Casting Emission Reduction Program

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FY 2003 Tasks

Baseline
Pouring, Cooling, Shakeout of Phenolic Urethane No-Bake Molds Poured with Iron

Technikon #1410-123 FL

19 December 2003
(This document revised for public distribution)

United States Environmental Protection Agency

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

DaimlerChrysler Ford Motor Company General Motors

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Pouring, Cooling, Shakeout of Phenolic Urethane No-Bake Molds Poured with Iron

Technikon # 1410-123 FL

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

Research Chemist	// Original Signed // Carmen Hornsby	Date
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V.P. Measurement Technology	// Original Signed // Clifford R. Glowacki, CIH	Date
V.P. Operations	// Original Signed // George Crandell	Date
President	// Original Signed // William Walden	Date

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

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Executive Summary

This report contains the results of emission testing to evaluate the pouring, cooling, and shakeout emissions from Test FL, a phenolic urethane No-Bake system. Test FL will be used as a baseline against which other No-Bake binder systems will be compared. All testing was conducted by Technikon, LLC in its research foundry. The emissions results are reported in pounds of analyte per ton of metal poured and pounds of emissions per pound of binder.

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, binder and mold; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack temperature, pressure, volumetric flow rate, and moisture content. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the tests runs. Samples were collected and analyzed for sixty-six (66) 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 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 are shown in the following table reported as both lbs/tn metal and lb/lb binder.

Test Plan FL Average Emissions Results

	TGOC as Propane	HC as Hexane	Sum of VOCs	Sum of HAPs	Sum of POMs
Test FL (Lb/Tn Metal)	12.672	4.043	2.488	1.763	0.040
Test FL (Lb/Lb Binder)	0.2094	0.0670	0.0428	0.0303	0.0007

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

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). The parties to the CERP Cooperative Research and Development Agreement (CRADA) include The Environmental Research Consortium (ERC), a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Tank-automotive and Armaments Command, Armament Research, Development, and Engineering Center (TACOM-ARDEC), a laboratory of the United States Army; the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). Other technical partners directly supporting the project include: The US Environmental Protection Agency (US EPA); The California Air Resources Board (CARB) and individual foundries and industry suppliers.

CERP's purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes

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 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 specially designed to facilitate the collection and evaluation of airborne emissions and associated process data.

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.

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 <u>relative emission reductions</u> 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 <u>should not</u> 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 coreless No-Bake mold system. 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 emissions and process data included in Appendix B and C of this report respectively. Section 4 of this report contains a discussion of the results.

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

1.4 Specific Test Plan and Objectives

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

Table 1-1 Test Plan Summary

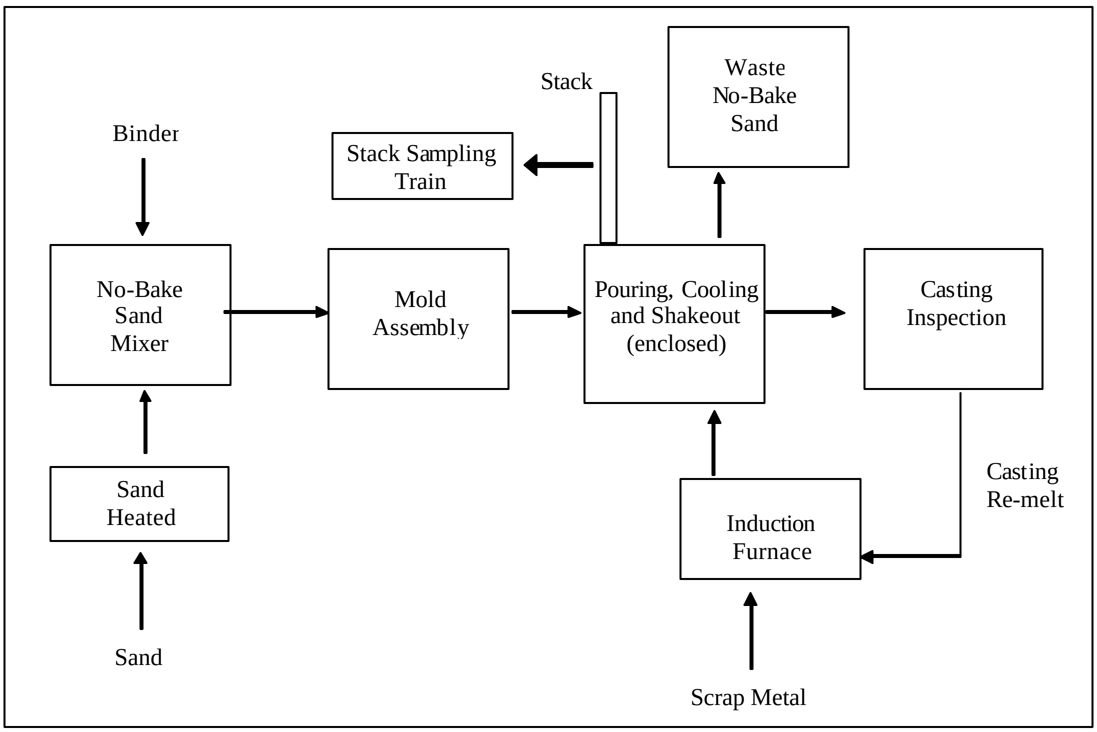
	Test Plan
Type of Process tested	Phenolic Urethane No-Bake Baseline
Test Plan Number	1410 123 FL
Binder System	HA Int'l TECHNISET 6000/6433/17-727
Metal Poured	Iron
Casting Type	4-on Gear
Number of molds poured	9 Sampling
Test Dates	10/6/03 < 10/8/03
Emissions Measured	TGOC as Propane, HC as Hexane, 66 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Binder & Mold Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate

2.0 Test Methodology

2.1 Description of Process and Testing Equipment

Figure 2-1 is a diagram of the Pre-Production Foundry process equipment.

Figure 2-1 Pre-Production Foundry Layout Diagram



2.2 Description of Testing Program

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

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

2. **<u>Mold 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°F. The sand was placed in 24 x 25 x 5 flasks and vibrated from the time the flasks were almost full until ten (10) seconds after they were full. Sand and binder calibration and mold weight was recorded on the Process Data Summary Sheet.

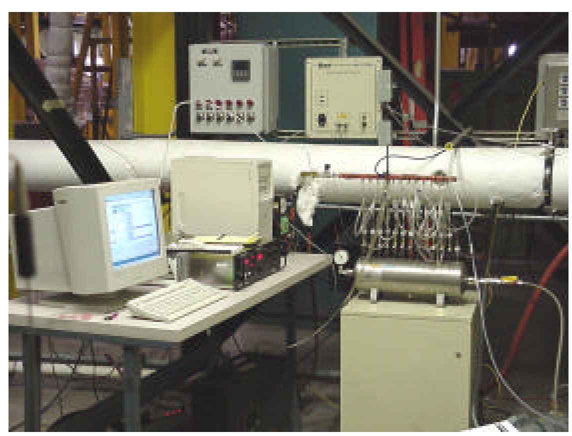
3. **<u>Metal Preparation:</u>** Iron is melted in a 1000 lb. Ajax induction furnace. The amount of metal melted is determined from the poured weight of the casting and the number of molds to be poured. The metal composition is prescribed by a metal composition worksheet. The weight of metal poured into each mold is recorded on the process data summary sheet.

4-on No-Bake Gear Mold

4. **<u>Individual Sampling Events:</u>** Replicate tests are performed on nine (9) mold packages. The mold packages are placed into an enclosed test stand heated to approximately 85°F. Iron is poured through an opening in the top of the emission enclosure.

Total Enclosure Test Stand

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.



Method 25A (TGOC) and Method 18 Sampling Train

5. **Process Parameter Measurements:** Table 2-1 lists the process parameters that are monitored during each test. The analytical equipment and methods used are also listed.

Table 2-1 Process Parameters Measured

Parameter	Analytical Equipment and Methods
Mold Weight	Cardinal 748E Platform Scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
Binder Weight	Mettler PJ8000 Digital Scale (Gravimetric)
Volatiles	Mettler PB302 Scale (AFS Procedure 2213-00-S)
LOI, % at Mold and Shakeout	Denver Instruments XE-100 Analytical Scale (AFS procedure 5100-00-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C Immersion Pyrometer)
Carbon/Silicon Solidification Temperature	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale
Carbon/Silicon	Electro-Nite DataCast 2000 (thermal arrest)

6. **Air Emissions Analysis:** The specific sampling and analytical methods used in the Pre-Production Foundry tests are based on the US EPA reference methods shown in Table 2-2. The details of the specific testing procedures and their variance from the reference methods are included in the Technikon Standard Operating Procedures.

Table 2-2 Sampling and Analytical Methods

Measurement Parameter	Test Method
Port Location	EPA Method 1
Number of Traverse Points	EPA Method 1
Gas Velocity and Temperature	EPA Method 2
Gas Density and Molecular Weight	EPA Method 3a
Gas Moisture	EPA Method 4, gravimetric
HAPs Concentration	EPA Method 18, TO11, NIOSH 2002
VOCs Concentration	EPA Method 18, 25A, TO11, NIOSH 2002

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

7. **Data Reduction, Tabulation and Preliminary Report Preparation:** The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter, and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the casting poured or the total cal-

culated binder weight to provide emissions data in pounds of analyte per ton of metal and pounds of emissions per pound of binder.

The results of each of the sampling events are included in Appendices B and C of this report. The emissions results of each test are also averaged and are shown in Tables 3-1 and 3-2. The process conditions for each run are averaged and shown in Table 3-3.

7. **Report Preparation and Review:** The Preliminary Draft Report is reviewed by the Process Team and Emissions Team to ensure its completeness, consistency with the test plan, and adherence to the prescribed QA/QC procedures. Appropriate observations, 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 laboratory analytical procedures are included in the Technikon Emissions Testing and Analytical Testing Standard Operating Procedures. In order to ensure the timely review of critical quality control parameters, the following procedures are followed:

- Immediately following the individual sampling events performed for each test, specific process parameters are reviewed by the Manager - Process Engineering to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Manager - Process Engineering and the Vice President - Operations determine whether the individual test samples should be invalidated or flagged for further analysis following review of the laboratory data.

- The source (stack) and sampling parameters, analytical results and corresponding laboratory QA/QC data are reviewed by the Emissions Measurement Team to confirm the validity of the data. The VP-Measurement Technologies reviews and approves the recommendation, if any, that individual sample data should be invalidated. Invalidated data are not used in subsequent calculations.

3.0 Test Results

The average emission results in pounds per ton of metal poured and pounds per pound of binder are presented in Tables 3-1 and 3-2, 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 table also includes the TGOC as propane, HC as hexane, methane, carbon dioxide, and carbon monoxide.

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.

Figures 3-4 to 3-6 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-2 in graphical form.

Appendix B contains the detailed emissions data including the results for all analytes measured. Table 3-3 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.

The best, median, and worst appearing Cavity-A castings are shown in Figures 3-7, 3-8, and 3-9 respectively.

All cavity-A castings are shown in Appendix C.

The ranking of casting appearance is in Table 3-4.

Table 3-1 Summary of Test Plan FL Average Results – Lb/Tn Metal

Analytes	Test FL (Lb/Tn Metal)	STDEV
TGOC as Propane	12.67	0.4189
HC as Hexane	4.043	0.3848
Sum of VOCs	2.488	0.1574
Sum of HAPs	1.763	0.1424
Sum of POMs	0.040	0.0038
Individual Organic HAPs		
o,m,p-Cresol	0.8654	0.0480
Phenol	0.5106	0.0369
Benzene	0.2521	0.0064
Toluene	0.0575	0.0020
o,m,p-Xylene	0.0453	0.0015
Other VOCs		
Dodecane	0.3726	0.0332
Trimethylbenzenes	0.1911	0.0097
1,3-Diethylbenzene	0.0822	0.0011
Indan	0.0476	0.0027
Dimethylphenols	0.0265	0.0121
Other Analytes		
Carbon Monoxide	0.0683	0.2050
Methane	0.0628	0.0069
Carbon Dioxide	33.67	1.552

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

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

Background Carbon Monoxide, Methane, and Carbon Dioxide were found at 0.6151, 0.0614, and 36.30 Lb/Tn Metal respectively.

Table 3-2 Summary of Test Plan FL Average Results – Lb/Lb Binder

Analytes	Test FL (Lb/Lb Binder)	STDEV
TGOC as Propane	0.2094	0.0086
HC as Hexane	0.0670	0.0074
Sum of VOCs	0.0428	0.0067
Sum of HAPs	0.0303	0.0049
Sum of POMs	0.0007	0.0001
Individual Organic HAPs		
o,m,p-Cresol	0.0148	0.0021
Phenol	0.0088	0.0014
Benzene	0.0044	0.0006
Toluene	0.0010	0.0001
o,m,p-Xylene	0.0008	0.0001
Other VOCs		
Dodecane	0.0064	0.0010
Trimethylbenzenes	0.0033	0.0005
1,3-Diethylbenzene	0.0014	0.0002
Indan	0.0008	0.0001
Dimethylphenols	0.0005	0.0002
Other Analytes		
Carbon Monoxide	0.0011	0.0034
Methane	0.0010	0.0001
Carbon Dioxide	0.5568	0.0277

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

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

Background Carbon Monoxide, Methane, and Carbon Dioxide were found at 0.0103, 0.0010 and 0.6002 Lb/Lb Binder respectively.

Table 3-3 Summary of Test Plan FL Average Process Parameters

No-Bake Mix/Make/Cure	
Test Dates	10/6/2003 - 10/8/2003
Test FL	**Average**
Sand Dispensing Rate, lbs/15 sec	**30**
Binder Part1 + Part3 Dispensing Rate, gms/15 sec	**84.9**
Binder Part 2 Dispensing Rate, gms/15 sec	**63.5**
Calculated Standard % Binder	**1.08**
Calculated % Binder (BOS)	**1.09**
Mold Weight, lbs	**331.1**
Calculated Total Binder Weight, lbs	**3.57**
1800F LOI, % (Note 1)	**1.10**
Sand Temperature, deg F	**82**
Dogbone Core 2 hr. Tensile Strength, psi	**42**

No-Bake PCS	
Test Dates	10/7/2003 - 10/9/2003
Test FL	**Average**
Pouring Temp, deg F	**2632**
Pouring Time, sec.	**33**
Cast Weight (all metal inside mold), Lbs.	**117.92**
Process Air Temperature in Hood, deg F	**87**
Mold Temperature when placed in hood, deg F	**79**
Ambient Temperature, deg F	**75**
Mold Age When Poured, hr	**23.8**
Test Length, hr	**75.0**

Figure 3-1 Emission Indicators from Test Series FL – Lb/Tn Metal

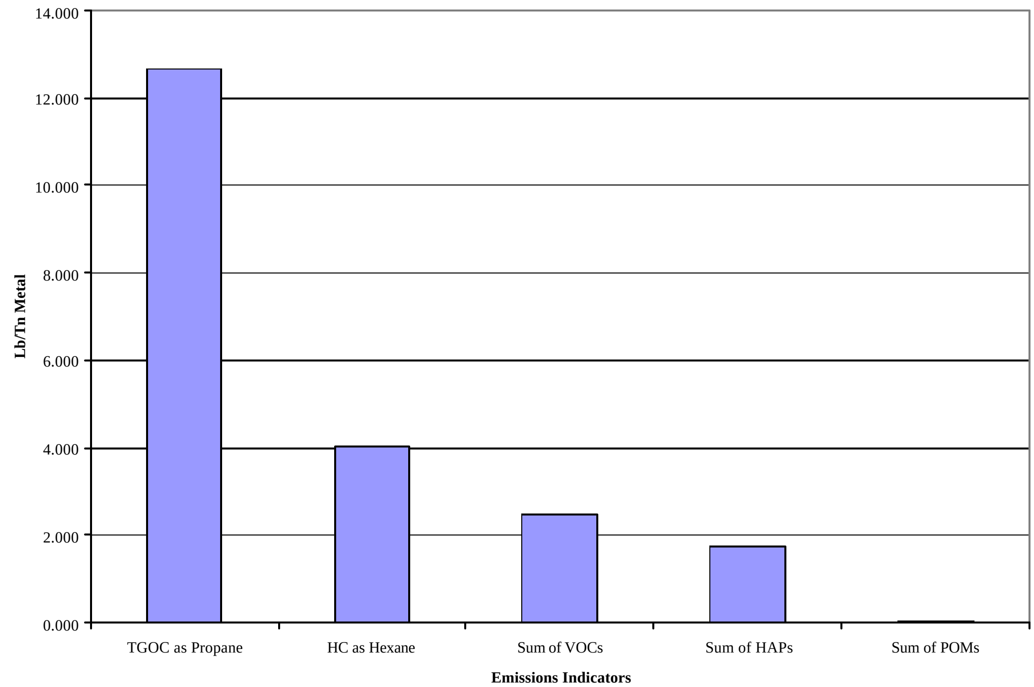


Figure 3-2 Selected HAP Emissions from Test Series FL – Lb/Tn Metal

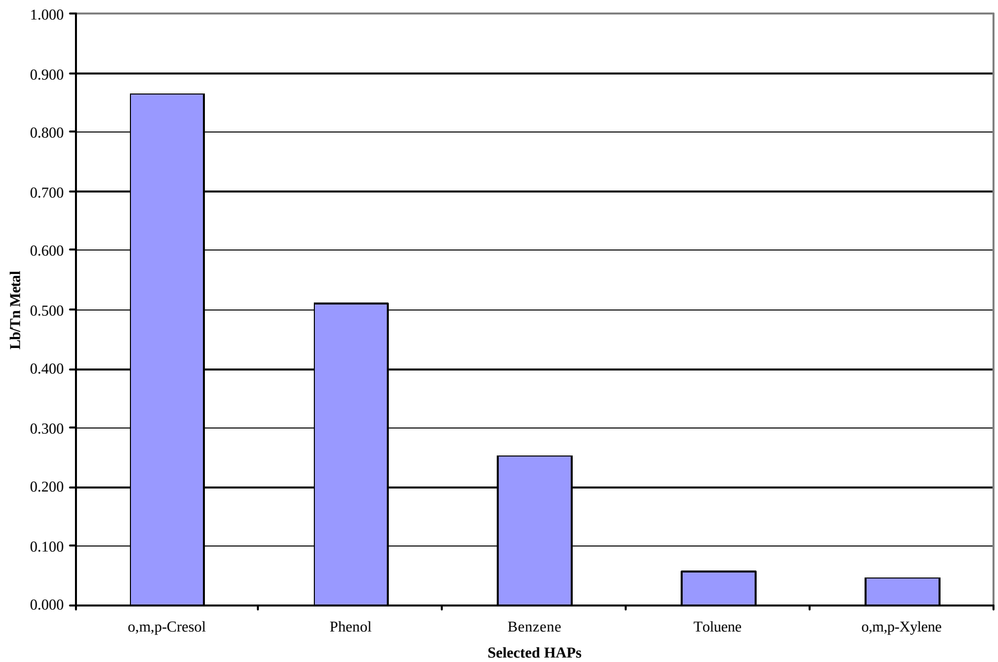


Figure 3-3 Selected VOC Emissions from Test Series FL – Lb/Tn Metal

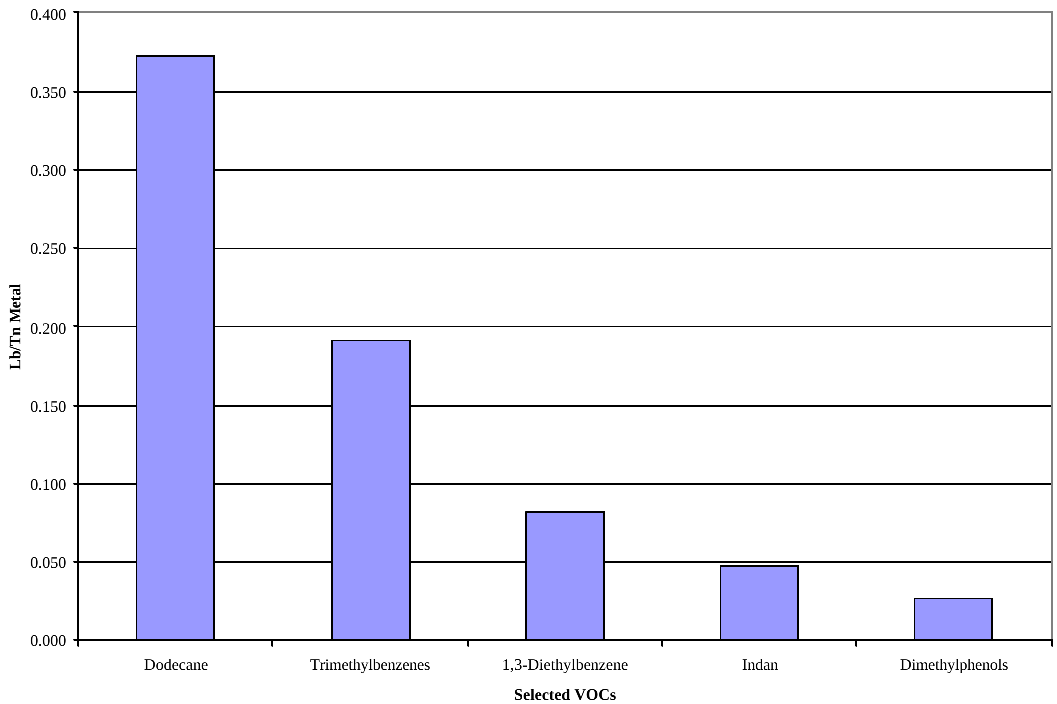


Figure 3-4 Selected Emissions Indicators from Test Series FL – Lb/Lb Binder

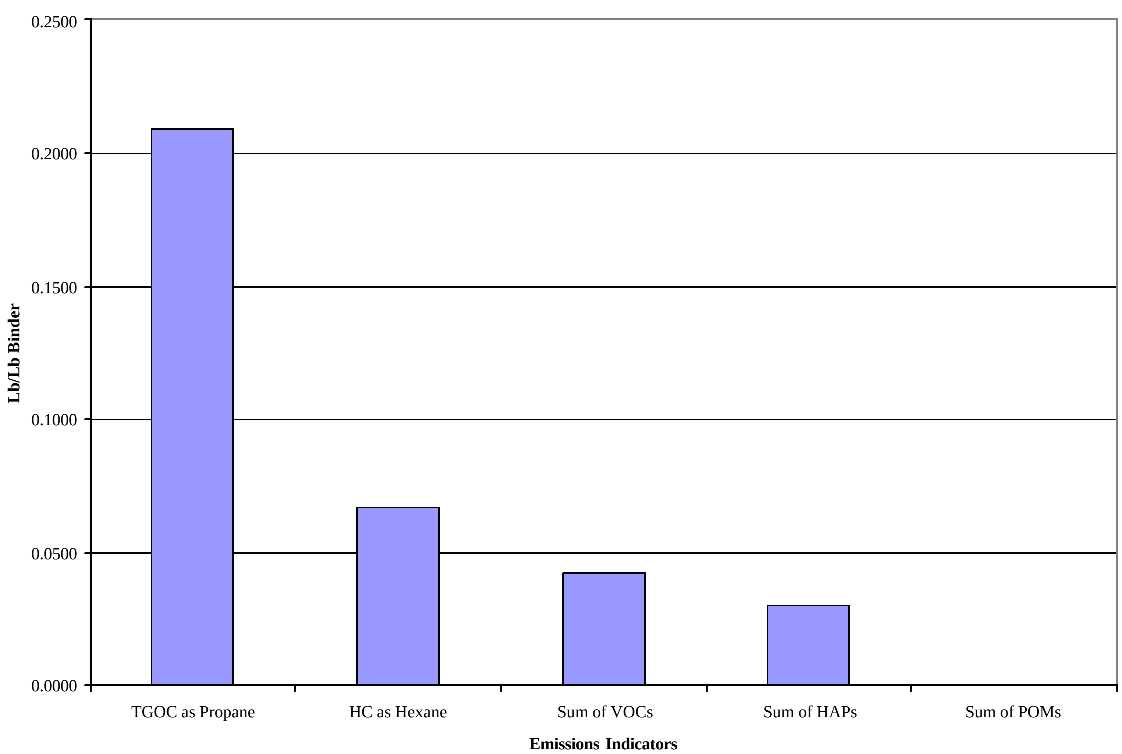


Figure 3-5 Selected HAP Emissions from Test Series FL – Lb/Lb Binder

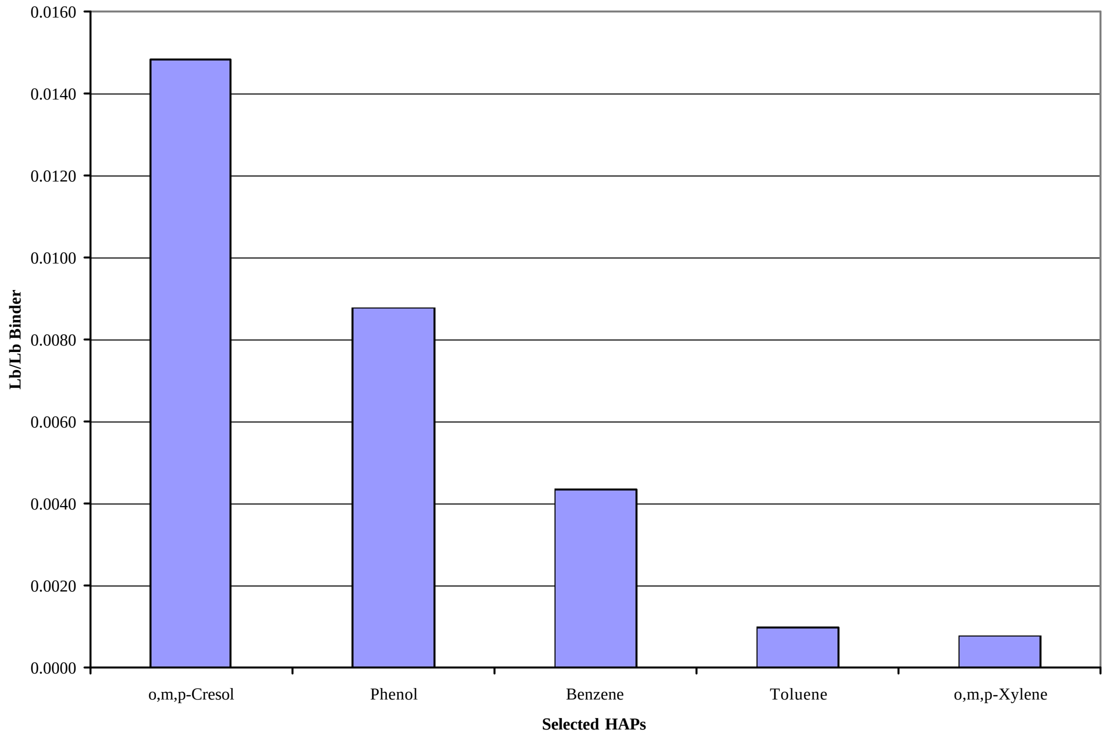


Figure 3-6 Selected Emissions from Test Series FL – Lb/Lb Binder

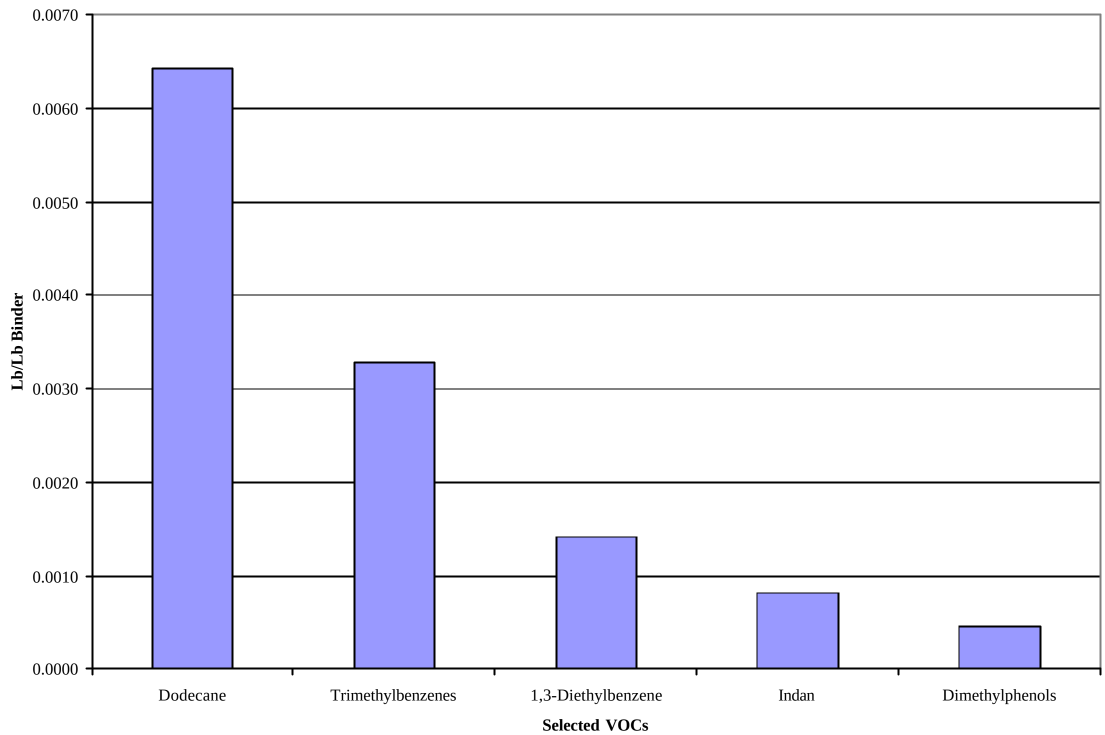


Table 3-4 Rank Order of Casting Surface Quality

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

Body of table is mold number FL00x
Cavity "a" is the reference cavity
The best of cavity "b" = rank 7 on cavity "a"
The best of cavity "c" = rank 5 on cavity "a"
The best of cavity "d" = rank 6 on cavity "a"

Figure 3-7 Best Appearing Cavity A Casting from Mold FL002

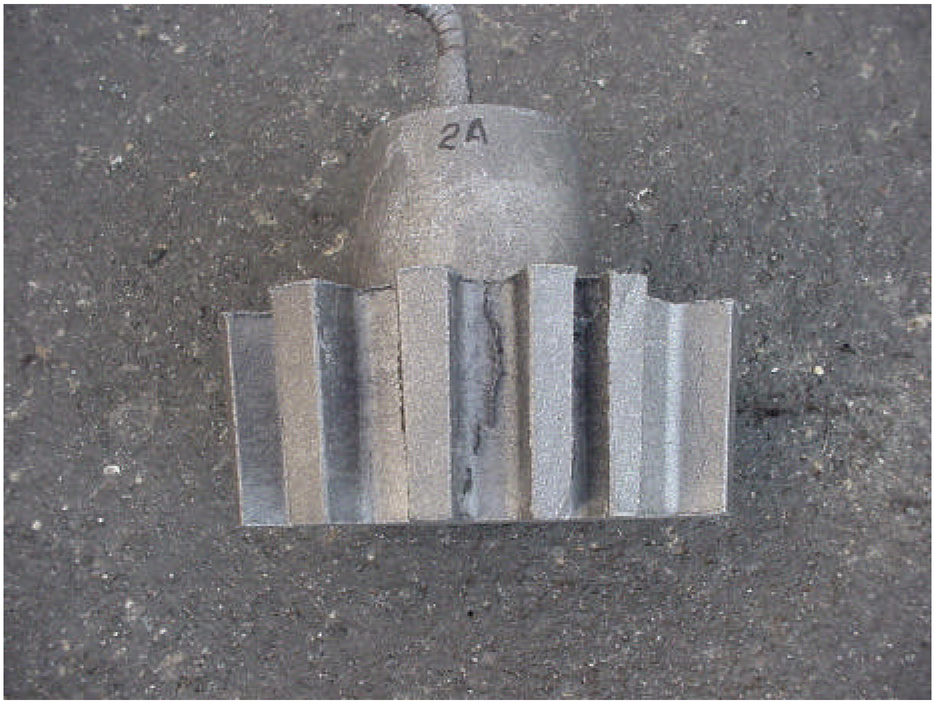


Figure 3-8 Picture of Median Appearance Cavity A Casting from Mold FL004

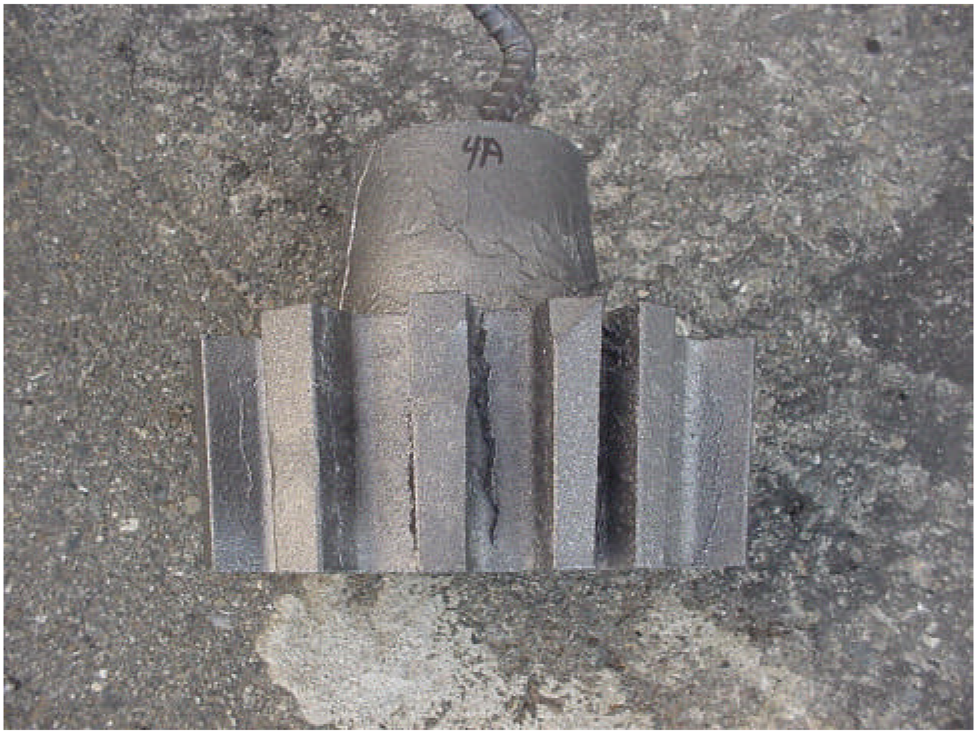
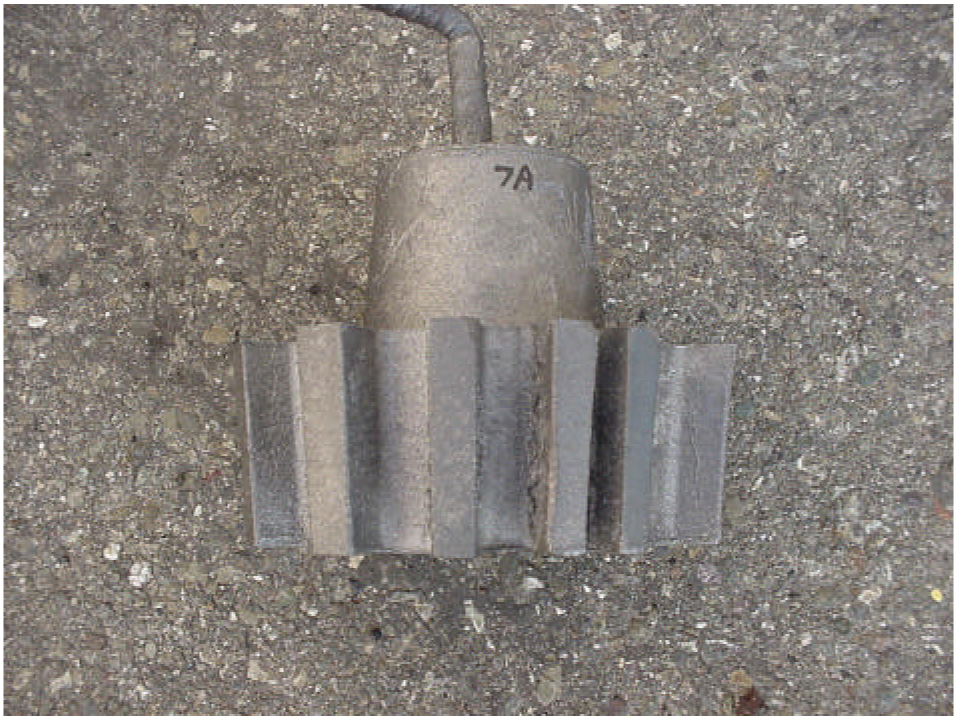


Figure 3-9 Worst Appearing Cavity A Casting from Mold FL007



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4.0 Discussion of Results

Ten (10) of the measured compounds comprised greater than 95% of the mass of all VOCs emitted by the Phenolic Urethane No-Bake baseline test series FL. O,m,p-Cresol comprised approximately 49%, phenol 29%, and benzene 14% of the total HAPs. Dodecane, trimethylbenzenes, and other cyclic hydrocarbons together comprised approximately 29% of the total VOCs.

Carbon dioxide, carbon monoxide, and methane were found in the ambient air sample for Test FL at approximately the same concentrations as measured in the emissions.

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 binder are shown in Appendix B.

Observation of measured process parameters indicates that the tests were run within the specifications established by the CERP working teams. The objective of this test was to measure emissions. Casting quality results are noted for reader information. The same cavities are always compared in casting quality evaluations.

The casting surface appearance was recorded for each mold. The castings' surface quality were ranked in order of best to worst by 4 experienced foundry personnel based on a strict set of surface defects most likely caused by mold sand characteristics. Other surface defects originating from slag inclusions, broken molds or the loose sand that result from disruption of the mold were ignored. The criteria chosen were penetration, both burn-in and burn-on, expansion defects, and general surface texture both visual and as a tactile sensation. All cavities were rank-ordered within cavity and then the cavities were compared. In test FL cavity "A" most consistently exhibited the superior surface at each level of the rank-order. The mold FL002 cavity A casting was judged to have the best casting surface based on the criteria, mold FL004 cavity A was judged to be a median casting, and mold FL007 cavity "A" was judged to have the worst casting surface. The best cavity "B" casting, FL001b, was similar to rank 7 of cavity a (FL006). The best cavity "C" casting, FL001c, was similar to rank 5 of cavity A (FL004). The best cavity "D" casting, FL001d, was similar to rank 6 of cavity A (FL005). Photographs of all castings and cavities are shown in Appendix C.

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APPENDIX A APPROVED TEST PLAN AND SAMPLE PLAN FOR TEST SERIES FL

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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.

Process Engineering Manager (Technikon)	Date
V.P. Measurement Technology (Technikon)	Date
V.P. Operations (Technikon)	Date
President (Technikon)	
Test Design Committee Representative	Date
Emission Committee Representative	Date

Series FL

Iron No-bake Baseline 2003

Process Instructions

A. Experiment:

1. 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:

   a. Wexford W450 Lakesand
   b. Casting cleaning

2. 1.1 % 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:

   a. 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

D. Cleaning castings.

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

E. 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 FH001, compare it to castings from mold FH002.
   c. Place the better appearing casting in the first position and the lesser appearing casting in the second position.
   d. 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.
   e. Repeat this comparison to next neighbors for each casting number.
   f. When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
   g. Repeat this comparison until all concur with the ranking order.

5. 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.

F. Mold requirements

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

G. Phenolic Urethane No-bake Core Sand preparation:

1. Load the Kloster core sand mixer with 80-90^{o}F Wexford sand.
2. 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.
3. Calibrate the Kloster no-bake sand mixer to dispense 240 pounds of sand /min more or less.
4. Calibrate the resin pumps:

   a. Premix Part I resin and Part III activator in a 20:1 weight ratio.
   b. 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.
   c. Part II: Based on the actual measured sand dispensing rate calibrate the Part II co-reactant to be 42.86% of 1.1 % (.471% BOS) total binder.

d. All calibrations to have a tolerance of +/- 1% of the calculated value.

5. Run an 1800°F core LOI on three (3) samples from each mold. Report the average value for each mold.

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

I. 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 CoreFix 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^oF.

J. 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^oF.
- **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..

K. 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.

L. 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 2630 +/- 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.

M. 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.

N. 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.
f. When all casting numbers have been compared go to the beginning of the line and begin again comparing each casting to its nearest neighbor. Move the castings so that each casting is inferior to the next one closer to the beginning of the line and superior to the one next toward the tail of the line.
g. Repeat this comparison until all concur with the ranking order.

5. Record mold number by rank-order series for each cavity.
6. 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

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

APPENDIX B TEST SERIES FL DETAILED EMISSION RESULTS

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Test Plan FL Individual Emission Test 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 Emission Test 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 Emission Test 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 FL Individual Emission Test 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 Emission Test 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 Emission Test 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 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 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

APPENDIX C TEST SERIES FL DETAILED PROCESS DATA

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Test FL Detailed Process Data

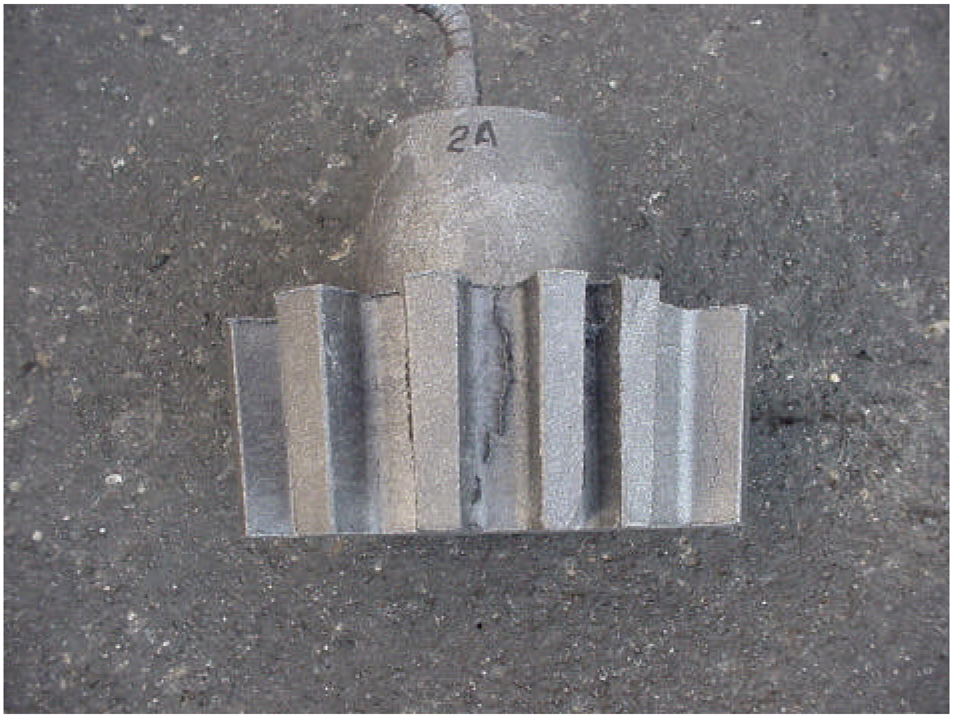
No-Bake Mix/Make/Cure										
Test Dates	**10/6/2003**	**10/6/2003**	**10/6/2003**	**10/7/2003**	**10/7/2003**	**10/7/2003**	**10/8/2003**	**10/8/2003**	**10/8/2003**	**Average**
Emissions Sample # Production Sample #	**FL 001**	**FL 002**	**FL 003**	**FL 004**	**FL 005**	**FL 006**	**FL 007**	**FL 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	

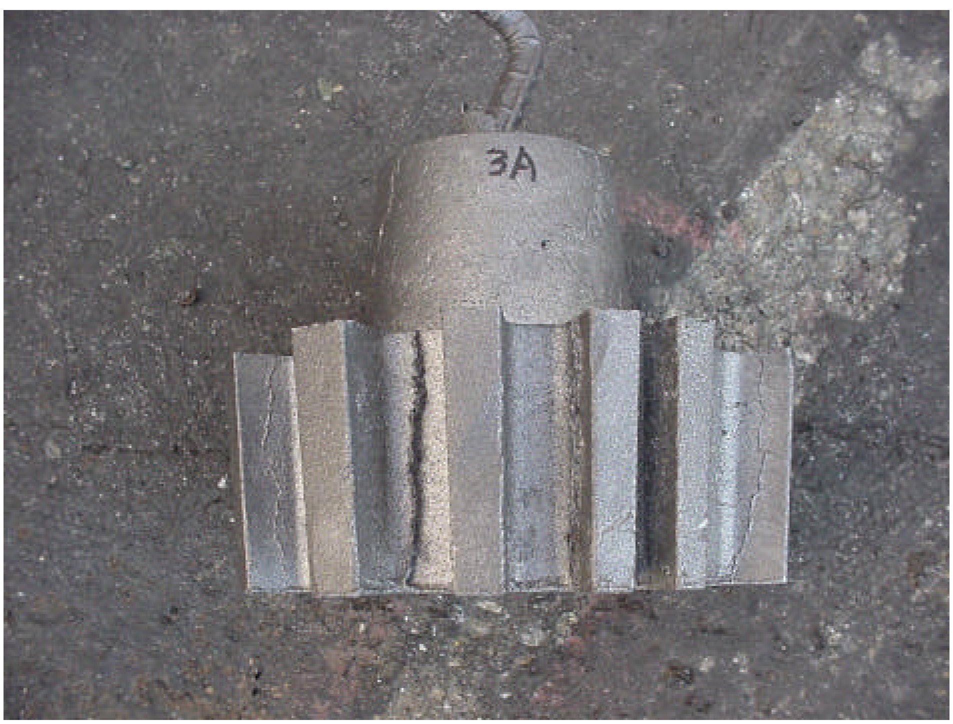
Note 1: 1800F LOI is the net sample weight difference when combusted at 1800F for 2 hours and includes decomposition of carbonates that originate in the source sand.

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.

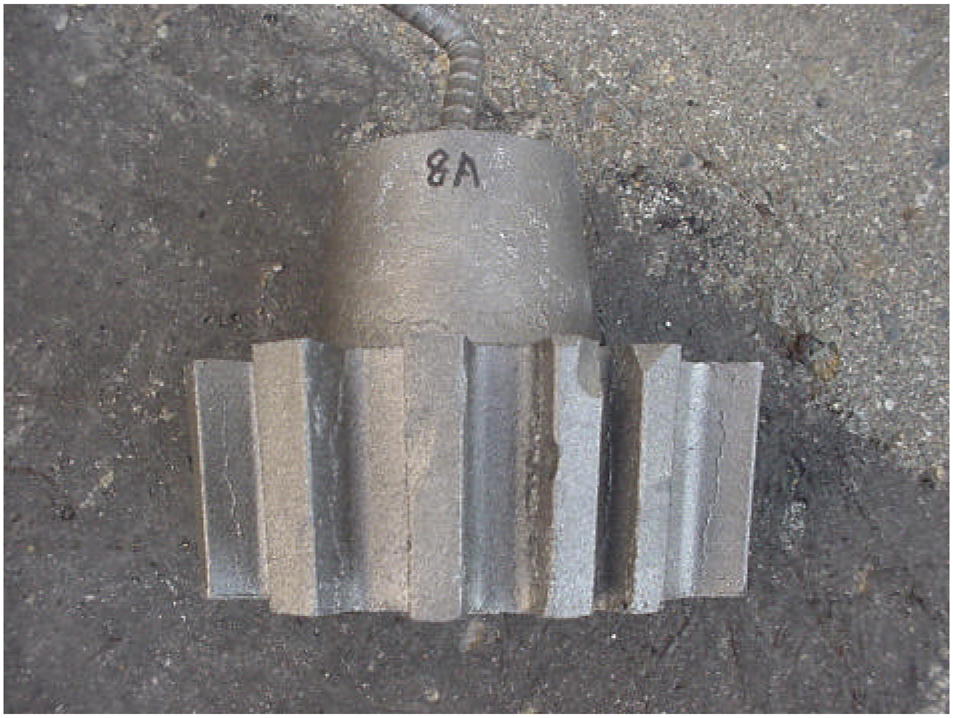
Picture C1 Mold FL002 Cavity A Casting Ranked 1 of 9.



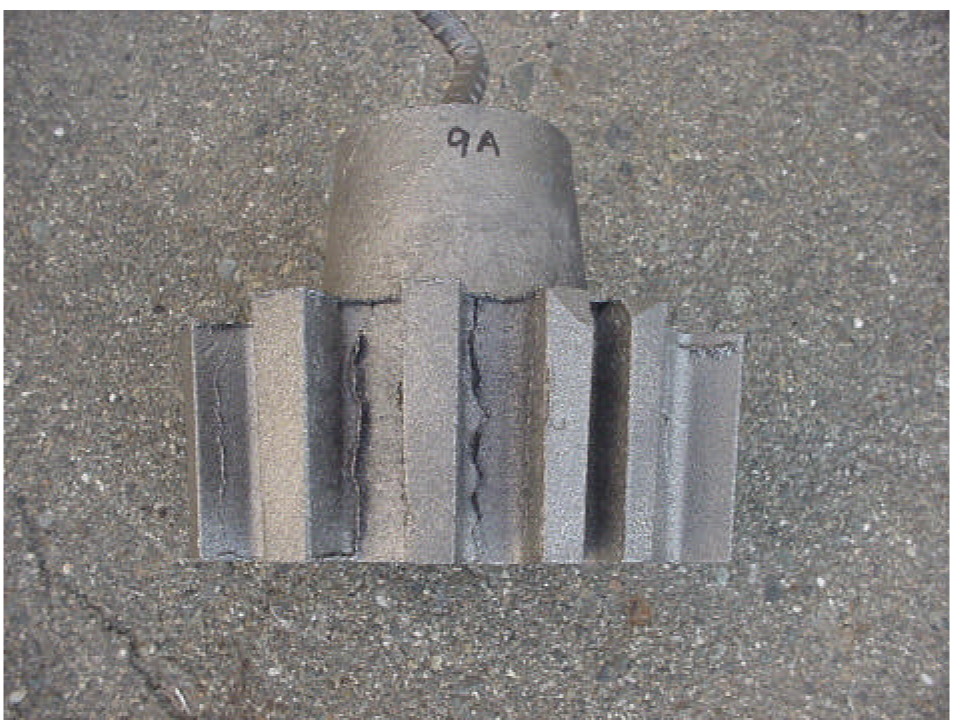
Picture C2 Mold FL003 Cavity A Casting Ranked 2 of 9.



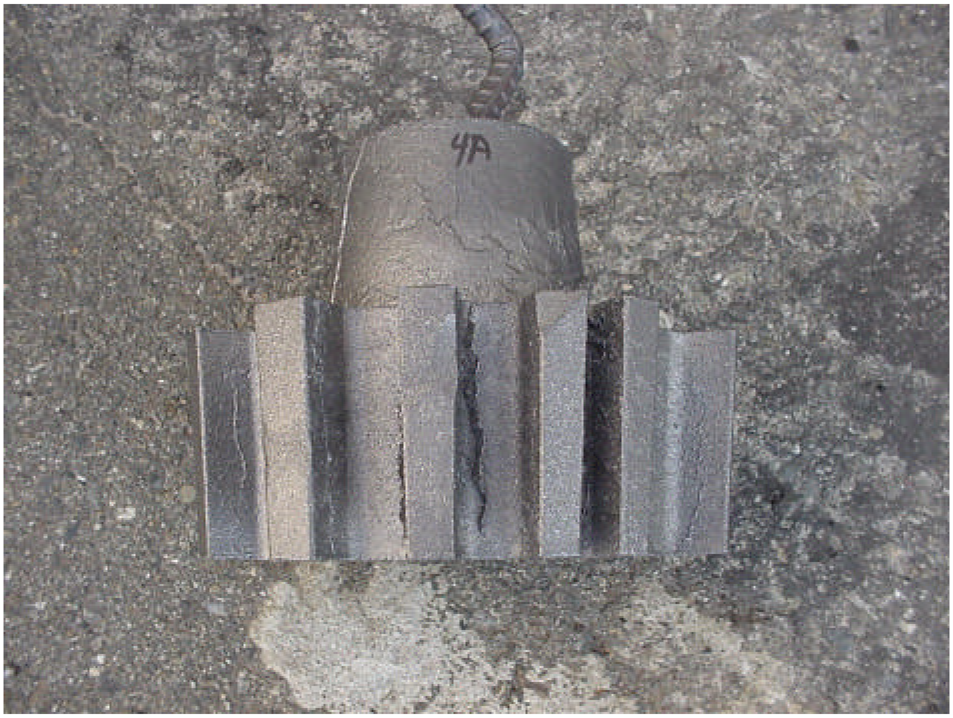
Picture C3 Mold FL008 Cavity A Casting Ranked 3 of 9



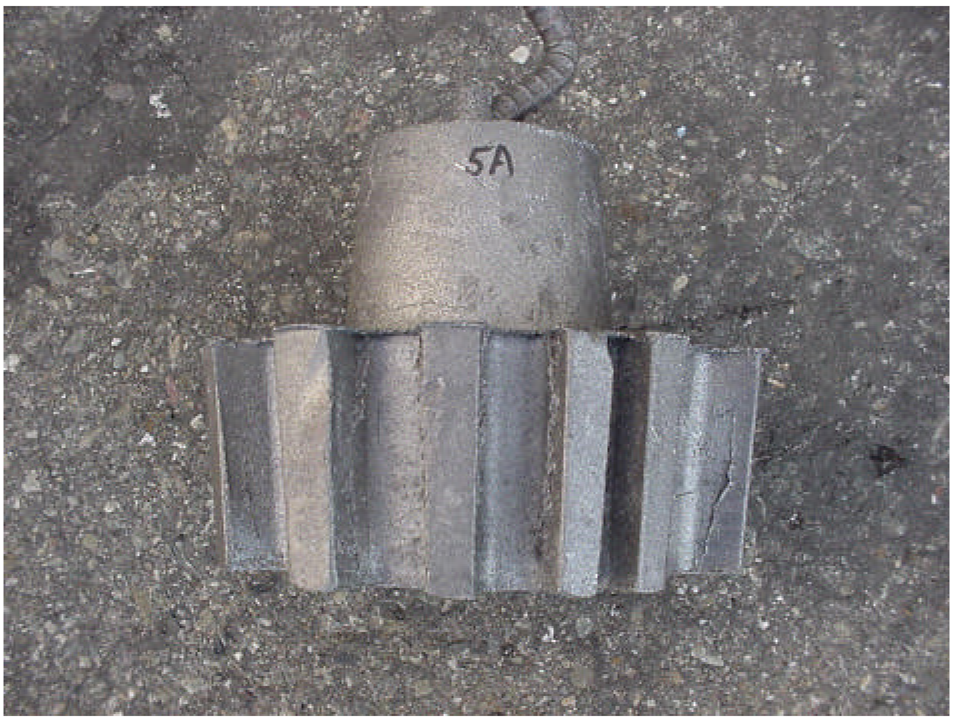
Picture C4 Mold FL009 Cavity A Casting Ranked 4 of 9



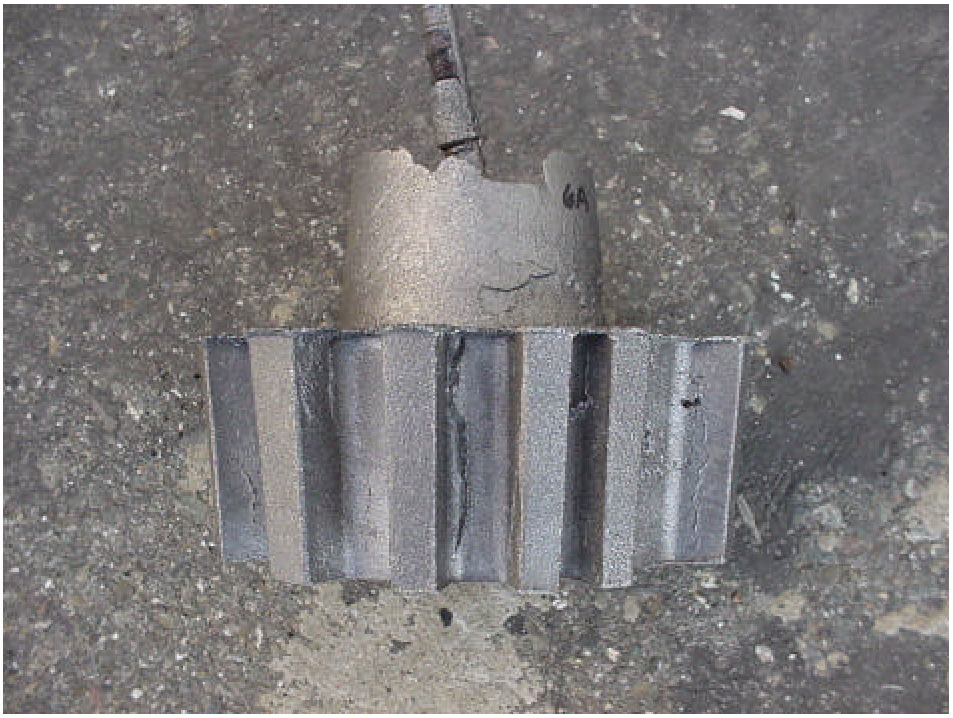
Picture C5 Mold FL004 Cavity A Casting Ranked 5 of 9



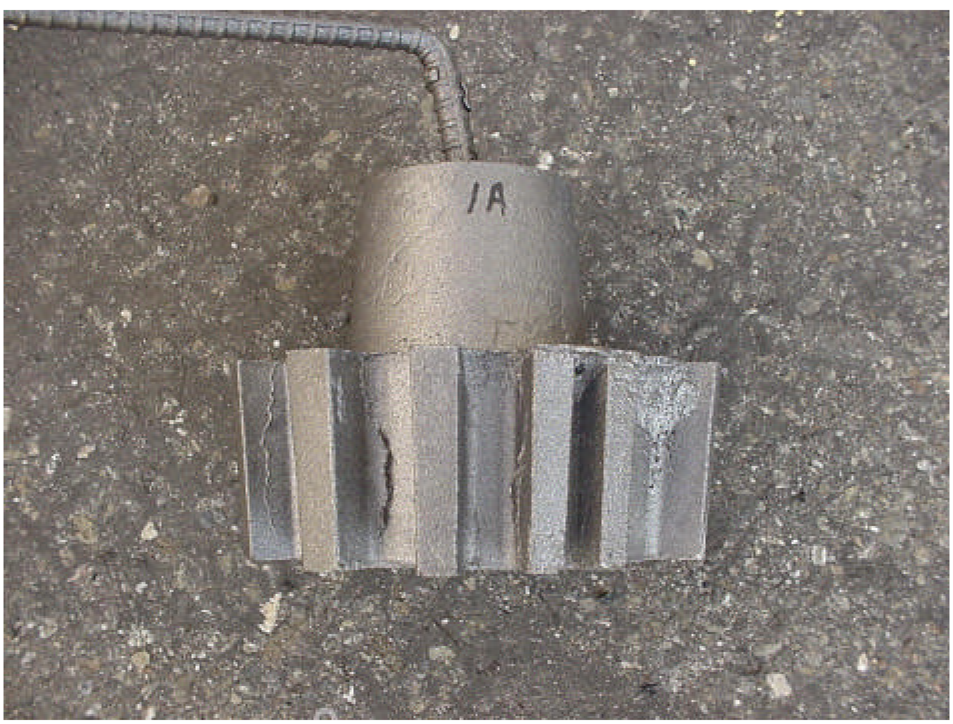
Picture C6 Mold FL005 Cavity A Casting Ranked 6 of 9



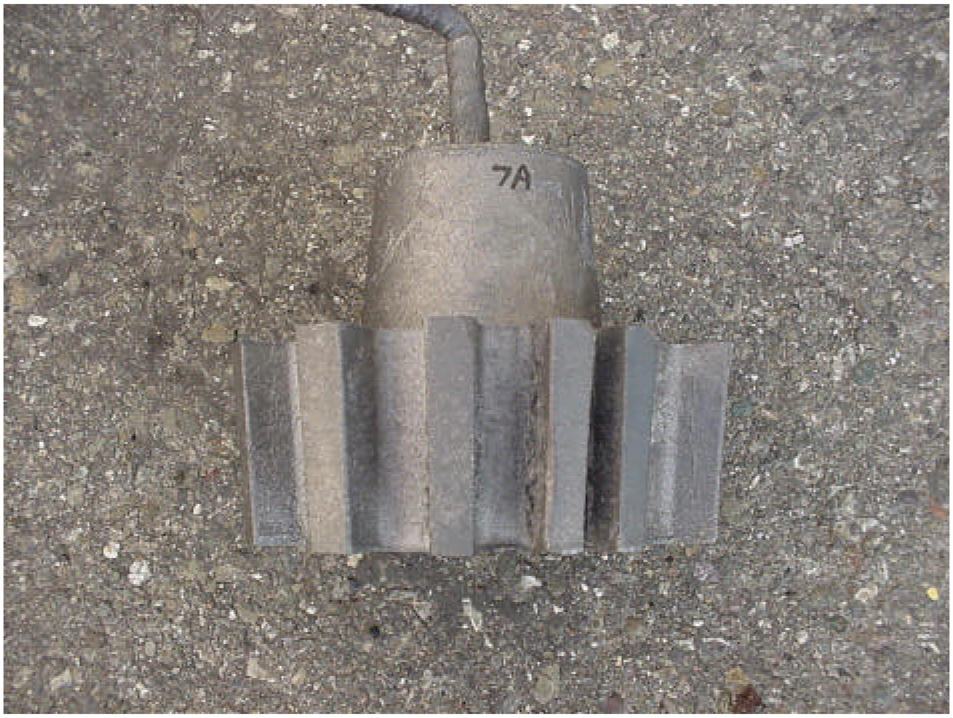
Picture C7 Mold FL006 Cavity A Casting Ranked 7 of 9



Picture C8 Mold FL001 Cavity A Casting Ranked 8 0f 9



Picture C9 Mold FL007 Cavity A Casting Ranked 9 of 9



APPENDIX D METHOD 25A CHARTS

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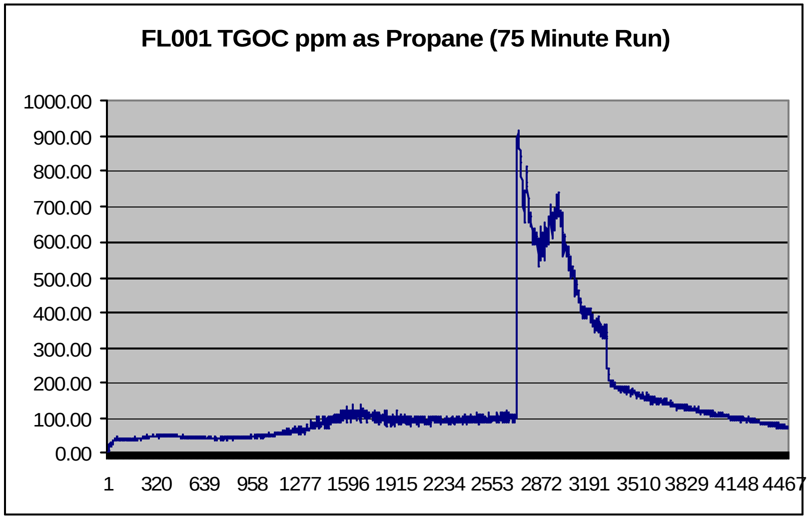
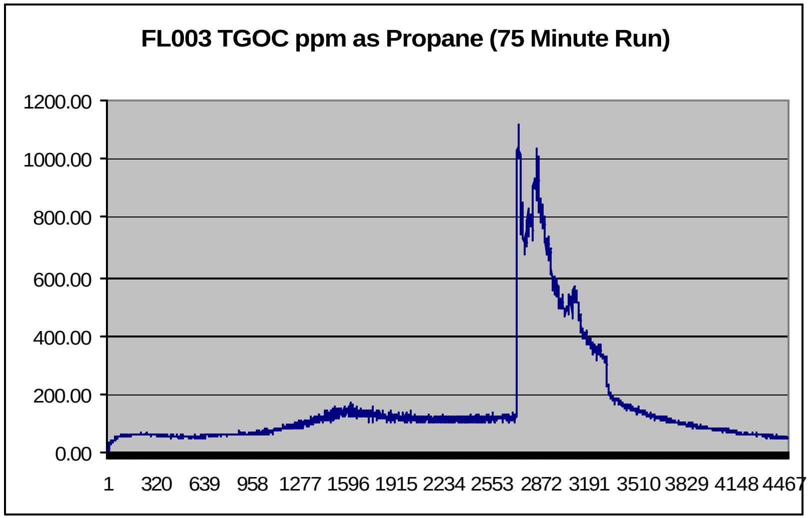
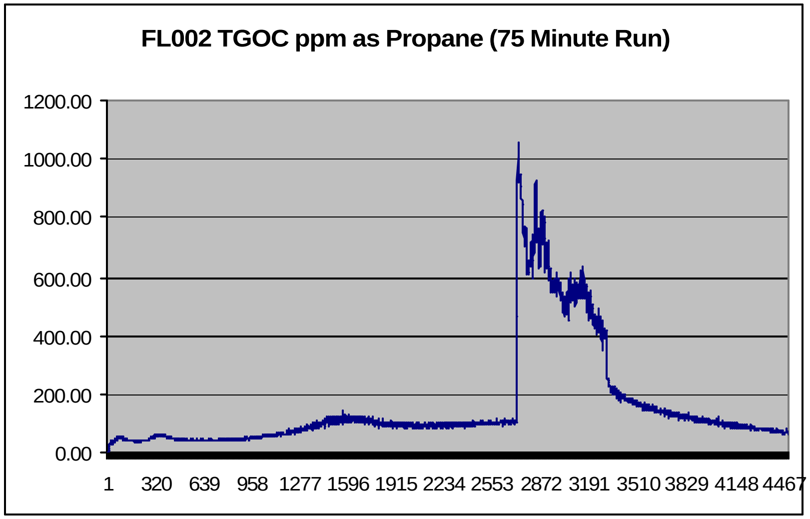
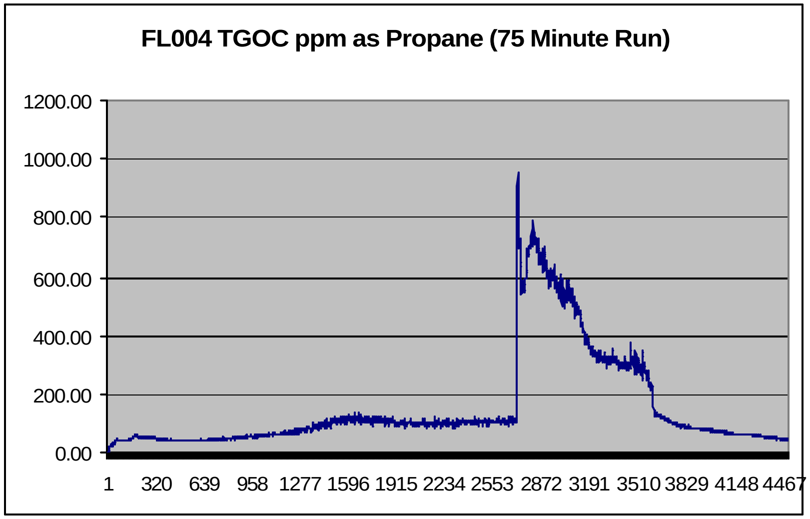
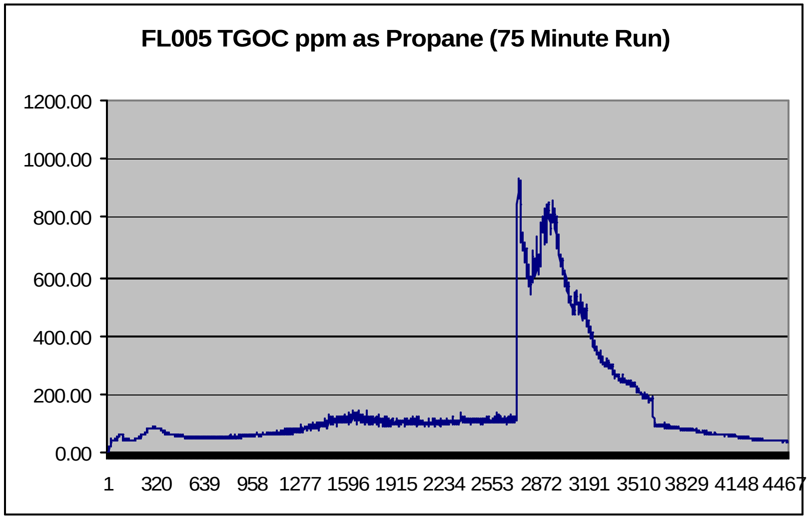
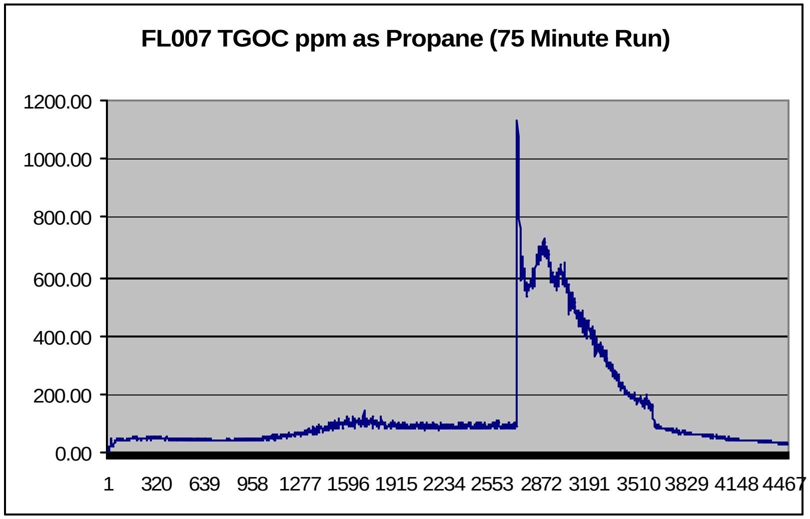

FL001 TGOC ppm as Propane (75 Minute Run)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467

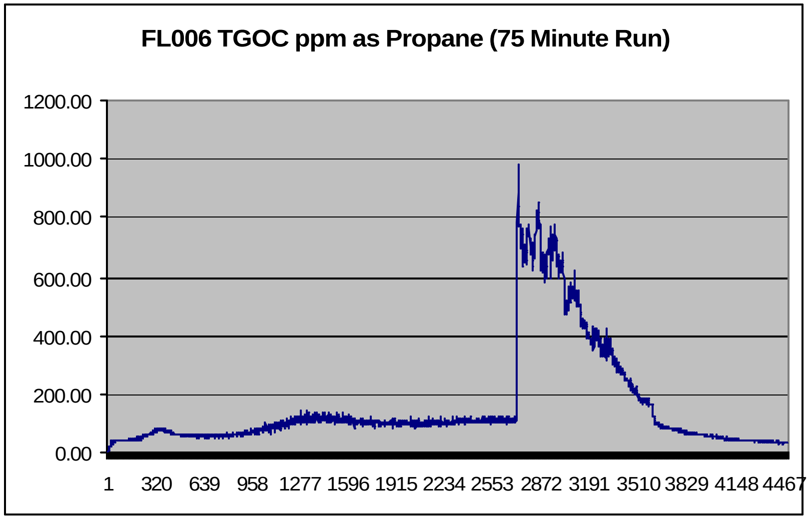

FL003 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467

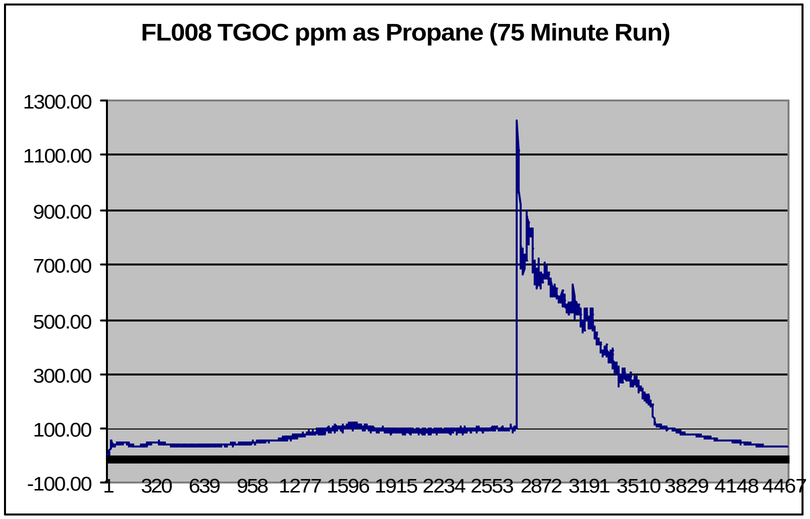

FL002 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467

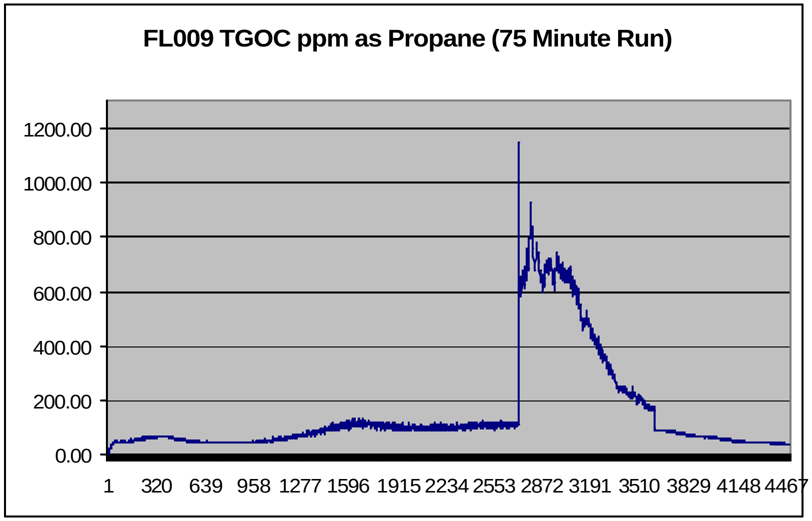

FL004 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467


FL005 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467


FL007 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467


FL006 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467


FL008 TGOC ppm as Propane (75 Minute Run)
1300.00
1100.00
900.00
700.00
500.00
300.00
100.00
-100.00
1 320 639 958 1277 1596 1915 2234 2553 2872 3191 3510 3829 4148 4467


FL009 TGOC ppm as Propane (75 Minute Run)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1
320
639
958
1277
1596
1915
2234
2553
2872
3191
3510
3829
4148
4467

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APPENDIX E GLOSSARY

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Glossary

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