	
	12	**3**	

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4.0 Discussion of Results

Test FZ consisted of preparing molds using a light weight aggregate (ALWA) or sand and comparing the resultant emissions and casting appearance of a thin wall casting. The ALWA segment contained test runs FZ001 to FZ009, and the baseline (standard) segment contained test runs FZ010 to FZ012.

Observation of the measured process parameters indicates that the tests were run within an acceptable range. In Tables 3-1 and 3-3, the "% Change from Baseline" 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 the ALWA segment to the sand baseline show a **14%** reduction in TGOC as propane, a **20%** reduction in HC as hexane, a **11%** reduction in Sum of Target Analytes, a **12%** reduction in Sum of HAPs, and a **26%** reduction in Sum of POMs when expressed in pounds per ton of metal. O,m,p-Cresol and phenol were found to be the largest contributors to the total HAPs and Target Analytes for both the ALWA segment and the baseline (approximately 40% each for both analytes of the total HAPs). Carbon monoxide and carbon dioxide emissions from the ALWA segment were **425%** and **152%** higher than the sand baseline.

An independent test for volatile matter content based on EPA Method 24 was performed to determine the amount of available Target Analytes in the binder system used for this test. Approximately 54% of the available Target Analytes were recovered for Test FZ Baseline and 46% for Test FZ ALWA (Table 3-2).

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 (FZ0010 – FZ012) castings, were all superior to those of the light weight aggregate (FZ001 – FZ009). The ALWA castings were marked by significant amounts of gaseous defects.

When preparing the sand and ALWA materials it was intended that they both have the same absolute weight of binder per unit of volume in the compacted mold. Owing to the significant differences in the loose and compacted bulk densities and the material compacting characteristics, the absolute weights of binder in the compacted molds of the two materials turned out to be about 8% different from each other. The reader is advised to not confuse the absolute binder content with that same binder content expressed as a % of their respective aggregate mold weights because the different bulk densities will give significantly different results (2.3 % based on sand weight for the mold and 8.1 % based on the ALWA weight for the same mold shape). Results for the emission indicators are shown in the following tables reported as Lbs/Lb of binder and Lbs/ton of metal. The emissions are different by each of the reporting methods partially because the approximately 8% greater binder content in the sand baseline material than in the ALWA material. The emissions when reported as Lb/lb of binder look closer because the binder content differences are normalized in the calculation of the reported values.

APPENDIX A APPROVED TEST PLAN FOR TEST SERIES FZ

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TECHNIKON TEST PLAN

> **CONTRACT NUMBER:**	1410	**TASK NUMBER**	7.1.0	**SERIES**	FZ

- > **SITE:** Pilot Foundry
- > **TEST TYPE:** Thin wall casting cast in light weight insulating mold aggregate
- > **METAL TYPE:** Class 30 gray iron
- > **MOLD TYPE:** 1-on No-Bake® star
- > **NUMBER OF MOLDS:** Twelve (12); Nine (9) molds with 100% Ashland Light Weight Aggregate (ALWA) Exactherm® G 220 having 8 w/o binder + three (3) molds with 100% Wedron 530 silica sand with the same binder and binder weight per unit volume of aggregate as the previous nine molds.
- > **CORE TYPE:** N/A
- > **CORE COATING:** None
- > **SAMPLE EVENTS:** 12
- > **TEST DATE(S):** **START:** 7 June 2004
  FINISH: 25 June 2004

TEST OBJECTIVES:

Measure Pouring, Cooling, & Shakeout emissions and compare the cast surface appearance.

Part A: ALWA molds having 8 w/o total binder content based on weight of ALWA (BOA). Compare emissions and casting surface appearance to part B.

Part B: Three (3) silica sand molds having the same total binder weight as the molds in part A.

Results shall be reported as pounds of emission/pound of binder and pounds of emission /ton of metal poured based on analyte list A.

VARIABLES:

The pattern shall be the 1-on star with a single sided riser as originally designed for this pattern. Part A molds shall be made with Ashland Light Weight Aggregate (ALWA) Exactherm® G 220, 8 w/o (BOA) Ashland PEPSET® XI-1000/XII-2000 in a 55/45% ratio mixed in 15 pound (more or less) batches in a paddle-wheeled core sand mixer for a fixed total time between 2 & 3 minutes TBD buy working life. Part three (3) activator, Ashland PEPSET® 3500, shall be 5 w/o of Part one (1) for ALWA and 2-3 w/o of Part one (1) for the sand. Part one (1) and Part three

(3) shall be premixed before adding to the sand.

The Part B molds shall be made on the same pattern using Wedron 530 silica sand and the same weight per unit volume of aggregate (sand) with the same binder system as was used for the ALWA based molds.

Molds will be poured with iron at 2680 +/- 10 degrees F. Mold cooling will be 45minutes follow by 15 minutes of shakeout.

Emission testing shall include the 45 minutes of pouring & cooling, 15 minutes of shakeout, and 15 minutes of the post shakeout period for a total of 75 minutes.

BRIEF OVERVIEW:

Previous testing has demonstrated that the ability to make thin walled castings depends on the rate that the metal solidifies because it limits the distance a given alloy can flow and influences the resulting metal microstructure. Lightweight aggregate, because of its lower mass and greater insulating characteristicis reduces the rate of heat extraction from the metal and thereby delays solidification. The result should permit the filling of geometries that are farther away or of thinner cross section.

Additonally the insulating characteristic should limit the propogation of heat into the mold material keeping its temperature lower in the same time period so that the volume of material reaching the temperatures characteristic for emissions is reduced. Reduced emissions may follow. Secondly, those emission that do evolve may be have a higher fraction of those species that are a result of thermal decomposition and recombination versus evaporation.

SPECIAL CONDITIONS:

The initial process air temperature will be maintained at 85-90 degrees F. All materials shall be maintained at 70-80 degrees F prior to pouring.

Series FZ

Thin Wall Iron Casting Technology
PCS emissions from a Light Weight and Silica Aggregate No-Bake® Mold Poured with Iron

A. Experiment: Measure airborne pouring, cooling, & shakeout emissions from the 1-on star mold made from Ashland light weight aggregate Exactherm® G 220 & Ashland PEPSET® resin. Compare to Silica sand molds made with the same quantity per mold of this binder system. Compare casting appearance. Compare to Iron No-Bake® PCS Baseline Test FL.

B. Materials:
  1) No-Bake® molds: Ashland Exactherm® G 220 Light weight aggregate (ALWA) and Wedron 530 silica sand bound with 1.4% Ashland PEPSET® No-Bake® Phenolic-Urethane core binder composed of XI-1000 part I resin, XII-2000 part II co-reactant, & 3500 part III activator. This binder is designed for iron applications.

C. Metal: Class-30 Gray cast iron.

Caution: Observe all safety precautions attendant to these operations as delineated in the Pre-production operating and safety instruction manual. 13435674

D. Mold requirements
  1) Make Twelve (12) molds according to standards determined in test series CW & CP capability studies. Nine molds (9) shall be made with Exactherm® G 220 light weight aggregate containing 8 w/o (BOA) PEPSET® binder. Three (3) molds shall be made with Wedron 530 silica sand having the same weight of binder per mold.

E. Phenolic Urethane No-Bake® Core Sand preparation:
  1) Prior to preparing the bound aggregate or sand for the molds measure the settled bulk density of the ALWA and the silica sand.
  2) Prior to preparing the bound aggregate or sand for the molds determine the appropriate amount of part III activator to achieve a viable set up time & bench life.
  3) Prior to preparing the bound aggregate or sand for the molds determine the appropriate mixing time to achieve homogeneity.
  4) Use the ratio of the ALWA bulk density to that of the silica sand to determine the weight of ALWA that is equivalent to a nominal 50 pound batch of silica sand.
  5) The phenolic urethane No-Bake® sand shall be 1.4 % total resin (BOA), Part I/Part II ratio 55/45, Part III at 5% of Part I.
  6) Weigh 55% of 8% (4.40% BOA) to +/- 1% of the nominal calculated value of the equivalent ALWA batch weight as part I binder.
  7) Weigh the part III activator, as determined in D.2 to +/- 1% of the nominal calculated value and mix with the part I binder.
  8) Weigh 45 % of 8 % (3.6% BOA) to +/- 1% of the nominal calculated value of the equivalent ALWA weight as part II binder.

9) Measure the temperature of the aggregate and adjust the temperature so that it is in the range 70-80°F. Record the use temperature of the aggregate.
10) Add the ALWA material or the silica sand in the quantity determined in D.4 to the pedestal mixer.
11) Add the mixture of the part I + part III binder to the sand and mix for a period of time as determined in D.3. Record the mix time.
12) Add the part II binder to the sand and mix for the same length of time as done in D.11. Record the mix time.

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) Flood the core box with aggregate.
4) Finger poke the sand into the cavities.
5) Strike off the core box to ½ inch deep.
6) Place a heavy weight on top of the aggregate.
7) Turn on the vibrating compaction table for 5 seconds.
8) Screed off most of the excess aggregate.
9) 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

10) Set aside for about 6-7 minutes or until hard to the touch.
11) Carefully remove the cores from the core box by separating the corebox components.
12) Perform tensile tests on 12 bones at 2 hours after dogbone manufacture using the Thwing-Albert tensile tester.
13) Report the average and standard deviation for each set of twelve (12) for each mold.
14) Weigh each dogbone and record the weight to the nearest 0.1 grams using the SB-12000 electronic scale at the time it is tensile tested.

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

15) Run an 1800°F core LOI on three (3) of the tensile test dogbones. Report the average value for each mold.

G. No-Bake® mold making: 1-on star core box.
1) Inspect the box for cracks and other damage. Repair before use.
2) Prepare the match plate halves with a light coating of Ashland Zipslip® IP 78. Allow to fully dry.
3) Place the fully assembled pattern and flasks on the vibrating compaction table.
4) Fill the drag side first.
5) Begin filling the box.
6) Manually spread the sand around the box as it is filling.

7) When the box is about full start the table vibration.
8) Allow the vibrator to run an additional 5 seconds after the box is full.
9) Strike off the core box so that the core mold is full.
10) Set the core box aside for 5 to 6 minutes or until it is hard to the touch.
11) Invert the flasks and place on a transport pallet.
12) Remove the pattern by lightly tapping on the plate flask with a soft hammer.
13) Remove the flask.
14) Reassemble the flasks and pattern and make the cope using the same procedure.
15) Rotate the unboxed core to set it on edge.
16) Drill 9/16 inch vent holes in riser top and star top.
17) Blow out both mold halves.
18) Apply a 1/4-3/8 inch glue bead of water based Foseco Core Fix 825A one-half inch (1) in from the outer edge of the mold.
19) Immediately close cope onto drag. Visually check for closure.
20) Weigh and record the weight of the closed mold.
21) Install two (2) steel straps, one each direction the side of the pouring cup location, with 4 metal corner protectors each to hold the mold tightly closed.
22) Glue a pouring basin over the sprue hole with Foseco CoreFix 825A or equivalent no emission water based refractory adhesive
23) Store the mold for next day use at 80-90^{o}F.

H. Emission hood:
1) Loading.
a) Hoist the mold onto the small shakeout deck fixture within the emission hood with the pouring cup side toward the furnace.
b) Install a 3/8 inch casting hanger through the cope into riser cavity and suspend it over the shakeout.
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 sand off of the shakeout fixture, 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.

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 2700 ^{o}F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350^{o}F.
- **h)** Hold the furnace at 2500-2550^{o}F until near ready to tap.
- **i)** When ready to tap raise the temperature to 2700^{o}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 2700^{o}F metal into the cold ladle.
- **b)** Casually pour the metal back to the furnace.
- **c)** Cover the ladle.
- **d)** Reheat the metal to 2780 +/- 20^{o}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 2680 +/- 10^{o}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) Process each rotating basket for eight (8) minutes.
  b) Remove and remark casting ID on each casting.
  c) 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.

L. 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) For each casting:
  a) Place each casting initially in sequential mold number order.
  b) Beginning with casting from mold FZ001 compare it to casting from mold F2002.
  c) Place the better appearing casting in the first position and the lesser appearing casting in the second position.
  d) Repeat this procedure with mold FZ001 to its nearest neighbors until all castings closer to the beginning of the line are better appearing than mold FZ001 and the next casting farther down the line is inferior.
  e) Repeat this comparison to next neighbors for each casting number.
  f) When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
  g) Repeat this comparison until all evaluators concur with the ranking order.
    i) Record mold number by rank-order series.
    ii) Save the best, median, and worst castings for photographing and archiving.

Steven Knight
Mgr. Process Engineering

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/15/2004											
RUN 1											
THC	FZ001	X									TOTAL
CO, CO2	FZ001	X									TOTAL
M-18	FZ00101		1						30	1	Carbopak charcoal
M-18	FZ00102				1				0		Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00103		1						500	5	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FZ00104				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00105		1						500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FZ00106				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00107		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	FZ00108				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/15/2004											
RUN 2											
THC	FZ002	X									TOTAL
CO, CO2	FZ002	X									TOTAL
M-18	FZ00201		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00202		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00203		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00204		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/15/2004											
RUN 3											
THC	FZ003	X									TOTAL
CO, CO2	FZ003	X									TOTAL
M-18	FZ00301		1						30	1	Carbopak charcoal
M-18 MS	FZ00302		1						30	2	Carbopak charcoal
M-18 MS	FZ00303			1					30	3	Carbopak charcoal
	Excess								30	4	Excess
NIOSH 2002	FZ00304		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00305		1						500	7	DNPH Silica Gel (SKC 226-119)
	Excess								500	8	Excess
TO11	FZ00306		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/16/2004											
RUN 4											
THC	FZ004	X									TOTAL
CO, CO2	FZ004	X									TOTAL
M-18	FZ00401		1						30	1	Carbopak charcoal
M-18	FZ00402			1					30	2	Carbopak charcoal
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00403		1						500	5	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FZ00404			1					500	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 1500	FZ00405		1						500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FZ00406			1					500	8	100/50 mg Charcoal (SKC 226-01)
TO11	FZ00407		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	FZ00408			1					850	10	DNPH Silica Gel (SKC 226-119)
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/16/2004											
RUN 5											
THC	FZ005	X									TOTAL
CO, CO2	FZ005	X									TOTAL
M-18	FZ00501		1						30	1	Carbopak charcoal
M-18	FZ00502					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								40	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00503		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00504		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00505		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/16/2004											
RUN 6											
THC	FZ006	X									TOTAL
CO, CO2	FZ006	X									TOTAL
M-18	FZ00601		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00602		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00603		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00604		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/16/2004											
RUN 7											
THC	FZ007	X									TOTAL
CO, CO2	FZ007	X									TOTAL
M-18	FZ00701		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00702		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00703		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00704		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/17/2004											
RUN 8											
THC	FZ008	X									TOTAL
CO, CO2	FZ008	X									TOTAL
M-18	FZ00801		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00802		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00803		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00804		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/17/2004											
RUN 9											
THC	FZ009	X									TOTAL
CO, CO2	FZ009	X									TOTAL
M-18	FZ00901		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ00902		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ00903		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ00904		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/18/2004											**Baseline SS Sand**
RUN 10											
THC	FZ010	X									TOTAL
CO, CO2	FZ010	X									TOTAL
M-18	FZ01001		1						30	1	Carbopak charcoal
M-18	FZ01002			1					30	2	Carbopak charcoal
M-18 MS	FZ01003		1						30	3	Carbopak charcoal
M-18 MS	FZ01004			1					30	4	Excess
NIOSH 2002	FZ01005		1						500	5	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FZ01006			1					500	6	100/50 mg Silica Gel (SKC 226-10)
NIOSH 1500	FZ01007		1						500	7	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FZ01008			1					500	8	100/50 mg Charcoal (SKC 226-01)
TO11	FZ01009		1						850	9	DNPH Silica Gel (SKC 226-119)
TO11	FZ01010			1					850	10	DNPH Silica Gel (SKC 226-119)
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/18/2004											**Baseline SS Sand**
RUN 11											
THC	FZ011	X									TOTAL
CO, CO2	FZ011	X									TOTAL
M-18	FZ01101		1						30	1	Carbopak charcoal
M-18	FZ01102					1			30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ01103		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ01104		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ01105		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FZ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
6/18/2004											**Baseline SS Sand**
RUN 12											
THC	FZ012	X									TOTAL
CO, CO2	FZ012	X									TOTAL
M-18	FZ01201		1						30	1	Carbopak charcoal
	Excess								30	2	Excess
	Excess								30	3	Excess
	Excess								30	4	Excess
NIOSH 2002	FZ01202		1						500	5	100/50 mg Silica Gel (SKC 226-10)
	Excess								500	6	Excess
NIOSH 1500	FZ01203		1						500	7	100/50 mg Charcoal (SKC 226-01)
	Excess								500	8	Excess
TO11	FZ01204		1						850	9	DNPH Silica Gel (SKC 226-119)
	Excess								850	10	Excess
	Excess								850	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

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APPENDIX B DETAILED EMISSIONS DATA FOR TEST FZ

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Test Plan FZ Baseline Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ010	FZ011	FZ012	Average	STDEV
		Test Dates	**9/10/2004**	**9/10/2004**	**9/10/2004**		
		TGOC as Propane	2.34E-01	2.43E-01	2.48E-01	2.42E-01	7.17E-03
		HC as Hexane	2.10E-01	2.19E-01	2.20E-01	2.16E-01	5.46E-03
		Sum of VOCs	5.41E-02	5.74E-02	6.48E-02	5.87E-02	5.46E-03
		Sum of HAPs	4.26E-02	4.56E-02	5.11E-02	4.65E-02	4.33E-03
		Sum of POMs	4.81E-04	5.28E-04	7.12E-04	5.74E-04	1.22E-04
			Individual Organic HAPs				
x		**m,p-Cresol**	1.62E-02	1.68E-02	2.04E-02	1.78E-02	2.27E-03
x		**Phenol**	1.55E-02	1.68E-02	1.95E-02	1.73E-02	2.06E-03
x		**Benzene**	5.85E-03	6.66E-03	5.12E-03	5.88E-03	7.67E-04
x		**o-Cresol**	1.47E-03	1.50E-03	1.80E-03	1.59E-03	1.80E-04
x		**Toluene**	1.37E-03	1.45E-03	1.54E-03	1.45E-03	8.58E-05
x		**m,p-Xylene**	7.63E-04	9.22E-04	9.67E-04	8.84E-04	1.07E-04
x	z	**Naphthalene**	3.38E-04	3.68E-04	4.93E-04	4.00E-04	8.24E-05
x		**o-Xylene**	2.36E-04	2.86E-04	2.97E-04	2.73E-04	3.22E-05
x		**Aniline**	3.31E-04	2.46E-04	1.87E-04	2.55E-04	7.26E-05
x		**Formaldehyde**	1.47E-04	1.54E-04	1.47E-04	1.49E-04	4.19E-06
x		**Styrene**	9.61E-05	1.14E-04	1.26E-04	1.12E-04	1.51E-05
x	z	**2-Methylnaphthalene**	8.39E-05	9.33E-05	1.24E-04	1.00E-04	2.10E-05
x		**Hexane**	7.99E-05	ND	1.63E-04	8.11E-05	8.17E-05
x		**Acetaldehyde**	6.42E-05	6.37E-05	6.35E-05	6.38E-05	3.59E-07
x		**Ethylbenzene**	5.79E-05	5.97E-05	6.70E-05	6.15E-05	4.84E-06
x	z	**1-Methylnaphthalene**	3.99E-05	4.55E-05	6.55E-05	5.03E-05	1.34E-05
x		**Biphenyl**	2.07E-05	ND	5.24E-05	2.44E-05	2.64E-05
x	z	**1,3-Dimethylnaphthalene**	1.93E-05	2.10E-05	2.98E-05	2.34E-05	5.63E-06
x		**2-Butanone**	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	NA
x		**Propionaldehyde (Propanal)**	ND	ND	ND	ND	NA
x		**Dimethylaniline**	ND	ND	ND	ND	NA
x	z	**Acenaphthalene**	ND	ND	ND	ND	NA
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	NA

Test Plan FZ Baseline Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ010	FZ011	FZ012	Average	STDEV
		Test Dates	**9/10/2004**	**9/10/2004**	**9/10/2004**		
			Other VOCs				
		1,2,3-Trimethylbenzene	3.04E-03	3.13E-03	3.64E-03	3.27E-03	3.24E-04
		1,2,4-Trimethylbenzene	2.40E-03	2.59E-03	2.93E-03	2.64E-03	2.67E-04
		1,3-Diethylbenzene	1.65E-03	1.57E-03	1.66E-03	1.63E-03	4.95E-05
		Dodecane	1.07E-03	1.16E-03	1.49E-03	1.24E-03	2.21E-04
		2,6-Dimethylphenol	8.27E-04	8.80E-04	1.07E-03	9.27E-04	1.31E-04
		Butyraldehyde/Methacrolein	6.06E-04	7.71E-04	7.91E-04	7.23E-04	1.02E-04
		3-Ethyltoluene	5.57E-04	5.62E-04	6.05E-04	5.75E-04	2.62E-05
		Undecane	4.13E-04	2.98E-04	3.36E-04	3.49E-04	5.85E-05
		2-Ethyltoluene	2.65E-04	2.68E-04	3.09E-04	2.81E-04	2.42E-05
		2,4-Dimethylphenol	1.81E-04	1.58E-04	1.83E-04	1.74E-04	1.37E-05
		Propylbenzene	1.41E-04	1.30E-04	1.85E-04	1.52E-04	2.88E-05
		Decane	8.92E-05	8.76E-05	1.04E-04	9.36E-05	9.05E-06
		Tetradecane	7.63E-05	8.19E-05	1.06E-04	8.80E-05	1.57E-05
		Pentanal	4.94E-05	I	7.33E-05	6.14E-05	1.69E-05
		o,m,p-Tolualdehyde	6.08E-05	6.36E-05	5.94E-05	6.12E-05	2.12E-06
		Benzaldehyde	2.61E-05	2.90E-05	3.63E-05	3.05E-05	5.25E-06
		Hexaldehyde	1.60E-05	1.62E-05	2.06E-05	1.76E-05	2.61E-06
		Indene	ND	ND	I	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	NA
		Cyclohexane	ND	ND	ND	ND	NA
		Heptane	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	NA
		Nonane	ND	ND	ND	ND	NA
		Octane	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	NA
			Other Analytes				
		Acetone	4.98E-05	4.89E-05	5.18E-05	5.02E-05	1.51E-06
		Carbon Dioxide	1.51E-01	1.14E-01	1.83E-01	1.49E-01	3.46E-02
		Carbon Monoxide	2.17E-02	1.85E-02	2.08E-02	2.03E-02	1.64E-03

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.

Test Plan FZ Baseline Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ010	FZ011	FZ012	Average	STDEV
		Test Dates	**9/10/2004**	**9/10/2004**	**9/10/2004**		
		TGOC as Propane	4.17E+01	4.13E+01	4.14E+01	4.15E+01	2.13E-01
		HC as Hexane	3.75E+01	3.73E+01	3.67E+01	3.71E+01	4.13E-01
		Sum of VOCs	9.66E+00	9.76E+00	1.08E+01	1.01E+01	6.41E-01
		Sum of HAPs	7.61E+00	7.75E+00	8.54E+00	7.97E+00	5.03E-01
		Sum of POMs	8.58E-02	8.98E-02	1.19E-01	9.82E-02	1.81E-02
		Individual Organic HAPs					
x		**m,p-Cresol**	2.89E+00	2.86E+00	3.40E+00	3.05E+00	3.08E-01
x		**Phenol**	2.77E+00	2.86E+00	3.26E+00	2.96E+00	2.64E-01
x		**Benzene**	1.05E+00	1.13E+00	8.56E-01	1.01E+00	1.41E-01
x		**o-Cresol**	2.63E-01	2.56E-01	3.01E-01	2.73E-01	2.41E-02
x		**Toluene**	2.45E-01	2.47E-01	2.57E-01	2.50E-01	6.78E-03
x		**m,p-Xylene**	1.36E-01	1.57E-01	1.62E-01	1.52E-01	1.34E-02
x	z	**Naphthalene**	6.03E-02	6.26E-02	8.24E-02	6.84E-02	1.21E-02
x		**o-Xylene**	4.22E-02	4.86E-02	4.96E-02	4.68E-02	4.00E-03
x		**Aniline**	5.91E-02	4.19E-02	3.12E-02	4.41E-02	1.41E-02
x		**Formaldehyde**	2.62E-02	2.62E-02	2.45E-02	2.56E-02	9.62E-04
x		**Styrene**	1.72E-02	1.95E-02	2.10E-02	1.92E-02	1.95E-03
x	z	**2-Methylnaphthalene**	1.50E-02	1.59E-02	2.07E-02	1.72E-02	3.08E-03
x		**Hexane**	1.43E-02	ND	2.73E-02	1.39E-02	1.36E-02
x		**Acetaldehyde**	1.15E-02	1.08E-02	1.06E-02	1.10E-02	4.44E-04
x		**Ethylbenzene**	1.03E-02	1.02E-02	1.12E-02	1.06E-02	5.57E-04
x	z	**1-Methylnaphthalene**	7.13E-03	7.74E-03	1.09E-02	8.60E-03	2.04E-03
x		**Biphenyl**	3.70E-03	ND	8.75E-03	4.15E-03	4.39E-03
x	z	**1,3-Dimethylnaphthalene**	3.44E-03	3.58E-03	4.97E-03	4.00E-03	8.49E-04
x	z	**1,2-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	ND	ND	ND	ND	NA
x	z	**Acenaphthalene**	ND	ND	ND	ND	NA
x		**N,N-Dimethylaniline**	ND	ND	ND	ND	NA
x		**2-Butanone**	ND	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	NA
x		**Propionaldehyde**	ND	ND	ND	ND	NA

Test Plan FZ Baseline Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ010	FZ011	FZ012	Average	STDEV
		Test Dates	**9/10/2004**	**9/10/2004**	**9/10/2004**		
		Other VOCs					
		1,2,3-Trimethylbenzene	5.43E-01	5.33E-01	6.08E-01	5.61E-01	4.09E-02
		1,2,4-Trimethylbenzene	4.29E-01	4.41E-01	4.90E-01	4.53E-01	3.20E-02
		1,3-Diethylbenzene	2.95E-01	2.67E-01	2.78E-01	2.80E-01	1.38E-02
		Dodecane	1.90E-01	1.97E-01	2.48E-01	2.12E-01	3.18E-02
		2,6-Dimethylphenol	1.48E-01	1.50E-01	1.80E-01	1.59E-01	1.79E-02
		Butyraldehyde/Methacrolein	1.08E-01	1.31E-01	1.32E-01	1.24E-01	1.36E-02
		3-Ethyltoluene	9.94E-02	9.57E-02	1.01E-01	9.87E-02	2.76E-03
		Undecane	7.37E-02	5.07E-02	5.61E-02	6.02E-02	1.20E-02
		2-Ethyltoluene	4.74E-02	4.55E-02	5.15E-02	4.82E-02	3.07E-03
		2,4-Dimethylphenol	3.22E-02	2.69E-02	3.06E-02	2.99E-02	2.72E-03
		n-Propylbenzene	2.53E-02	2.22E-02	3.09E-02	2.61E-02	4.41E-03
		Decane	1.59E-02	1.49E-02	1.74E-02	1.61E-02	1.24E-03
		Tetradecane	1.36E-02	1.39E-02	1.77E-02	1.51E-02	2.27E-03
		Pentanal	8.83E-03	I	1.23E-02	1.05E-02	2.42E-03
		o,m,p-Tolualdehyde	1.09E-02	1.08E-02	9.92E-03	1.05E-02	5.25E-04
		Benzaldehyde	4.66E-03	4.94E-03	6.07E-03	5.22E-03	7.42E-04
		Hexaldehyde	2.85E-03	2.76E-03	3.45E-03	3.02E-03	3.70E-04
		Indene	ND	ND	I	ND	NA
		1,3,5-Trimethylbenzene	ND	ND	ND	ND	NA
		Cyclohexane	ND	ND	ND	ND	NA
		Heptane	ND	ND	ND	ND	NA
		Indan	ND	ND	ND	ND	NA
		Nonane	ND	ND	ND	ND	NA
		Octane	ND	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	NA
		Other Analytes					
		Acetone	8.89E-03	8.32E-03	8.66E-03	8.62E-03	2.91E-04
		Carbon Dioxide	2.69E+01	1.94E+01	3.06E+01	2.56E+01	5.72E+00
		Carbon Monoxide	3.88E+00	3.15E+00	3.47E+00	3.50E+00	3.65E-01

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.

Test Plan FZ ALWA Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	**6/15/04**	**6/15/04**	**6/15/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/17/04**	**6/17/04**		
		TGOC as Propane	2.31E-01	2.26E-01	2.21E-01	2.42E-01	2.25E-01	2.29E-01	2.16E-01	2.00E-01	2.25E-01	2.24E-01	1.15E-02
		HC as Hexane	1.87E-01	1.85E-01	1.82E-01	1.99E-01	1.82E-01	1.89E-01	I	1.66E-01	1.90E-01	1.85E-01	9.35E-03
		Sum of VOCs	I	5.57E-02	5.51E-02	6.68E-02	5.23E-02	5.86E-02	I	5.23E-02	5.45E-02	5.64E-02	5.03E-03
		Sum of HAPs	I	4.32E-02	4.30E-02	5.28E-02	4.03E-02	4.54E-02	I	4.03E-02	4.28E-02	4.40E-02	4.29E-03
		Sum of POMs	I	4.05E-04	4.11E-04	6.15E-04	3.79E-04	4.72E-04	I	4.30E-04	4.24E-04	4.48E-04	7.90E-05
			Individual Organic HAPs										
x		**Phenol**	I	1.75E-02	1.76E-02	2.34E-02	1.64E-02	1.88E-02	I	1.67E-02	1.75E-02	1.83E-02	2.38E-03
x		**m,p-Cresol**	I	1.55E-02	1.53E-02	1.84E-02	1.41E-02	1.64E-02	I	1.34E-02	1.46E-02	1.54E-02	1.66E-03
x		**Benzene**	I	5.23E-03	5.39E-03	5.66E-03	5.35E-03	5.44E-03	I	5.46E-03	5.83E-03	5.48E-03	2.04E-04
x		**o-Cresol**	I	1.44E-03	1.38E-03	1.61E-03	1.28E-03	1.47E-03	I	1.18E-03	1.31E-03	1.38E-03	1.40E-04
x		**Toluene**	I	1.32E-03	1.29E-03	1.41E-03	1.32E-03	1.38E-03	I	1.31E-03	1.43E-03	1.35E-03	5.34E-05
x		**m,p-Xylene**	I	6.61E-04	5.97E-04	7.05E-04	6.37E-04	6.77E-04	I	6.97E-04	6.91E-04	6.67E-04	3.85E-05
x	z	**Naphthalene**	I	3.09E-04	3.19E-04	4.51E-04	2.85E-04	3.57E-04	I	3.13E-04	3.26E-04	3.37E-04	5.48E-05
x		**Aniline**	3.51E-04	3.87E-04	3.47E-04	2.99E-04	2.54E-04	1.94E-04	I	2.57E-04	2.81E-04	2.96E-04	6.29E-05
x		**Formaldehyde**	2.08E-04	2.04E-04	1.39E-04	1.63E-04	1.48E-04	9.56E-05	I	2.63E-04	1.72E-04	1.74E-04	5.10E-05
x		**o-Xylene**	I	1.80E-04	1.58E-04	1.74E-04	1.65E-04	1.68E-04	I	1.74E-04	1.65E-04	1.69E-04	7.37E-06
x		**Styrene**	I	1.54E-04	1.27E-04	1.45E-04	1.25E-04	1.12E-04	I	1.49E-04	1.33E-04	1.35E-04	1.49E-05
x		**Acetaldehyde**	9.83E-05	9.31E-05	7.66E-05	9.47E-05	8.01E-05	6.99E-05	I	1.15E-04	8.73E-05	8.93E-05	1.41E-05
x		**Ethylbenzene**	I	8.77E-05	7.21E-05	7.57E-05	7.02E-05	6.85E-05	I	6.80E-05	7.94E-05	7.45E-05	7.10E-06
x	z	**2-Methylnaphthalene**	I	5.94E-05	5.76E-05	9.92E-05	5.39E-05	6.93E-05	I	7.02E-05	6.66E-05	6.80E-05	1.51E-05
x	z	**1-Methylnaphthalene**	I	2.80E-05	2.63E-05	4.57E-05	2.45E-05	3.16E-05	I	3.29E-05	3.09E-05	3.14E-05	6.97E-06
x	z	**1,3-Dimethylnaphthalene**	I	2.10E-05	1.71E-05	2.74E-05	1.28E-05	1.82E-05	I	1.58E-05	1.85E-05	1.87E-05	4.59E-06
x		**Hexane**	I	8.10E-06	8.33E-06	1.89E-05	1.60E-05	1.42E-05	I	1.43E-05	I	1.33E-05	4.30E-06
x	z	**1,8-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**2-Butanone**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Propionaldehyde**	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	**Acenaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Biphenyl**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,2-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FZ ALWA Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	6/15/04	6/15/04	6/15/04	6/16/04	6/16/04	6/16/04	6/16/04	6/17/04	6/17/04		
x	z	**1,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
			Other VOCs										
		1,2,3-Trimethylbenzene	I	2.96E-03	2.86E-03	3.31E-03	2.67E-03	3.01E-03	I	2.48E-03	2.73E-03	2.86E-03	2.68E-04
		1,2,4-Trimethylbenzene	I	2.88E-03	2.67E-03	3.06E-03	2.56E-03	2.80E-03	I	2.40E-03	2.56E-03	2.70E-03	2.23E-04
		1,3-Diethylbenzene	I	1.69E-03	1.65E-03	1.73E-03	1.53E-03	1.58E-03	I	1.55E-03	1.57E-03	1.61E-03	7.69E-05
		Dodecane	I	9.63E-04	9.99E-04	1.42E-03	1.50E-03	1.88E-03	I	1.69E-03	1.04E-03	1.36E-03	3.64E-04
		3-Ethyltoluene	I	9.87E-04	9.29E-04	9.87E-04	8.69E-04	9.43E-04	I	7.37E-04	8.44E-04	8.99E-04	8.98E-05
		2,6-Dimethylphenol	I	8.06E-04	7.88E-04	9.83E-04	7.25E-04	8.46E-04	I	7.59E-04	7.70E-04	8.11E-04	8.48E-05
		Butyraldehyde/Methacrolein	6.82E-04	6.40E-04	6.77E-04	7.68E-04	6.40E-04	6.58E-04	I	7.74E-04	7.78E-04	7.02E-04	6.09E-05
		Undecane	I	3.18E-04	3.31E-04	3.97E-04	4.93E-04	3.50E-04	I	4.97E-04	3.36E-04	3.89E-04	7.68E-05
		2-Ethyltoluene	I	4.21E-04	3.85E-04	4.25E-04	3.56E-04	3.91E-04	I	3.27E-04	3.56E-04	3.80E-04	3.59E-05
		Propylbenzene	I	2.91E-04	2.94E-04	2.86E-04	2.46E-04	2.62E-04	I	1.91E-04	2.13E-04	2.55E-04	4.03E-05
		2,4-Dimethylphenol	I	1.77E-04	1.95E-04	2.00E-04	1.70E-04	1.88E-04	I	1.91E-04	1.96E-04	1.88E-04	1.11E-05
		Decane	I	8.96E-05	8.54E-05	9.57E-05	7.66E-05	8.83E-05	I	7.11E-05	7.61E-05	8.33E-05	8.84E-06
		Tetradecane	I	6.21E-05	6.18E-05	1.09E-04	5.77E-05	7.13E-05	I	7.64E-05	7.49E-05	7.34E-05	1.74E-05
		o,m,p-Tolualdehyde	7.63E-05	I	6.20E-05	6.33E-05	6.28E-05	4.81E-05	I	7.92E-05	6.06E-05	6.46E-05	1.04E-05
		Benzaldehyde	6.24E-05	6.18E-05	4.97E-05	5.57E-05	4.92E-05	I	I	6.54E-05	4.90E-05	5.62E-05	7.03E-06
		Pentanal	4.96E-05	4.82E-05	4.82E-05	5.61E-05	I	3.55E-05	I	5.57E-05	4.79E-05	4.88E-05	6.82E-06
		Hexaldehyde	3.23E-05	3.13E-05	2.43E-05	2.19E-05	2.21E-05	1.37E-05	I	2.85E-05	2.43E-05	2.48E-05	5.99E-06
		Indan	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Cyclohexane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Heptane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Indene	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FZ ALWA Individual Emissions Results – Lb/Lb Binder

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	**6/15/04**	**6/15/04**	**6/15/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/17/04**	**6/17/04**		
		Nonane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Octane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
			Other Analytes										
		Acetone	6.22E-05	5.93E-05	6.66E-05	7.34E-05	5.06E-05	7.08E-05	I	6.94E-05	8.37E-05	6.70E-05	9.94E-06
		Carbon Dioxide	5.10E-01	4.91E-01	3.80E-01	3.45E-01	3.46E-01	2.26E-01	3.38E-01	6.01E-01	4.11E-01	4.05E-01	1.13E-01
		Carbon Monoxide	1.17E-01	1.05E-01	1.06E-01	1.25E-01	1.08E-01	1.10E-01	1.08E-01	1.36E-01	1.21E-01	1.15E-01	1.04E-02

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.

Test Plan FZ ALWA Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	**6/15/04**	**6/15/04**	**6/15/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/17/04**	**6/17/04**		
		TGOC as Propane	3.70E+01	3.65E+01	3.50E+01	3.75E+01	3.97E+01	3.62E+01	3.52E+01	2.93E+01	3.64E+01	3.59E+01	2.66E+00
		HC as Hexane	3.01E+01	2.98E+01	2.88E+01	3.08E+01	3.21E+01	2.98E+01	I	2.43E+01	3.08E+01	2.96E+01	2.16E+00
		Sum of VOCs	I	8.98E+00	8.72E+00	1.03E+01	9.20E+00	9.26E+00	I	7.66E+00	8.81E+00	9.00E+00	7.40E-01
		Sum of HAPs	I	6.98E+00	6.81E+00	8.18E+00	7.08E+00	7.18E+00	I	5.90E+00	6.92E+00	7.01E+00	6.19E-01
		Sum of POMs	I	6.73E-02	6.65E-02	9.66E-02	6.61E-02	7.52E-02	I	6.33E-02	7.15E-02	7.24E-02	1.06E-02
			Individual Organic HAPs										
x		**Phenol**	I	2.83E+00	2.79E+00	3.62E+00	2.88E+00	2.98E+00	I	2.45E+00	2.83E+00	2.91E+00	3.27E-01
x		**m,p-Cresol**	I	2.51E+00	2.43E+00	2.86E+00	2.48E+00	2.59E+00	I	1.96E+00	2.37E+00	2.46E+00	2.48E-01
x		**Benzene**	I	8.44E-01	8.54E-01	8.78E-01	9.41E-01	8.60E-01	I	8.00E-01	9.43E-01	8.74E-01	4.83E-02
x		**o-Cresol**	I	2.32E-01	2.19E-01	2.50E-01	2.26E-01	2.32E-01	I	1.73E-01	2.12E-01	2.21E-01	2.22E-02
x		**Toluene**	I	2.12E-01	2.05E-01	2.19E-01	2.33E-01	2.18E-01	I	1.93E-01	2.31E-01	2.16E-01	1.31E-02
x		**m,p-Xylene**	I	1.07E-01	9.46E-02	1.09E-01	1.12E-01	1.07E-01	I	1.02E-01	1.12E-01	1.06E-01	5.71E-03
x	z	**Naphthalene**	I	4.99E-02	5.05E-02	6.99E-02	5.01E-02	5.64E-02	I	4.59E-02	5.27E-02	5.36E-02	7.28E-03
x		**Aniline**	5.63E-02	6.25E-02	5.50E-02	4.64E-02	4.48E-02	3.07E-02	I	3.77E-02	4.54E-02	4.73E-02	9.66E-03
x		**Formaldehyde**	3.34E-02	3.28E-02	2.21E-02	2.52E-02	2.60E-02	1.51E-02	I	3.86E-02	2.78E-02	2.76E-02	6.86E-03
x		**o-Xylene**	I	2.90E-02	2.50E-02	2.70E-02	2.91E-02	2.65E-02	I	2.54E-02	2.66E-02	2.69E-02	1.48E-03
x		**Styrene**	I	2.49E-02	2.02E-02	2.24E-02	2.20E-02	1.77E-02	I	2.18E-02	2.15E-02	2.15E-02	2.02E-03
x		**Acetaldehyde**	1.58E-02	1.50E-02	1.21E-02	1.47E-02	1.41E-02	1.10E-02	I	1.68E-02	1.41E-02	1.42E-02	1.74E-03
x		**Ethylbenzene**	I	1.41E-02	1.14E-02	1.17E-02	1.24E-02	1.08E-02	I	9.95E-03	1.28E-02	1.19E-02	1.27E-03
x	z	**2-Methylnaphthalene**	I	9.58E-03	9.13E-03	1.54E-02	9.48E-03	1.10E-02	I	1.03E-02	1.08E-02	1.08E-02	1.97E-03
x	z	**1-Methylnaphthalene**	I	4.52E-03	4.16E-03	7.08E-03	4.32E-03	5.00E-03	I	4.82E-03	5.00E-03	4.99E-03	9.07E-04
x	z	**1,3-Dimethylnaphthalene**	I	3.39E-03	2.71E-03	4.24E-03	2.25E-03	2.88E-03	I	2.32E-03	3.00E-03	2.97E-03	6.34E-04
x		**Hexane**	I	1.31E-03	1.32E-03	2.93E-03	2.82E-03	2.24E-03	I	2.09E-03	I	2.12E-03	6.41E-04
x	z	**1,2-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,3-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,6-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x	z	**Acenaphthalene**	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FZ ALWA Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	**6/15/04**	**6/15/04**	**6/15/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/17/04**	**6/17/04**		
x		**Biphenyl**	I	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
x		**2-Butanone**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Acrolein**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
x		**Propionaldehyde**	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
			Other VOCs										
		1,2,3-Trimethylbenzene	I	4.78E-01	4.53E-01	5.13E-01	4.71E-01	4.76E-01	I	3.64E-01	4.41E-01	4.56E-01	4.33E-02
		1,2,4-Trimethylbenzene	I	4.64E-01	4.23E-01	4.74E-01	4.51E-01	4.43E-01	I	3.52E-01	4.13E-01	4.32E-01	3.80E-02
		1,3-Diethylbenzene	I	2.72E-01	2.61E-01	2.68E-01	2.68E-01	2.50E-01	I	2.26E-01	2.54E-01	2.57E-01	1.46E-02
		Dodecane	I	1.55E-01	1.58E-01	2.21E-01	2.64E-01	2.98E-01	I	2.48E-01	1.69E-01	2.16E-01	5.25E-02
		3-Ethyltoluene	I	1.59E-01	1.47E-01	1.53E-01	1.53E-01	1.49E-01	I	1.08E-01	1.36E-01	1.44E-01	1.59E-02
		2,6-Dimethylphenol	I	1.30E-01	1.25E-01	1.52E-01	1.28E-01	1.34E-01	I	1.11E-01	1.24E-01	1.29E-01	1.15E-02
		Butyraldehyde/Methacrolien	1.09E-01	1.03E-01	1.07E-01	1.19E-01	1.13E-01	1.04E-01	I	1.13E-01	1.26E-01	1.12E-01	7.17E-03
		Undecane	I	5.13E-02	5.25E-02	6.15E-02	8.68E-02	5.54E-02	I	7.29E-02	5.43E-02	6.21E-02	1.22E-02
		2-Ethyltoluene	I	6.79E-02	6.10E-02	6.58E-02	6.26E-02	6.17E-02	I	4.79E-02	5.75E-02	6.07E-02	6.04E-03
		n-Propylbenzene	I	4.69E-02	4.66E-02	4.43E-02	4.33E-02	4.14E-02	I	2.80E-02	3.45E-02	4.07E-02	6.48E-03
		2,4-Dimethylphenol	I	2.85E-02	3.09E-02	3.11E-02	2.98E-02	2.98E-02	I	2.80E-02	3.17E-02	3.00E-02	1.25E-03
		Decane	I	1.45E-02	1.35E-02	1.48E-02	1.35E-02	1.40E-02	I	1.04E-02	1.23E-02	1.33E-02	1.39E-03
		Tetradecane	I	1.00E-02	9.79E-03	1.69E-02	1.01E-02	1.13E-02	I	1.12E-02	1.21E-02	1.16E-02	2.30E-03
		o,m,p-Tolualdehyde	1.22E-02	I	9.83E-03	9.81E-03	1.11E-02	7.60E-03	I	1.16E-02	9.80E-03	1.03E-02	1.42E-03
		Benzaldehyde	1.00E-02	9.97E-03	7.88E-03	8.63E-03	8.66E-03	I	I	9.57E-03	7.92E-03	8.95E-03	8.41E-04
		Pentanal	7.95E-03	7.78E-03	7.64E-03	8.70E-03	I	5.62E-03	I	8.16E-03	7.75E-03	7.66E-03	8.94E-04
		Hexaldehyde	5.18E-03	5.05E-03	3.86E-03	3.39E-03	3.89E-03	2.16E-03	I	4.18E-03	3.94E-03	3.95E-03	8.86E-04
		1,3,5-Trimethylbenzene	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Cyclohexane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Heptane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Indan	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Indene	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Nonane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Octane	I	ND	ND	ND	ND	ND	I	ND	ND	ND	NA
		Crotonaldehyde	ND	ND	ND	ND	ND	ND	I	ND	ND	ND	NA

Test Plan FZ ALWA Individual Emissions Results – Lb/Tn Metal

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009	Average	STDEV
		Test Dates	**6/15/04**	**6/15/04**	**6/15/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/16/04**	**6/17/04**	**6/17/04**		
			Other Analytes										
		Acetone	9.98E-03	9.57E-03	1.06E-02	1.14E-02	8.91E-03	1.12E-02	I	1.02E-02	I	1.03E-02	8.10E-04
		Carbon Dioxide	8.18E+01	7.93E+01	6.02E+01	5.35E+01	6.10E+01	3.57E+01	5.52E+01	8.81E+01	6.64E+01	6.46E+01	1.54E+01
		Carbon Monoxide	1.88E+01	1.69E+01	1.68E+01	1.93E+01	1.91E+01	1.74E+01	1.76E+01	1.99E+01	1.95E+01	1.84E+01	1.14E+00

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.

Test Plan FZ Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	8.19E-06
1,2,4-Trimethylbenzene	8.19E-06
1,3,5-Trimethylbenzene	8.19E-06
1,3-Dimethylnaphthalene	8.19E-06
1-Methylnaphthalene	8.19E-06
2-Ethyltoluene	8.19E-06
2-Methylnaphthalene	8.19E-06
Benzene	8.19E-06
Ethylbenzene	8.19E-06
Hexane	8.19E-06
m,p-Xylene	8.19E-06
Naphthalene	8.19E-06
o-Xylene	8.19E-06
Styrene	8.19E-06
Toluene	8.19E-06
Undecane	8.19E-06
1,2-Dimethylnaphthalene	4.09E-05
1,3-Diethylbenzene	4.09E-05
1,5-Dimethylnaphthalene	4.09E-05
1,6-Dimethylnaphthalene	4.09E-05
1,8-Dimethylnaphthalene	4.09E-05

Analytes	Lb/Lb Binder
2,3,5-Trimethylnaphthalene	4.09E-05
2,3-Dimethylnaphthalene	4.09E-05
2,4-Dimethylphenol	4.09E-05
2,6-Dimethylnaphthalene	4.09E-05
2,6-Dimethylphenol	4.09E-05
2,7- Dimethylnaphthalene	4.09E-05
3-Ethyltoluene	4.09E-05
Acenaphthalene	4.09E-05
Biphenyl	4.09E-05
Cyclohexane	4.09E-05
Decane	4.09E-05
Dodecane	4.09E-05
Heptane	4.09E-05
Indan	4.09E-05
Indene	4.09E-05
m,p-Cresol	4.09E-05
Nonane	4.09E-05
o-Cresol	4.09E-05
Octane	4.09E-05
Phenol	4.09E-05
Propylbenzene	4.09E-05

Analytes	Lb/Lb Binder
Tetradecane	4.09E-05
HC as Hexane	2.59E-04
2-Butanone (MEK)	4.49E-06
Acetaldehyde	4.49E-06
Acetone	4.49E-06
Acrolein	3.00E-05
Benzaldehyde	4.49E-06
Butyraldehyde	4.49E-06
Crotonaldehyde	3.00E-05
Formaldehyde	4.49E-06
Hexaldehyde	4.49E-06
Butyraldehyde/Methacrolein	7.49E-06
o,m,p-Tolualdehyde	1.20E-05
Pentanal (Valeraldehyde)	4.49E-06
Propionaldehyde (Propanal)	4.49E-06
Aniline	5.11E-05
Dimethylaniline	1.02E-04
Carbon Monoxide	1.08E-03
Carbon Dioxide	1.69E-03

Test Plan FZ Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.33E-03
1,2,4-Trimethylbenzene	1.33E-03
1,3,5-Trimethylbenzene	1.33E-03
1,3-Dimethylnaphthalene	1.33E-03
1-Methylnaphthalene	1.33E-03
2-Ethyltoluene	1.33E-03
2-Methylnaphthalene	1.33E-03
Benzene	1.33E-03
Ethylbenzene	1.33E-03
Hexane	1.33E-03
m,p-Xylene	1.33E-03
Naphthalene	1.33E-03
o-Xylene	1.33E-03
Styrene	1.33E-03
Toluene	1.33E-03
Undecane	1.33E-03
1,2-Dimethylnaphthalene	6.63E-03
1,3-Diethylbenzene	6.63E-03
1,5-Dimethylnaphthalene	6.63E-03
1,6-Dimethylnaphthalene	6.63E-03
1,8-Dimethylnaphthalene	6.63E-03

Analytes	Lb/Tn Metal
2,3,5-Trimethylnaphthalene	6.63E-03
2,3-Dimethylnaphthalene	6.63E-03
2,4-Dimethylphenol	6.63E-03
2,6-Dimethylnaphthalene	6.63E-03
2,6-Dimethylphenol	6.63E-03
2,7- Dimethylnaphthalene	6.63E-03
3-Ethyltoluene	6.63E-03
Acenaphthalene	6.63E-03
Biphenyl	6.63E-03
Cyclohexane	6.63E-03
Decane	6.63E-03
Dodecane	6.63E-03
Heptane	6.63E-03
Indan	6.63E-03
Indene	6.63E-03
m,p-Cresol	6.63E-03
Nonane	6.63E-03
o-Cresol	6.63E-03
Octane	6.63E-03
Phenol	6.63E-03
Propylbenzene	6.63E-03

Analytes	Lb/Tn Metal
Tetradecane	6.63E-03
HC as Hexane	4.19E-02
2-Butanone (MEK)	7.28E-04
Acetaldehyde	7.28E-04
Acetone	7.28E-04
Acrolein	4.85E-03
Benzaldehyde	7.28E-04
Butyraldehyde	7.28E-04
Crotonaldehyde	4.85E-03
Formaldehyde	7.28E-04
Hexaldehyde	7.28E-04
Butyraldehyde/Methacrolein	1.21E-03
o,m,p-Tolualdehyde	1.94E-03
Pentanal (Valeraldehyde)	7.28E-04
Propionaldehyde (Propanal)	7.28E-04
Aniline	8.27E-03
Dimethylaniline	1.65E-02
Carbon Monoxide	1.75E-01
Carbon Dioxide	2.75E-01

APPENDIX C DETAILED PROCESS DATA FOR TEST FZ

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Test Series FZ Detailed Process Data

No-Bake Mix/Make/Cure														
Test Dates	6/15/04	6/15/04	6/15/04	6/16/04	6/16/04	6/16/04	6/16/04	6/17/04	6/17/04	Average FZ001-009	6/18/04	6/18/04	6/18/04	Average FZ010-012
Emissions Sample #	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009		FZ010	FZ011	FZ012	
Production Sample #	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009		FZ010	FZ011	FZ012	
Calculated Standard % Binder	7.527	7.556	7.525	7.523	7.544	7.527	7.517	7.527	7.513	**7.5**	2.247	2.247	2.246	**2.2**
Calculated % Binder (BOA)	8.140	8.174	8.138	8.135	8.160	8.140	8.128	8.140	8.123	**8.1**	2.298	2.299	2.301	**2.3**
Mold Weight, lbs	31.7	32.0	31.7	31.1	33.5	31.1	31.1	29.1	30.9	**31.4**	117.1	112.7	109.5	**113.1**
Calculated Total Binder Weight, lbs	2.39	2.42	2.38	2.34	2.53	2.34	2.33	2.19	2.32	**2.4**	2.63	2.53	2.46	**2.5**
1800F LOI, % (Note 1)	6.63	6.51	6.76	6.36	6.46	6.20	6.51	6.62	6.54	**6.5**	1.84	1.87	1.81	**1.8**
Sand Temperature at NB mixer, deg F	75	84	86	88	80	82	82	82	84	**82.6**	83	83	82	**83**
Dogbone Core 2 hr. Tensile Strength, psi	62.7	109.8	105.8	85.3	90.8	71.5	75.2	59.8	63.0	**81.1**	205.6	170.5	133.2	**169.7**

No-Bake PCS														
Test Dates	6/15/04	6/15/04	6/15/04	6/16/04	6/16/04	6/16/04	6/16/04	6/17/04	6/17/04	Average FZ001-009	6/18/04	6/18/04	6/18/04	Average FZ010-012
Emissions Sample #	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009		FZ010	FZ011	FZ012	
Production Sample #	FZ001	FZ002	FZ003	FZ004	FZ005	FZ006	FZ007	FZ008	FZ009		FZ010	FZ011	FZ012	
Pouring Temp, deg F	2683	2670	2662	2689	2684	2673	2688	2687	2670	**2677**	2676	2686	2685	**2682**
Pouring Time, sec.	17	14	14	13	18	14	16	13	16	**15**	16	12	17	**15**
Cast Weight (all metal inside mold), Lbs.	29.80	30.00	30.05	30.20	28.75	29.60	28.55	29.90	28.70	**29.63**	29.45	29.75	29.45	**29.55**
Process Air Temperature in Hood, deg F (Note 2)	85	88	90	88	88	90	94	86	87	**88**	85	86	86	**86**
Mold Temperature when placed in hood, deg F	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	77.00	78	79.00	**78**
Mold Age When Poured, hr	22.2	22.6	24.0	40.9	26.7	28.0	29.3	25.8	26.9	**27.1**	24.2	25.2	26.2	**25**
Test Length, Min	75	75	75	75	75	75	75	75	75	**75**	75.0	75.0	75.0	**75**
Rank order 1-on star ALWA	9	6	12	5	7	4	11	8	10					
Rank order 1-on star sand			Note 3				Note 4			Note 4	1	2	3	

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.

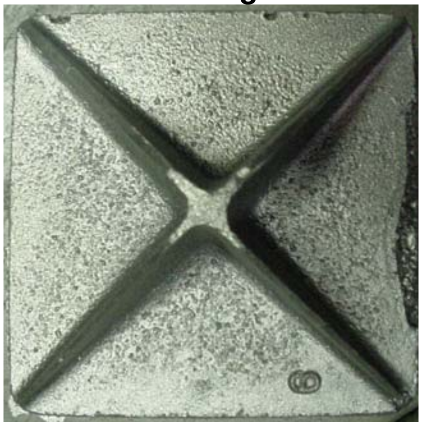
Note 3: FZ004 bagged for hold after 21 hours

Note 4: FZ007 invalidated do to loss of emission data. FZ007 not included in average

Ashland LWA

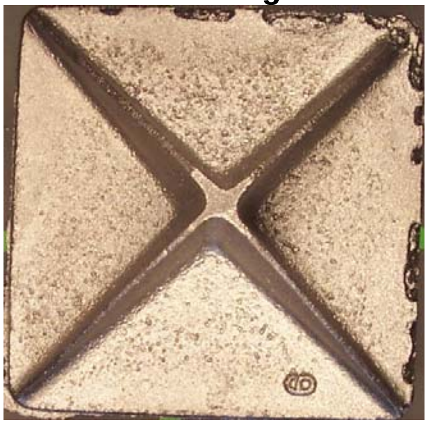
Wedron 530

Best Casting FZ006



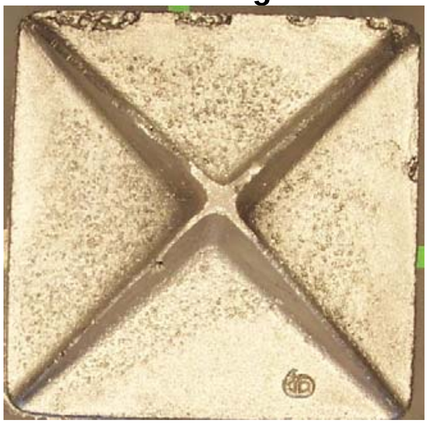
Best Casting FZ010

Median Casting FZ008

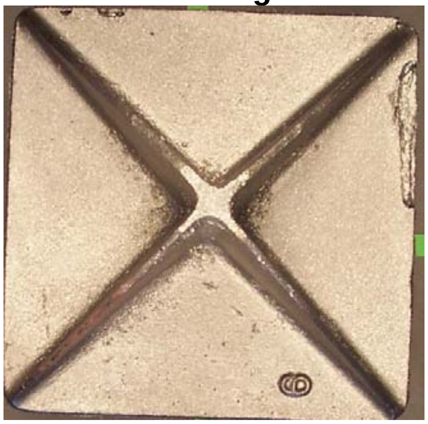


Median Casting FZ011

Worst Casting FZ003



Worst Casting FZ012



APPENDIX D METHOD 25A CHARTS

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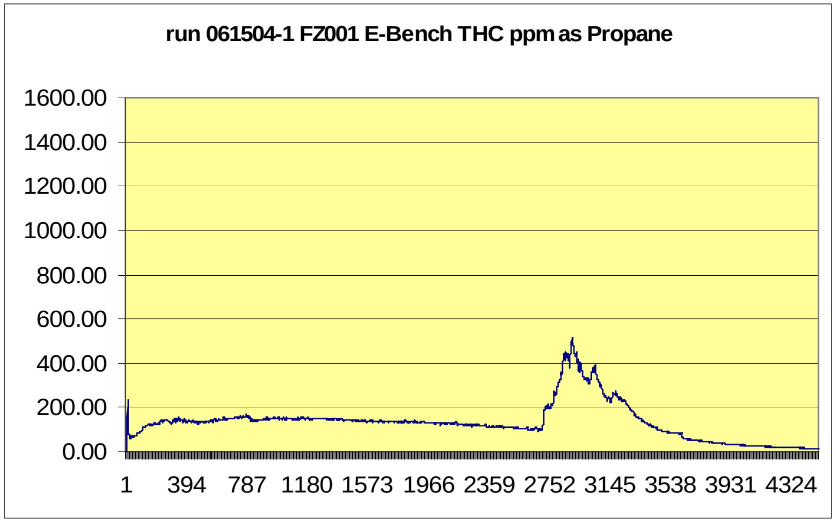
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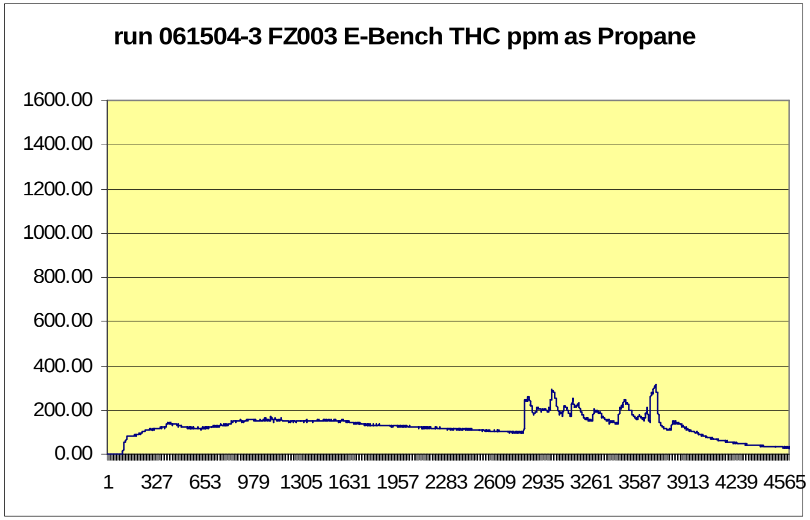
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 394 787 1180 1573 1966 2359 2752 3145 3538 3931 4324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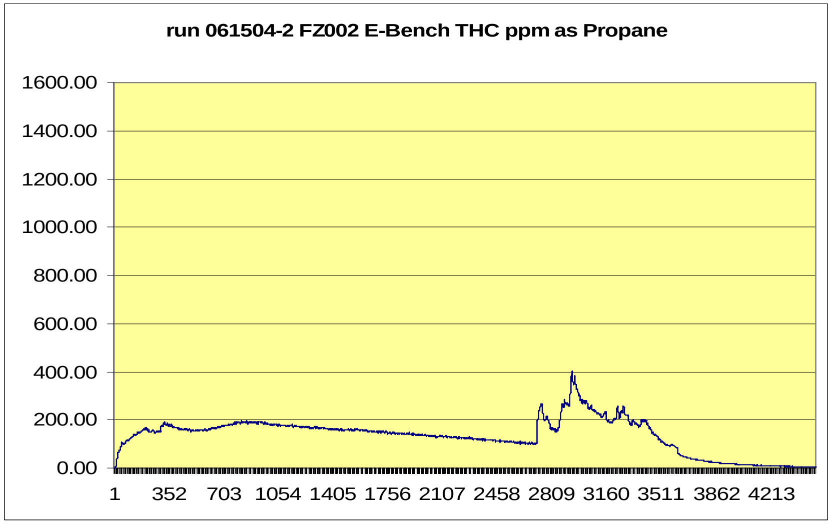
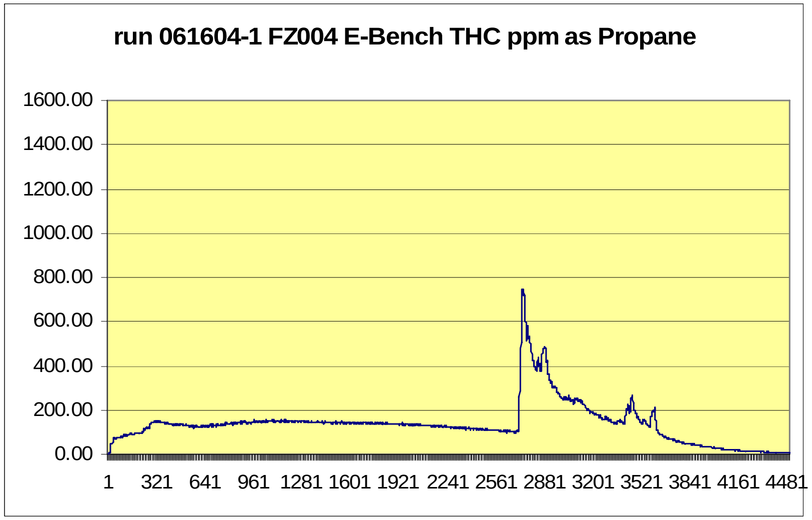
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 327 653 979 1305 1631 1957 2283 2609 2935 3261 3587 3913 4239 4565


run 061504-2 FZ002 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 352 703 1054 1405 1756 2107 2458 2809 3160 3511 3862 4213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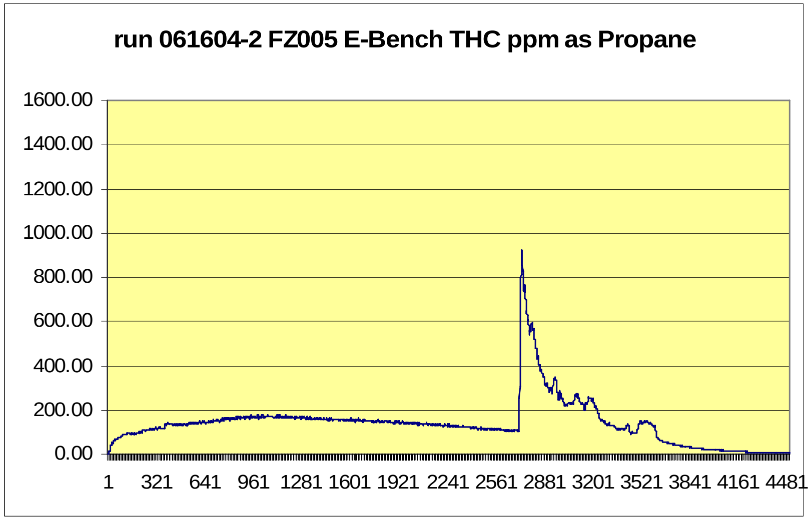
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481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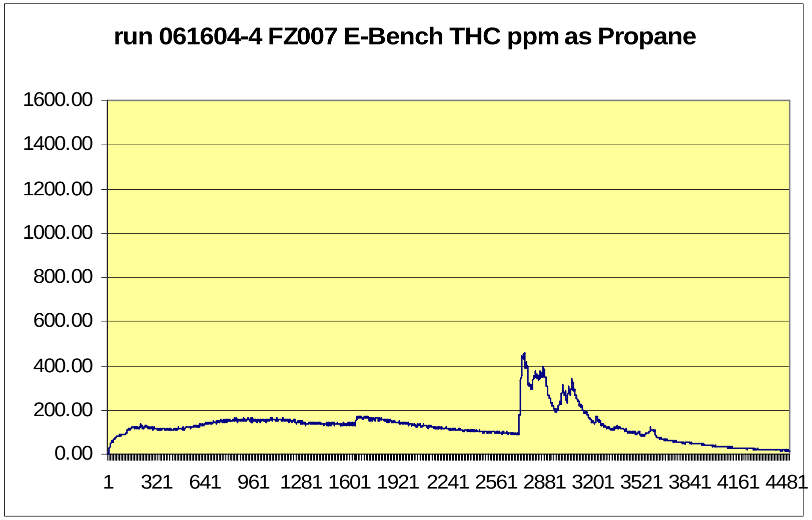
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 061604-4 FZ007 E-Bench THC ppm as Propane
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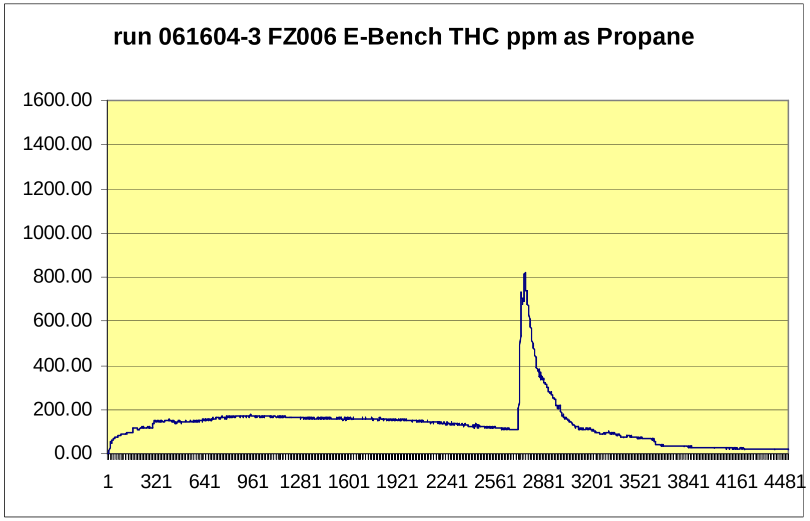
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 061604-3 FZ006 E-Bench THC ppm as Propane
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1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
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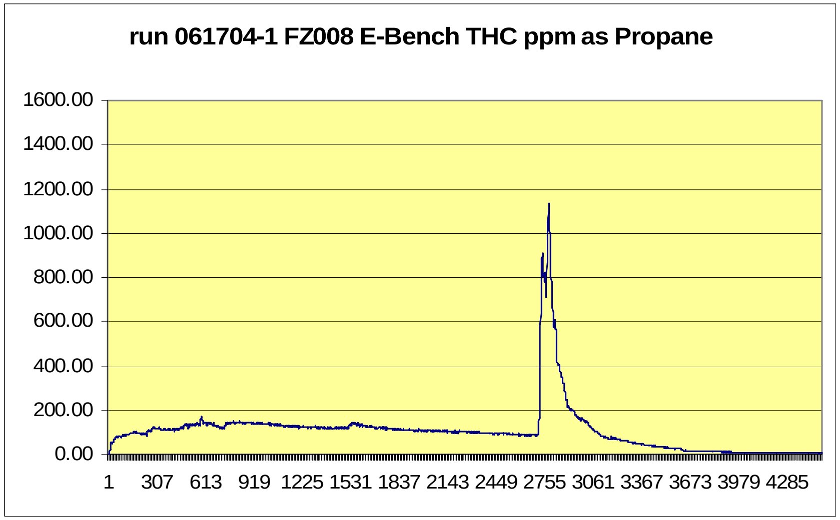
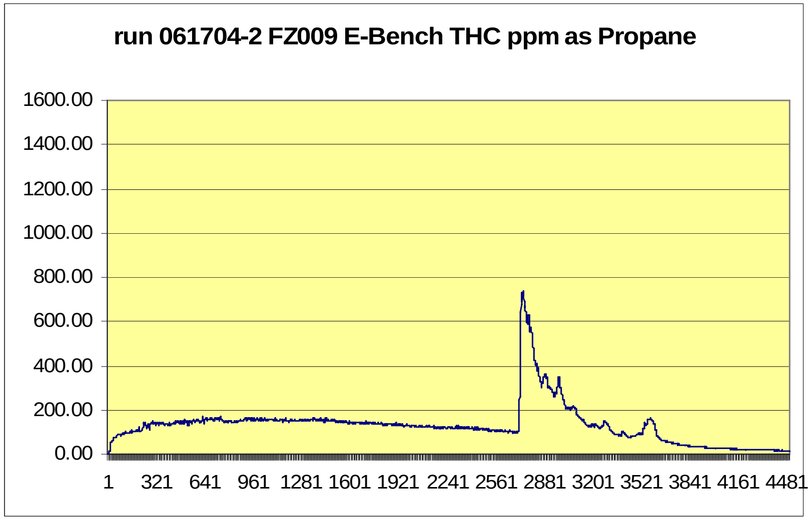
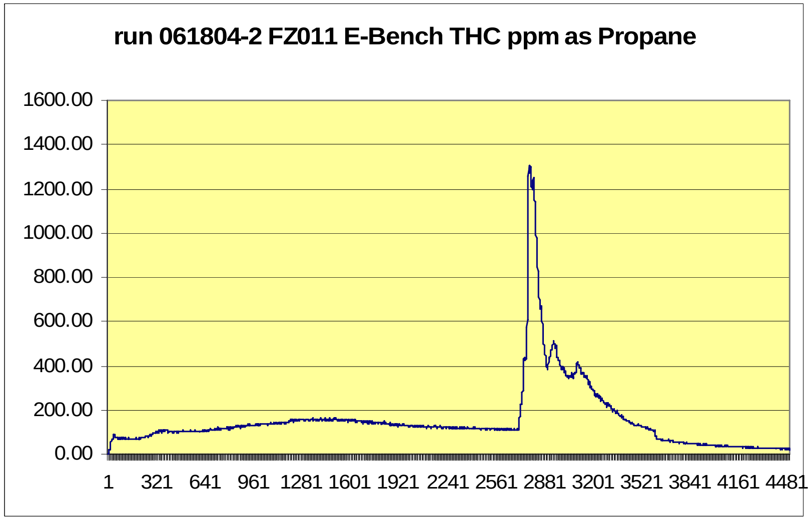
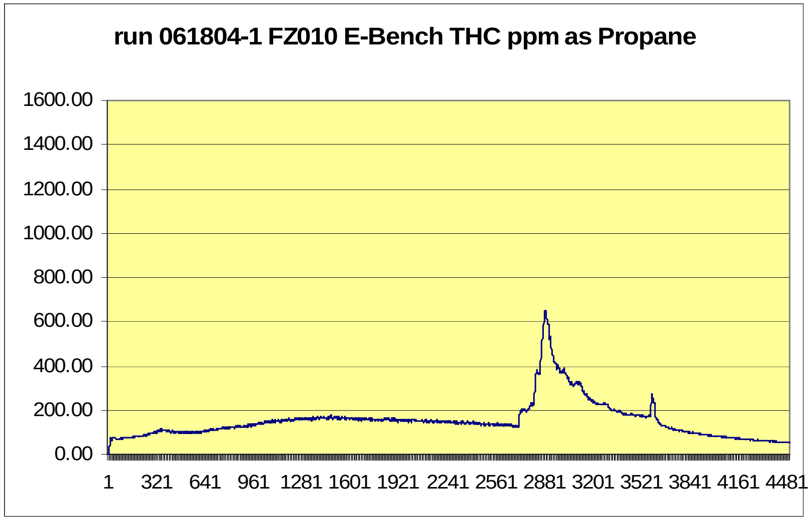
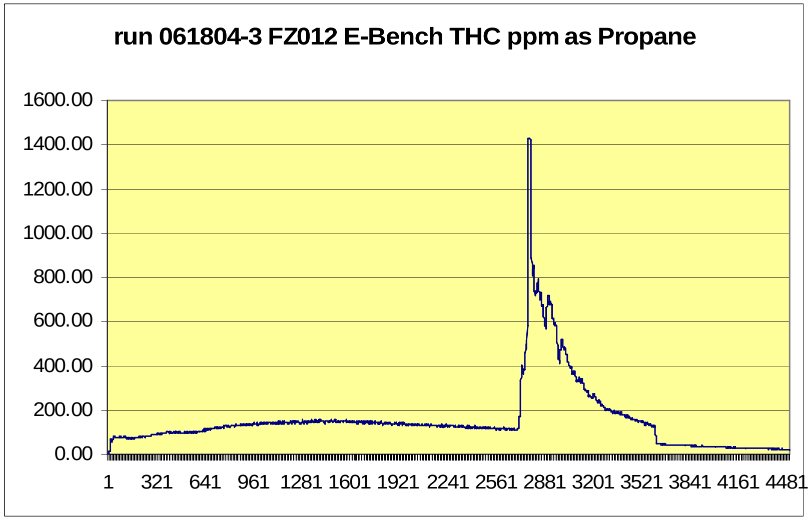

run 061704-1 FZ008 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 307 613 919 1225 1531 1837 2143 2449 2755 3061 3367 3673 3979 4285


run 061704-2 FZ009 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 061804-2 FZ011 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 061804-1 FZ010 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481


run 061804-3 FZ012 E-Bench THC ppm as Propane
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 321 641 961 1281 1601 1921 2241 2561 2881 3201 3521 3841 4161 4481

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APPENDIX E GLOSSARY

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Glossary

ACFM	Actual Cubic Feet Per Minute
BO	Based on ( ).
BOA	Based on Aggregate
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, Not Available
ND	Non-Detect
NT	Not Tested, 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