CERP

Casting Emission Reduction Program

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FY 2003

Baseline Test:
Pouring, Cooling, Shakeout of Coated Phenolic Urethane Core (Greensand without Seacoal, Iron)

Technikon #1410-124 FQ

March 2004
(revised for public distribution)

United States Environmental Protection Agency

CISA

AFS

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

USCAR

DaimlerChrysler Ford Motor Company General Motors

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1410-124 FQ

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

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Executive Summary

This report contains the results of emission testing to evaluate the pouring, cooling, and shakeout emissions from Test FQ, a coated core in greensand without seacoal. Test FQ will be used as a core baseline against which other products and processes are to be compared. All testing was conducted by Technikon, LLC in its Pre-Production foundry. The emissions results are reported in both pounds of analyte per pound of binder and pounds of analyte per ton of metal poured.

The testing performed involved the collection of continuous air samples over a seventy-five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and include: the weights of the casting, mold, and binder; Loss on Ignition (LOI) values for the mold prior to the test; metallurgical data; and stack temperature, pressure, volumetric flow rate, and moisture content were also collected. 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-nine (69) 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 individual 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 in both lbs/lb of binder and lbs/tn of metal.

Test Plan FQ Emissions Indicators

Analytes	TGOC as Propane	HC as Hexane	Sum of VOCs	Sum of HAPs	Sum of POMs
Test FQ (Lb/Lb Binder)	0.0974	0.0232	0.0341	0.0327	0.0055
Test FQ (Lb/Tn Metal)	0.7255	0.1726	0.2737	0.2630	0.0411

Results of this test represent a new coated core baseline that is different than previous CERP core baseline. The major differences are:

- ~ A core coating was applied to the phenolic urethane cores and the cores dried in a 325^{o}F core wash drying oven.
- ~ The resin level was reduced to 1.4% compared to the previous standard of 1.75%.
- ~ A new pattern was used with 4 cavities versus the previous 8-on pattern.

A pictorial casting record was made of the NE (northeast) cavity 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 baseline testing performed is not suitable for use as emission factors or for purposes other than evaluating the relative emission reductions associated with the use of alternative materials, equipment, or processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests, and should not be used as the basis for estimating emissions from actual commercial foundry applications.

1.0 Introduction

1.1 Background

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (USCAR). 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 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 relative emission reductions associated with the use of alternative materials, equipment, or manufacturing processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests. These measurements should not be used as the basis for estimating emissions from actual commercial foundry applications

1.3 Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate VOC emissions from a cored greensand 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 data included in the appendices of this report. 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

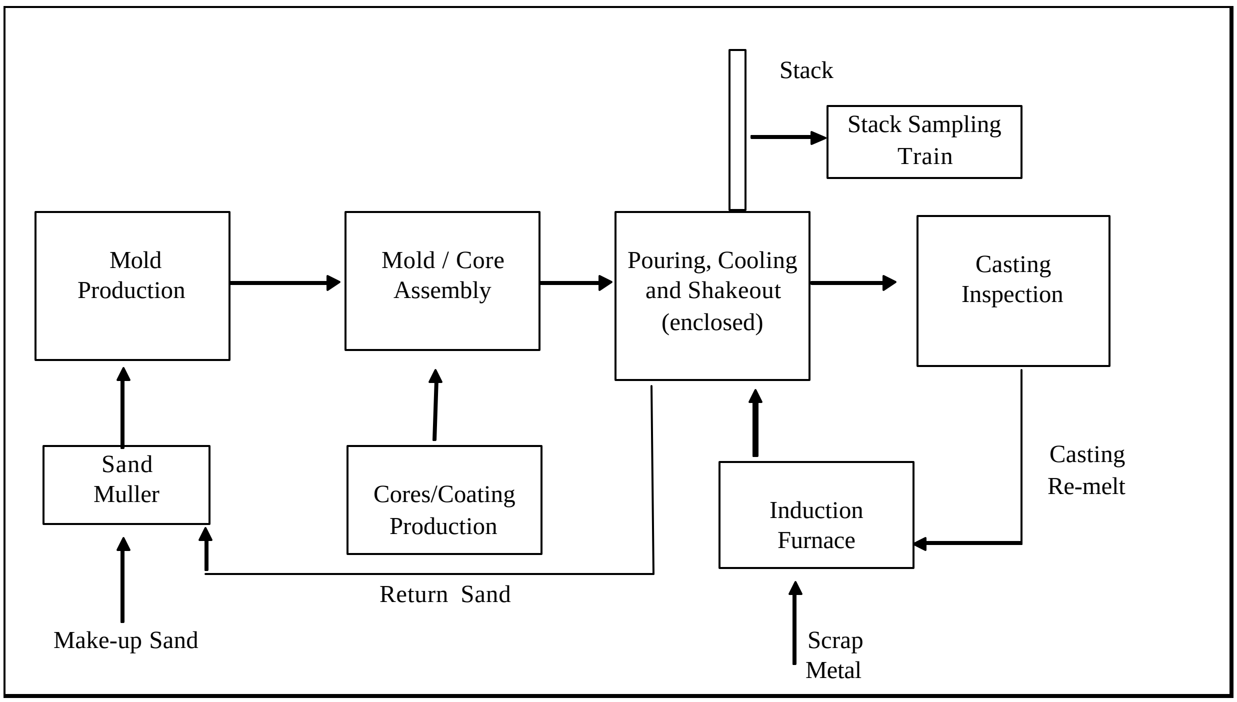
	Test Plan
Type of Process tested	Coated Core, Greensand without Seacoal, Iron PCS Baseline
Test Plan Number	1410 124 FQ
Greensand System	Wexford W450, Western and Southern Bentonite
Metal Poured	Iron
Casting Type	4-on Step Core
Core	1.4% Ashland ISOCURE® 305/904
Core Coating	Ashland Velvaplast® CGW 9022SL
Number of molds poured	3 Conditioning + 9 Sampling
Test Dates	12/18/03 < 12/23/03
Emissions Measured	TGOC as Propane, HC as Hexane, 69 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Mold, Binder Weights; Metallurgical data, % LOI; Stack Temperature, Moisture Content, Sand Temperature, Pressure, and Volumetric Flow Rate

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

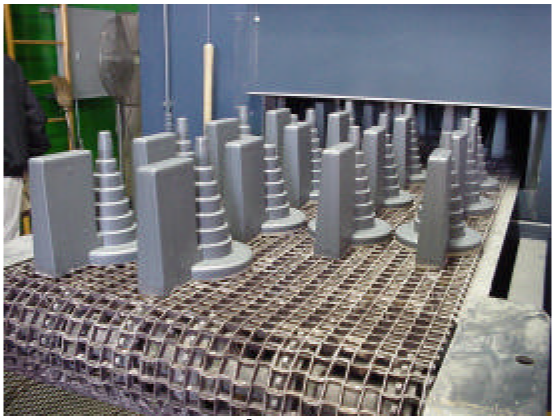


2.2 Description of Testing Program

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

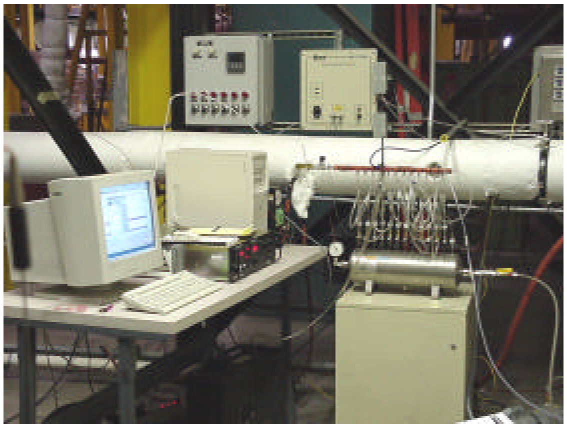
1. **<u>Test Plan Review and Approval:</u>** The proposed test plan was reviewed and approved by the Technikon staff.

2. **Mold, Core and Metal Preparation:** The molds and cores were prepared to a standard composition by the Technikon production team. The cores were blown in a Redford/Carver core blower and then coated with the vendor supplied core coating. Relevant process data was collected and recorded. Iron was melted in a 1000 lb. Ajax induction furnace. The amount of metal melted was determined from the poured weight of the casting and the number of molds to be poured. The metal composition was Class-30 Gray Iron as prescribed by a metal composition worksheet. The weight of metal poured into each mold was recorded on the process data summary sheet.


Coated Step Cores


Total Enclosure Test Stand

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


Method 25A (TGOC) and Method 18 Sampling Train

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

4. **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	Acme 4260 Crane Scale (Gravimetric)
Casting Weight	Ohaus MP2 Scale
Muller water weight	Cardinal 748E platform scale (Gravimetric)
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 Fusion Temperature	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Ohaus MP2 Scale
Mold Compactability	Dietert 319A Sand Squeezer (AFS Procedure 2221-00-S)
Carbon/Silicon	Electro-Nite DataCast 2000 (thermal arrest)

5. **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 1500, 2002
VOCs Concentration	EPA Method 18, 25A, TO11, NIOSH 1500, 2002

*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 provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the

measured stack gas velocity and duct diameter, and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight and moisture content. The total mass of analyte is then divided by the weight of the casting poured to provide emissions data in both pounds of analyte per pound of binder and pounds of analyte per ton of metal.

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

7. **Report Preparation and Review:** The Preliminary Draft Report is reviewed by the Process Team and Emissions Team to ensure its completeness, consistency with the test plan, and adherence to the prescribed QA/QC procedures. Appropriate observations, 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 pound of binder and pounds per pound of metal 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 tables also include the TGOC as propane, HC as hexane, methane, and carbon dioxide.

Figures 3-1 and 3-2 present the five emissions indicators and selected individual HAP and VOC emissions data from Table 3-1 in graphical form.

Figures 3-3 and 3-4 present the five emissions indicators and selected 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 test is 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 NE Cavity castings are shown in Figures 3-5, 3-6, and 3-7 respectively.

All NE Cavity castings are shown in Appendix C.

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

Table 3-1 Summary of Test Plan FQ Average Results – Lb/Lb Binder

Analytes	Test FQ (Lb/Lb Binder	STDEV
TGOC as Propane	0.0974	0.0051
HC as Hexane	0.0232	0.0016
Sum of VOCs	0.0341	0.0073
Sum of HAPs	0.0327	0.0071
Sum of POMs	0.0055	0.0005
Individual Organic HAPs		
Phenol	0.0107	0.0017
Benzene	0.0096	0.0007
Methylnaphthalenes	0.0028	0.0003
Aniline	0.0027	0.0004
o,m,p-Cresol	0.0022	0.0003
Toluene	0.0019	0.0001
Naphthalene	0.0017	0.0001
Dimethylnaphthalenes	0.0010	0.0002
o,m,p-Xylene	0.0008	<0.0001
Acetaldehyde	0.0005	<0.0001
Other VOCs		
Trimethylbenzenes	0.0005	0.0002
Other Analytes		
Carbon Dioxide	2.654	0.1844
Carbon Monoxide	0.0194	0.0213
Methane	0.0050	0.0004

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 dioxide, carbon monoxide, and methane were found at 2.802, 0.0248, and 0.0051 Lb/Lb Binder respectively.

Table 3-2 Summary of Test Plan FQ Average Results – Lb/Tn Metal

Analytes	Test FQ (Lb/Tn Metal)	STDEV
TGOC as Propane	0.7255	0.0372
HC as Hexane	0.1726	0.0118
Sum of VOCs	0.2737	0.0156
Sum of HAPs	0.2630	0.0150
Sum of POMs	0.0411	0.0034
Individual Organic HAPs		
Phenol	0.0794	0.0125
Benzene	0.0717	0.0051
Methylnaphthalenes	0.0211	0.0024
Aniline	0.0203	0.0031
o,m,p-Cresol	0.0165	0.0019
Toluene	0.0145	0.0008
Naphthalene	0.0124	0.0009
Dimethylnaphthalenes	0.0076	0.0015
o,m,p-Xylene	0.0062	0.0003
Acetaldehyde	0.0037	0.0001
Other VOCs		
Trimethylbenzenes	0.0038	0.0012
Other Analytes		
Carbon Dioxide	19.77	1.393
Carbon Monoxide	0.1451	0.1593
Methane	0.0370	0.0028

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 dioxide, carbon monoxide, and methane were found at 20.70, 0.2280, and 0.0381 Lb/Tn Metal respectively.

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

Greensand PCS	
	Test FQ
Test Dates	12/17-12/23/03
Cast Weight (all metal inside mold), Lbs.	106.91
Pouring Time, sec.	25
Pouring Temp ,°F	2630
Pour Hood Process Air Temp at Start of Pour, ºF	87
Mixer auto dispensed batch weight, Lbs	51.40
Calibrated auto dispensed binder weight, Lbs	0.727
Core binder calibrated weight, %BOS	1.41
Core binder calibrated weight, %BOS	1.39
Total uncore weight in mold, Lbs.	28.52
Total binder weight in mold, Lbs.	0.398
Core LOI, %	1.37
Total dried core coating weight in mold, Lbs.	0.33
Core age, hours	133
Muller Batch Weight, Lbs.	900
GS Mold Sand Weight, Lbs.	613
Mold compactability, %	55
Mold Temperature, ºF	76
Average Green Compression , psi	13.44
GS Compactability, %	45
GS Moisture Content, %	1.94
GS MB Clay Content, %	6.18
MB Clay reagent, ml	26.4
1800°F LOI - Mold Sand, %	0.83
900°F Volatiles , %	0.38
Appearance ranking: 1 = best, 9 = worst	
Rank1	FQ007
Rank2	FQ003
Rank3	FQ008
Rank4	FQ001
Rank5	FQ005
Rank6	FQ002
Rank7	FQ006
Rank8	FQ009
Rank9	FQ004

Figure 3-1 Emission Indicators from Test Series FQ – Lb/Lb Binder

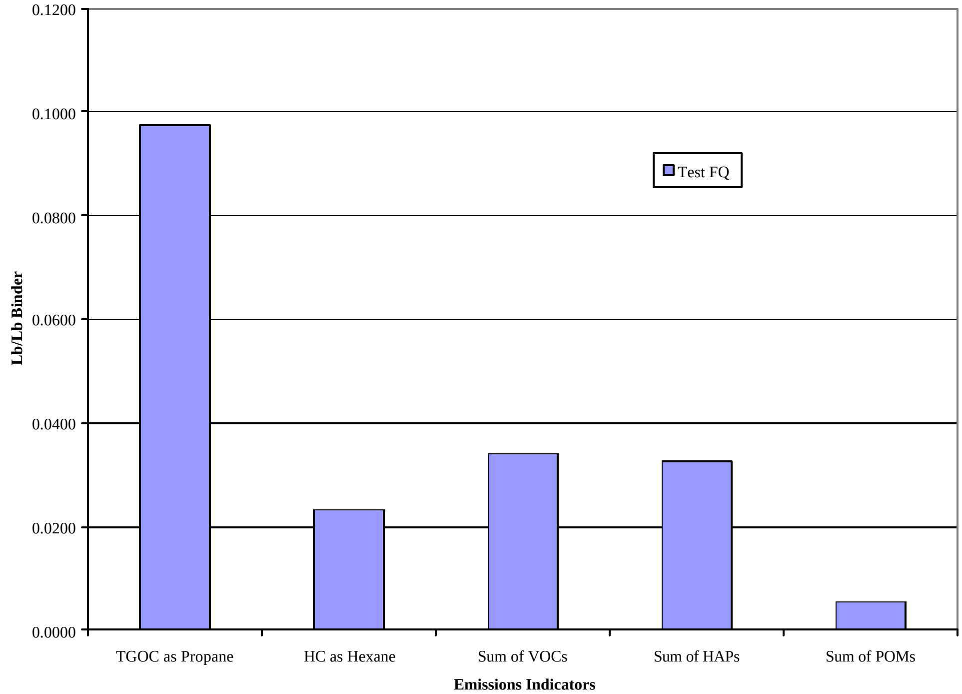


Figure 3-2 Selected HAP and VOC Emissions from Test Series FQ – Lb/Lb Binder

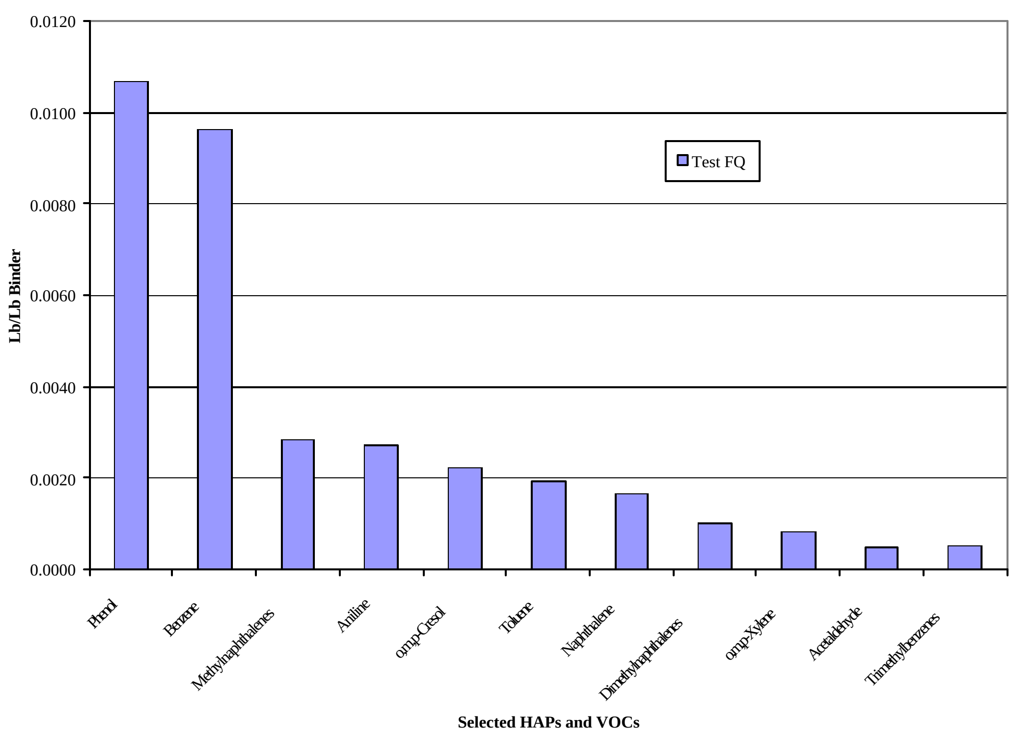


Figure 3-3 Emissions Indicators from Test Series FQ – Lb/Tn Metal

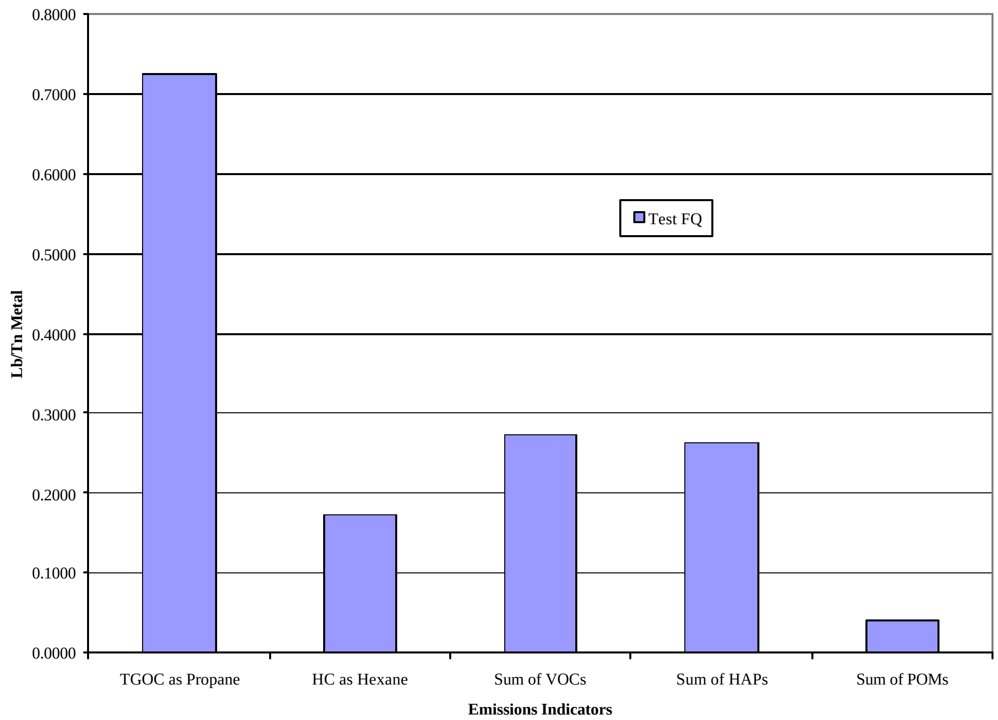


Figure 3-4 Selected HAPs and VOCs from Test Series FQ – Lb/Tn Metal

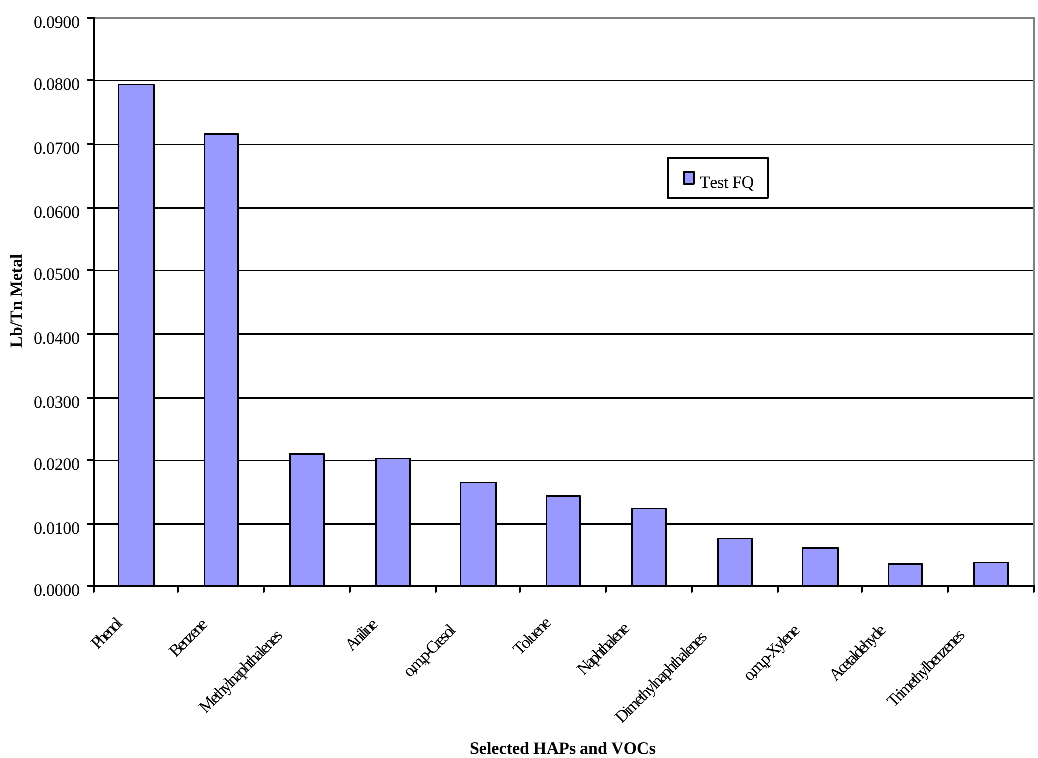


Table 3-4 Rank Order of Casting Surface Quality

FQ CASTING QUALITY MATRIX

Cavity Location (Number)	Best				Median				Worst	Average Cavity Ranking	Frequency
NE(2)	7 (1)	3 (1)	8 (3)	1 (1)	5 (1)	2 (1)	6 (3)	9 (2)	4 (1)	1.6	6-1,1-2,2-3,0-4
NW(4)	7 (3)	3 (2)	8 (2)	4 (3)	5 (2)	9 (4)	1 (1)	2 (4)	6 (4)	2.8	1-1,3-2,2-3,3-4
SE(3)	7 (2)	8 (4)	3 (1)	6 (2)	5 (4)	4 (2)	1 (2)	9 (3)	2 (2)	2.4	1-1,5-2,1-3,2-4
SW(1)	7 (4)	8 (3)	1 (4)	3 (4)	5 (3)	6 (3)	4 (4)	2 (1)	9 (3)	3.2	1-1,0-2,4-3,4-4
RANK	1	2	3	4	5	6	7	8	9		
Predominant run rumber	7	3,8	8	none	5	none	1	2	none		

Sand Hopper

Best | Median +

NE 2	SE 3
4 NW	1 SW

Median - | Worst

Operator

Numbers in body of table are FQ run numbers, those in parentheses are cavity ranking within each overall rank
Cavity location is compass quadrant on pattern
Cavity number is a embossed number on the pattern cavity added after test FQ

Figure 3-5 Best Appearing Casting from Mold FQ007

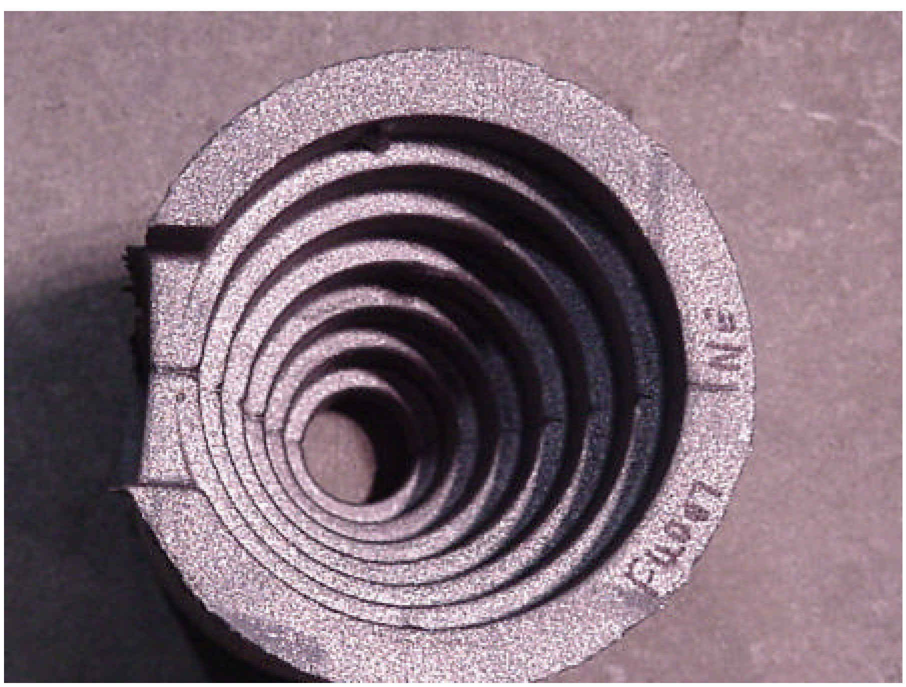


Figure 3-6 Picture of Median Appearance from Mold FQ005

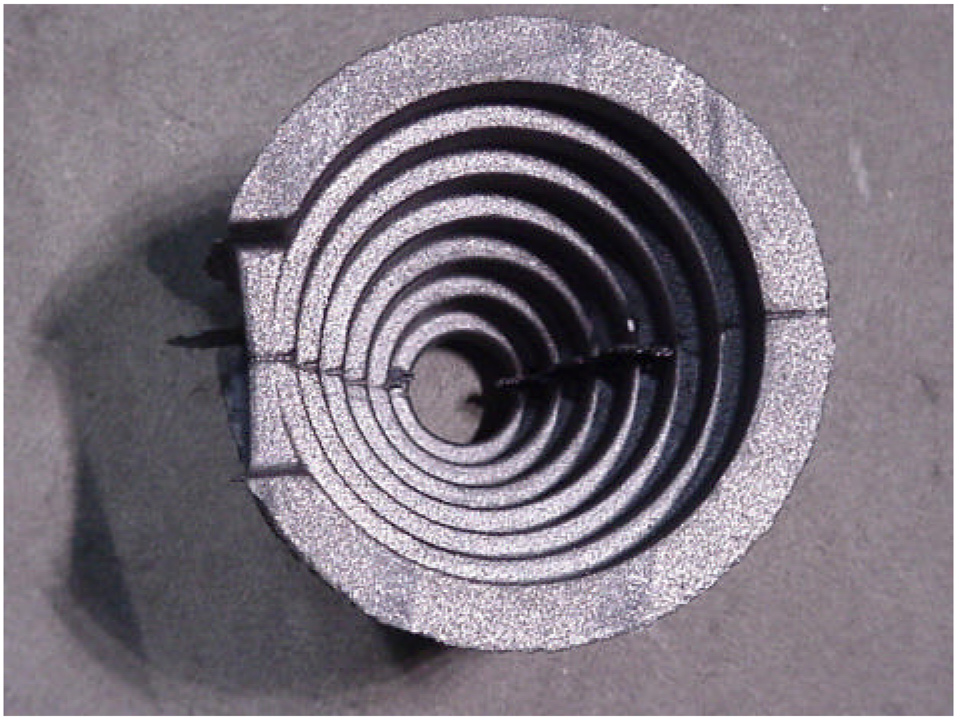
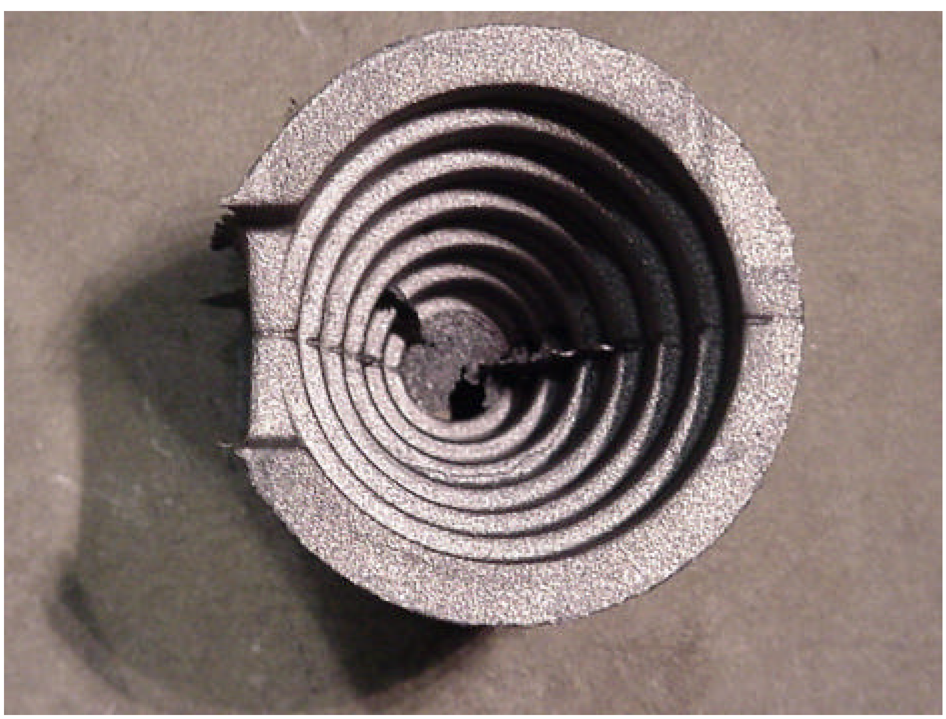


Figure 3-7 Worst Appearing Casting from Mold FQ004



4.0 Discussion of Results

Eleven (11) of the measured compounds comprised greater than 95% of the mass of all VOCs detected by the coated core in Greensand without seacoal baseline test series. Both phenol and benzene comprised approximately 30% each of the total HAPs. The remaining HAPs listed in the table individually contributed 1-8% of the total HAPs. See Table 3-1.

Two methods were employed to measure undifferentiated hydrocarbon emissions, TGOC 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).

A test for volatile matter content based on EPA Method 24 was performed to determine the amount of available VOCs in the binder system used for this test. The HC as Hexane determination for this test was 8% of the total VOCs available as represented by Method 24. This is lower than reported for uncoated cores and may be the result of the additional heated core drying step, i.e. solvent evaporation, not done in other evaluations of the current and other binder systems.

The HC as hexane emission indicator was found to be lower than the total Sum of VOCs. This is probably due, in part, to the relatively high amounts of phenol and cresols in the emissions that would not be completely recovered by the HC as Hexane method.

Carbon dioxide and methane were detected in the ambient sample for Test FQ.

An additional analysis was performed for o-toluidine, which is an HAP on the Clean Air Amendment Act 1990 analyte list. Detection was confirmed by the laboratory and subsequent quantification was performed for each sample. Detailed data is found in Appendix B of this report.

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

Observation of measured process parameters indicates that the tests were run within an acceptable range.

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

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TECHNIKON TEST PLAN

> **CONTRACT NUMBER:** 1410 TASK NUMBER: 1.2.4 **Series:** FQ

> **SITE:** Pre-production

> **TEST TYPE:** Baseline: Coated Core Greensand, pouring, cooling, shakeout

> **METAL TYPE:** Class-30 gray iron

> **MOLD TYPE:** 4-on coated step-cored greensand with no seacoal.

> **NUMBER OF MOLDS:** 1-3 engineering +3 conditioning + 9 Sampling

> **CORE TYPE:** Step: 1.4 % Ashland Isocure ® Phenolic Urethane LF305 part I (55%), 904GR Part II (45%), amine cured. 50-120 hrs old.

> **CORE COATING:** Ashland Velvaplast® CGW 9022 SL

> **SAMPLE EVENTS:** 9

> **TEST DATE:** **START:** 15 Dec 2003
> **FINISHED:** 9 Jan 2004

TEST OBJECTIVES:

Establish an Emission baseline (pouring, cooling, & shakeout) for the standard coated-core mechanically-produced clay, water, coal-less greensand mold.

VARIABLES:

The pattern will be the 4-on step core. The mold will be made with Wexford W450 sand, western and southern bentonite in a 5:2 ratio to yield 7.0 +/- 0.5% MB Clay, no seacoal, and tempered to 40-45% compactability, mechanically compacted. The molds will be maintained at 80-90^{o}F prior to pouring. The sand heap will be maintained at 900 pounds. 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, followed by 15 minutes additional sampling for a total of 75 minutes. The core coating material, and weight or thickness, and application method will be developed by Ashland Chemical. They will instruct Technikon personnel as to the procedure. This core coating procedure shall become the standard for future product testing.

BRIEF OVERVIEW:

This is the first test to include coated cores as the standard. It underscores the increased awareness that along with emission reduction must go maintenance of casting quality and cost. These greensand molds will be produced on mechanically assisted Osborne molding machines. (Ref. CERP test FH). The new 4-on step-core standard mold is a 24 x 24 x 10/10 inch 4-on array of AFS standard drag only step core castings to make a new baseline against which future coated core products can be compared.

SPECIAL CONDITIONS:

The process will include rigorous maintenance of the size of sand heap and maintenance of the material and environmental testing temperatures to reduce seasonal and daily temperature dependent influence on the emissions. Initially a 1300 pound greensand heap will be created from a single muller batch. Nine hundred pounds will become the re-circulating heap. The balance will be used to makeup for attrition. Cores will be produced with Wexford W450 sand at 85-90^{o}F. The core coating shall be dried with a surface temperature of 250-300^{o}F and immediately cooled to and maintained at 80-90^{o}F awaiting insertion in the mold. The cores shall be coated and dried within 1 hour of manufacture and be 50-120 hours old when tested.

Series FQ

PCS Greensand Core Baseline with Ashland 305/904 core binder & Mechanized Molding

Process Instructions

A. Experiment:

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

B. Materials:

1. Mold sand: Virgin mix of Wexford W450 lake sand, western and southern bentonites in ratio of 5:2, and potable water per recipe.
2. Core: Coated step core made with virgin Wexford W450 sand and 1.4% Ashland Isocure® LF305/52-904GR regular phenolic urethane binder in a 55/45 ratio, TEA catalyzed.
3. Core coating: Ashland Velvaplast® CGW 9022 SL
4. Metal: Class-30 gray cast iron poured at 2630 +/- 10^{o}F.
5. Pattern Spray: Black Diamond, hand wiped.

C. Briefing:

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

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

D. ISOCURE® Regular Step Cores:

1. Klein vibratory core sand mixer.
   - **a.** Attach the day tanks with the intended part I and part II binder components via respective binder shut-off valves so that they gravity feed to the respective pumps. The binder components should be 80-85^{o}F.
   - **b.** On the main control panel turn the AUTO/MAN switch to MANUAL, turn on main disconnects and MASTER START push button.

c. Fill the Part I and Part II pumps and de-air the lines.
d. Turn on the Kloster heater-cooler and set the set-point at 90°F.

(1) Wait until the sand temperature reaches the set-point to mix sand.

e. Conduct a capability study on material fill rates.

(1) Remove the mixing bowl skirt to gain access to the binder injection tubes and the bottom side of the batch hopper outlet gate.

(2) Calibrate sand.

(a) Turn the AUTO/MAN switch to MANUAL on main control panel.
(b) Place one bucket of sand, of at least fifty-two (52) pounds net weight, into the sand hopper and manually fill batch hopper using max. and min. proximity switches.
(c) Discharge the sand from the batch hopper using the single cycle push button. Catch the sand as it leaves the batch hopper and record the net weight and the dispensing time.
(d) Repeat 10 times to determine the weight variation. The sand should be 80-85°F.

(3) Calibrate the binder pumps.

(a) Adjust the part I dispensing rate by adjusting the part I pump stroke to be 55% of 1.4 % (0.77 % BOS) of the average sand batch weight dispensed in D.1.e.2.d.
(b) Adjust the machine's inlet air pressure to dispense the binder in about the same time as the sand is dispensed, about 10-15 seconds.
(c) Record the pressure and dispensing time, and net weight.
(d) Repeat 10 times to determine the variation in dispensing rate.
(e) Adjust the part II dispensing rate by adjusting the part II pump stroke to be 45 % of 1.4 % (.63% BOS) of the average sand rate dispensed in D.1.e.2.d.
(f) Repeat D.1.e.3.c, & d for Part II pump.

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

f. Turn on the mixer and turn the AUTO/MAN switch to AUTO.
g. Press the SINGLE CYCLE push button on the operator's station to make a batch of sand. Make four batches to start the Redford Carver core machine.
h. Make a batch of sand for every 7 core machine cycles when using the step core. About two (2) batches will be retained in the core machine sand magazine.

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

2. Redford/Carver core machine

a. Mount the Step-Core core box on the Carver/Redford core machine.
b. Start the core machine auxiliary equipment per the Production Foundry OSI for that equipment.
c. Set up the core machine in the cold box mode with gassing and working pressures and gas and purge time according to the core recipe sheet.
d. Core process setup

(1) Set the TEA to a nominal 5 grams per blow (gas time 0.75 sec (R/C), flow .019 lbs/sec (Luber).
(2) Set the blow pressure to 30+/-2 psi for 3 seconds (R/C).
(3) Set the max purge pressure to 45 psi on the Luber gas generator.
(4) Purge for 20 seconds(R/C) with a 10 second rise time (Luber).
(5) Total cycle time approximately 1 minute.

e. Run the core machine for three (3) cycles and discard the cores. When the cores appear good begin test core manufacture. Five (5) good cores are required for each mold. Make nine (9) additional 50 pound sand batches and run the sand out making core. A minimum of 60 cores are required.
f. One half hour to 1 hour after manufacture randomly perform a scratch hardness test on the outer edge of the blow surface on 10 % of the cores and record the results on the Core Production Log. Values less than 25 shall be marked with a HOLD TAG until they can be 100 % scratch hardness tested to re-qualify. Contact the Process Engineer for disposition on all cores with values less than 15 after 1 hour. Weigh each core and log the results.
g. The sand lab will sample, at the time of manufacture, one (1) core from each row of each shelf (1 of 11) on each core rack. Those cores will be tested for LOI using the standard 1800 oF core LOI test method and reported out associated with the core rack shelf it represents. Qualified cores receiving the green Quality Checked tag must have LOI values between 1.25-1.50 %. Individual rows that qualify may have the Quality Checked tag affixed. Only cores with the green Quality Tag bearing the current test series and dates and signature of the lab technician and core rack/shelf/position on shelf may be taken to the mold assembly area.

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

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

3. Core coating.

- **a.** Ashland Velvaplast® CGW 9022 SL core coating material will be used to dip-coat the cores.
- **b.** Weigh the uncoated core and log the weight.
- **c.** Coat the entire core up to the ½ inch from the invest side.
- **d.** Normalize the core coating temperature to 70 -80^{o}F.
- **e.** Dip the core into the core wash and hold for a count of two(2).
- **f.** Shake the core vertically until the coating ceases to drip.
- **g.** Weigh the wet core and log the weight.
- **h.** Place the core invest side down on the OSI oven lear (chain belt).
- **i.** Dry the core at 275^{o}F for 1 hour in the OSI core drying oven.
- **j.** Weigh the dried and cooled coated core and log the weight.

E. Sand preparation

1. Start up batch: make 1, FQCD1.

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

2. Re-mulling: FQCD2

a. Add to the sand recovered from poured mold FQCD1 sufficient pre-blended sand so that the sand batch weight is 900 +/- 10 pounds. Record the sand weight.
b. Return the sand to the muller and dry blend for about one minute.
c. Add the clays, as directed by the process engineering staff, slowly to the muller to allow them to be distributed throughout the sand mass.
d. Add 5 pounds of water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
e. Follow the above procedure beginning at E.1.f.

3. Re-mulling: FQCD3, FQ001-FQ0XX

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

F. Molding: Step core pattern.

1. Pattern preparation:

a. Inspect and tighten all loose pattern and gating pieces.
b. Repair any damaged pattern or gating parts.

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

Caution: Do not pour gross amounts of parting oil on the pattern to be blown with air. This practice will leave sufficient oil at the parting line to be adsorbed by the sand weakening it and the burning oil will be detected by the emission samplers.

3. Mount a cope follower board containing a pour cup pattern to the underside of the squeeze head plate.
4. Check the alignment of the pour cup by manually raising the table using the squeeze bypass valve at the bottom rear of the machine until the sprue pierces the pour cup pattern. Move the pour cup pattern as necessary.
5. Use the overhead crane to place the pre-weighed drag/cope flask on the mold machine table, parting line surface down.

6. Locate a 24 x 24 x4 inch deep wood upset on top of the flask.
7. Make the green sand mold cope or drag on the Osborn Whisper Ram Jolt-Squeeze mold machine

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

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

- **a.** Open the air supply to the mold machine.

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

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

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

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

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

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

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

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

G. Pig molds

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

H. Emission hood:

1. Loading.

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

2. Shakeout.

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

3. When the emission sampling is completed remove the flask with casting, and recover the sand from the hopper and surrounding floor.

- **a.** Weigh and record the metal poured and the total sand weight recovered and rejoined with the left over mold sand from the molding hopper, spilled molding sand, and sand loosely adhered to the casting.
- **b.** Add sufficient unused premixed sand to the recycled sand to return the sand heap to 900 +/- 10 pounds.

I. Melting:

1. Initial iron charge:

- **a.** Charge the furnace according to the heat recipe.
- **b.** Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
- **c.** Place a pig on top on top.
- **d.** Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
- **e.** Add the balance of the metallics under full power until all is melted and the temperature has reached 2600 to 2700^{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, and pour temperature. Record all furnace activities with an associated time.

2. Back charging.

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

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

Steven M. Knight
Mgr. Process Engineering

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/16/2003											**FQ CONDITIONING - RUN 1**
FQ CR-1											
THC		x									

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/16/2003											**FQ CONDITIONING - RUN 2**
FQ CR-2											
THC		x									

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/17/2003											**FQ CONDITIONING - RUN 3**
FQ CR-3											
THC		x									

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/18/2003											
RUN 1											
THC	FQ001	X									TOTAL
M-18	FQ00101		1						60	1	Carbopak charcoal
									60	2	Excess
									60	3	Excess
Gas, CO, CO2	FQ00102		1						60	4	Tedlar Bag
Gas, CO, CO2	FQ00103				1				0		Tedlar Bag
NIOSH 1500	FQ00104		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FQ00105				1				0		100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00106		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FQ00107				1				0		100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00108		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FQ00109				1				0		DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/18/2003											
RUN 2											
THC	FQ002	X									TOTAL
M-18	FQ00201		1						60	1	Carbopak charcoal
M-18	FQ00202			1					60	2	Carbopak charcoal
M-18	FQ00203				1				0		Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FQ00204		1						60	4	Tedlar Bag
NIOSH 1500	FQ00205		1						1000	5	100/50 mg Charcoal (SKC 226-01)
NIOSH 1500	FQ00206			1					1000	6	100/50 mg Charcoal (SKC 226-01)
NIOSH 2002	FQ00207		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00208		1						1000	9	DNPH Silica Gel (SKC 226-119)
TO11	FQ00209			1					1000	10	DNPH Silica Gel (SKC 226-119)
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/19/2003											
RUN 3											
THC	FQ003	X									TOTAL
M-18	FQ00301		1						60	1	Carbopak charcoal
M-18	FQ00302					1			60	1	Carbopak charcoal
M-18 MS	FQ00303		1						60	2	Carbopak charcoal
M-18 MS	FQ00304			1					60	3	Carbopak charcoal
Gas, CO, CO2	FQ00305		1						60	4	Tedlar Bag
NIOSH 1500	FQ00306		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00307		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
NIOSH 2002	FQ00308			1					1000	8	100/50 mg Silica Gel (SKC 226-10)
TO11	FQ00309		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/19/2003											
RUN 4											
THC	FQ004	X									TOTAL
M-18	FQ00401		1						60	1	Carbopak charcoal
M-18	FQ00402			1					60	2	Carbopak charcoal
	Excess								60	3	Excess
Gas, CO, CO2	FQ00403		1						60	4	Tedlar Bag
NIOSH 1500	FQ00404		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00405		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00406		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/22/2003											
RUN 5											
THC	FQ005	X									TOTAL
M-18	FQ00501		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FQ00502		1						60	4	Tedlar Bag
NIOSH 1500	FQ00503		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00504		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00505		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/22/2003											
RUN 6											
THC	FQ006	X									TOTAL
M-18	FQ00601		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FQ00602		1						60	4	Tedlar Bag
NIOSH 1500	FQ00603		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00604		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00605		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/22/2003											
RUN 7											
THC	FQ007	X									TOTAL
M-18	FQ00701		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FQ00702		1						60	4	Tedlar Bag
NIOSH 1500	FQ00703		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00704		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00705		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/23/2003											
RUN 8											
THC	FQ008	X									TOTAL
M-18	FQ00801		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FQ00802		1						60	4	Tedlar Bag
NIOSH 1500	FQ00803		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00804		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00805		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

PRE-PRODUCTION FQ - SERIES SAMPLE PLAN

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
12/23/2003											
RUN 9											
THC	FQ009	X									TOTAL
M-18	FQ00901		1						60	1	Carbopak charcoal
	Excess								60	2	Excess
	Excess								60	3	Excess
Gas, CO, CO2	FQ00902		1						60	4	Tedlar Bag
NIOSH 1500	FQ00903		1						1000	5	100/50 mg Charcoal (SKC 226-01)
	Excess								1000	6	Excess
NIOSH 2002	FQ00904		1						1000	7	100/50 mg Silica Gel (SKC 226-10)
	Excess								1000	8	Excess
TO11	FQ00905		1						1000	9	DNPH Silica Gel (SKC 226-119)
	Excess								1000	10	Excess
	Excess								1000	11	Excess
	Moisture		1						500	12	TOTAL
	Excess								5000	13	Excess

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APPENDIX B TEST SERIES FQ DETAILED EMISSION RESULTS

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

HAPs	POMs	Compound/Sample Number	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	**12/17/03**	**12/18/03**	**12/18/03**	**12/19/03**	**12/22/03**	**12/22/03**	**12/22/03**	**12/23/03**	**12/23/04**		
		TGOC as Propane	I	9.52E-02	9.01E-02	I	9.70E-02	1.00E-01	1.05E-01	1.02E-01	9.33E-02	9.74E-02	5.06E-03
		HC as Hexane	I	2.60E-02	2.18E-02	I	2.33E-02	2.15E-02	2.45E-02	2.33E-02	2.20E-02	2.32E-02	1.64E-03
		Sum of VOCs	I	1.81E-02	3.45E-02	I	3.52E-02	3.87E-02	3.94E-02	3.77E-02	3.50E-02	3.41E-02	7.31E-03
		Sum of HAPs	I	1.73E-02	3.32E-02	I	3.37E-02	3.71E-02	3.80E-02	3.63E-02	3.37E-02	3.27E-02	7.08E-03
		Sum of POMs	I	4.77E-03	5.57E-03	I	5.31E-03	5.36E-03	6.11E-03	6.05E-03	5.43E-03	5.52E-03	4.61E-04
			Individual Organic HAPs										
x		**Phenol**	I	8.05E-03	9.72E-03	I	9.95E-03	1.30E-02	1.24E-02	1.06E-02	1.09E-02	1.07E-02	1.68E-03
x		**Benzene**	I	I	9.64E-03	I	9.79E-03	8.78E-03	9.81E-03	1.07E-02	9.01E-03	9.63E-03	6.84E-04
x		**Aniline**	I	I	2.23E-03	I	2.47E-03	3.21E-03	3.28E-03	2.50E-03	2.67E-03	2.73E-03	4.24E-04
x		**Toluene**	I	I	1.95E-03	I	1.98E-03	1.85E-03	1.94E-03	2.11E-03	1.84E-03	1.95E-03	9.89E-05
x	z	**2-Methylnaphthalene**	I	1.60E-03	1.81E-03	I	1.79E-03	2.27E-03	2.04E-03	1.96E-03	1.80E-03	1.89E-03	2.15E-04
x		**o-Cresol**	I	2.02E-03	1.52E-03	I	1.63E-03	2.10E-03	1.74E-03	1.62E-03	1.71E-03	1.76E-03	2.17E-04
x	z	**Naphthalene**	I	1.54E-03	1.62E-03	I	1.60E-03	1.86E-03	1.67E-03	1.76E-03	1.56E-03	1.66E-03	1.16E-04
x	z	**1-Methylnaphthalene**	I	9.70E-04	1.10E-03	I	1.07E-03	I	1.21E-03	1.17E-03	1.08E-03	1.10E-03	8.39E-05
x		**m,p-Xylene**	I	7.28E-04	6.54E-04	I	6.85E-04	6.36E-04	6.66E-04	7.12E-04	6.57E-04	6.77E-04	3.32E-05
x		**Acetaldehyde**	I	5.00E-04	5.18E-04	I	5.00E-04	4.94E-04	5.17E-04	4.73E-04	I	5.00E-04	1.65E-05
x		**m,p-Cresol**	I	3.44E-04	3.92E-04	I	4.13E-04	5.88E-04	4.94E-04	4.51E-04	4.86E-04	4.53E-04	7.99E-05
x	z	**1,3-Dimethylnaphthalene**	I	3.22E-04	4.06E-04	I	4.12E-04	5.53E-04	4.70E-04	4.54E-04	4.22E-04	4.34E-04	7.05E-05
x		**o-Toluidine**	I	2.02E-04	3.88E-04	I	3.71E-04	5.17E-04	5.22E-04	3.84E-04	4.12E-04	4.00E-04	1.07E-04
x	z	**2,6-Dimethylnaphthalene**	I	2.11E-04	2.64E-04	I	2.67E-04	3.60E-04	3.04E-04	2.96E-04	2.76E-04	2.83E-04	4.54E-05
x	z	**1,6-Dimethylnaphthalene**	I	1.29E-04	1.64E-04	I	1.62E-04	2.16E-04	1.84E-04	1.78E-04	1.66E-04	1.71E-04	2.63E-05
x		**o-Xylene**	I	1.66E-04	1.49E-04	I	1.52E-04	1.51E-04	1.48E-04	1.60E-04	1.50E-04	1.54E-04	6.68E-06
x		**Formaldehyde**	I	1.42E-04	1.32E-04	I	1.09E-04	1.04E-04	8.67E-05	9.65E-05	9.22E-05	1.09E-04	2.08E-05
x		**Ethylbenzene**	I	1.01E-04	8.75E-05	I	9.47E-05	9.02E-05	9.11E-05	9.79E-05	9.33E-05	9.37E-05	4.66E-06
x		**Hexane**	I	8.72E-05	8.43E-05	I	7.88E-05	8.47E-05	I	8.78E-05	8.37E-05	8.44E-05	3.20E-06
x	z	**2,3-Dimethylnaphthalene**	I	ND	1.27E-04	I	ND	ND	1.43E-04	1.48E-04	1.36E-04	7.91E-05	7.43E-05
x		**Styrene**	I	7.04E-05	6.32E-05	I	7.32E-05	7.53E-05	7.29E-05	8.15E-05	6.92E-05	7.23E-05	5.65E-06
x	z	**1,2-Dimethylnaphthalene**	I	ND	8.27E-05	I	ND	1.05E-04	8.79E-05	8.54E-05	0.00E+00	5.16E-05	4.88E-05
x		**Propionaldehyde**	I	4.28E-05	4.48E-05	I	3.61E-05	3.52E-05	3.53E-05	3.87E-05	3.51E-05	3.83E-05	4.00E-06
x		**2-Butanone**	I	2.78E-05	3.20E-05	I	2.98E-05	3.04E-05	2.75E-05	3.04E-05	3.03E-05	2.97E-05	1.58E-06
x	z	**Acenaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x		**Biphenyl**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x		**Dimethylaniline**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x		**Acrolein**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA

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

HAPs	POMs	Compound/Sample Number	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	**12/17/03**	**12/18/03**	**12/18/03**	**12/19/03**	**12/22/03**	**12/22/03**	**12/22/03**	**12/23/03**	**12/23/04**		
			Other VOCs										
		1,2,4-Trimethylbenzene	I	I	4.10E-04	I	4.12E-04	4.17E-04	4.14E-04	4.25E-04	4.05E-04	4.14E-04	6.81E-06
		1,2,3-Trimethylbenzene	I	1.47E-04	1.56E-04	I	1.66E-04	1.78E-04	1.58E-04	1.66E-04	1.48E-04	1.60E-04	1.11E-05
		3-Ethyltoluene	I	1.51E-04	1.43E-04	I	1.40E-04	1.53E-04	1.66E-04	1.51E-04	1.52E-04	1.51E-04	8.20E-06
		Indene	I	1.26E-04	1.38E-04	I	1.52E-04	1.64E-04	1.46E-04	1.52E-04	1.34E-04	1.45E-04	1.29E-05
		2,4-Dimethylphenol	I	1.54E-04	1.00E-04	I	1.24E-04	1.57E-04	9.89E-05	9.86E-05	9.41E-05	1.18E-04	2.73E-05
		2-Ethyltoluene	I	1.08E-04	9.56E-05	I	8.68E-05	1.14E-04	1.00E-04	1.20E-04	9.89E-05	1.03E-04	1.14E-05
		Undecane	I	I	8.83E-05	I	9.55E-05	9.33E-05	8.40E-05	8.15E-05	7.74E-05	8.67E-05	7.01E-06
		Dodecane	I	ND	8.99E-05	I	1.35E-04	8.63E-05	8.64E-05	7.77E-05	ND	6.79E-05	5.00E-05
		Butyraldehyde/Methacrolein	I	5.95E-05	6.83E-05	I	6.46E-05	6.42E-05	7.01E-05	6.39E-05	5.69E-05	6.39E-05	4.59E-06
		1,3-Diethylbenzene	I	9.86E-05	ND	I	1.41E-04	1.40E-04	ND	ND	ND	5.43E-05	6.91E-05
		Crotonaldehyde	I	ND	ND	I	ND	ND	1.24E-04	8.75E-05	8.47E-05	4.23E-05	5.42E-05
		Benzaldehyde	I	2.46E-05	2.73E-05	I	2.61E-05	2.59E-05	2.54E-05	2.49E-05	2.36E-05	2.54E-05	1.18E-06
		Cyclohexane	I	I	ND	I	ND	ND	ND	ND	ND	ND	NA
		Decane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	I	I	ND	I	ND	ND	ND	ND	ND	ND	NA
		Heptane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Indan	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Nonane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Octane	I	I	ND	I	ND	ND	ND	ND	ND	ND	NA
		Propylbenzene	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		1,3,5-Trimethylbenzene	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Pentanal	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA

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

HAPs	POMs	Compound/Sample Number	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	**12/17/03**	**12/18/03**	**12/18/03**	**12/19/03**	**12/22/03**	**12/22/03**	**12/22/03**	**12/23/03**	**12/23/04**		
			Other Analytes										
		Acetone	I	2.40E-04	2.46E-04	I	2.34E-04	2.37E-04	2.56E-04	2.67E-04	2.38E-04	2.46E-04	1.19E-05
		Carbon Dioxide	I	2.59E+00	3.01E+00	I	2.66E+00	2.61E+00	2.50E+00	2.55E+00	I	2.65E+00	1.84E-01
		Carbon Monoxide	I	ND	3.76E-02	I	4.14E-02	ND	ND	3.77E-02	I	1.94E-02	2.13E-02
		Methane	I	5.05E-03	5.59E-03	I	4.94E-03	4.85E-03	4.44E-03	4.96E-03	I	4.97E-03	3.70E-04
		Ethane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Propane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Isobutane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Butane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Neopentane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Isopentane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA
		Pentane	I	ND	ND	I	ND	ND	ND	ND	I	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

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

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

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	**12/17/03**	**12/18/03**	**12/18/03**	**12/19/03**	**12/22/03**	**12/22/03**	**12/22/03**	**12/23/03**	**12/23/04**		
		TGOC as Propane	I	7.08E-01	6.71E-01	I	7.25E-01	7.49E-01	7.74E-01	7.58E-01	6.93E-01	7.25E-01	3.72E-02
		HC as Hexane	I	1.93E-01	1.62E-01	I	1.74E-01	1.61E-01	1.81E-01	1.74E-01	1.63E-01	1.73E-01	1.18E-02
		Sum of VOCs	I	I	2.57E-01	I	2.63E-01	2.90E-01	2.91E-01	2.81E-01	2.60E-01	2.74E-01	1.56E-02
		Sum of HAPs	I	I	2.47E-01	I	2.52E-01	2.78E-01	2.80E-01	2.71E-01	2.50E-01	2.63E-01	1.50E-02
		Sum of POMs	I	3.55E-02	4.15E-02	I	3.97E-02	4.01E-02	4.52E-02	4.52E-02	4.03E-02	4.11E-02	3.39E-03
			Individual Organic HAPs										
x		**Phenol**	I	5.98E-02	7.24E-02	I	7.44E-02	9.74E-02	9.17E-02	7.94E-02	8.11E-02	7.94E-02	1.25E-02
x		**Benzene**	I	I	7.18E-02	I	7.32E-02	6.57E-02	7.25E-02	8.00E-02	6.69E-02	7.17E-02	5.11E-03
x		**Aniline**	I	I	1.66E-02	I	1.85E-02	2.40E-02	2.43E-02	1.87E-02	1.99E-02	2.03E-02	3.12E-03
x		**Toluene**	I	I	1.45E-02	I	1.48E-02	1.38E-02	1.43E-02	1.58E-02	1.37E-02	1.45E-02	7.55E-04
x	z	**2-Methylnaphthalene**	I	1.19E-02	1.35E-02	I	1.34E-02	1.69E-02	1.51E-02	1.46E-02	1.34E-02	1.41E-02	1.62E-03
x		**o-Cresol**	I	1.50E-02	1.13E-02	I	1.22E-02	1.57E-02	1.29E-02	1.21E-02	1.27E-02	1.31E-02	1.62E-03
x	z	**Naphthalene**	I	1.15E-02	1.21E-02	I	1.20E-02	1.39E-02	1.24E-02	1.32E-02	1.15E-02	1.24E-02	8.88E-04
x	z	**1-Methylnaphthalene**	I	7.21E-03	8.19E-03	I	8.04E-03	I	8.93E-03	8.75E-03	7.99E-03	8.19E-03	6.15E-04
x		**m,p-Xylene**	I	5.41E-03	4.87E-03	I	5.13E-03	4.76E-03	4.92E-03	5.32E-03	4.88E-03	5.04E-03	2.48E-04
x		**Acetaldehyde**	I	3.71E-03	3.86E-03	I	3.74E-03	3.69E-03	3.82E-03	3.53E-03	I	3.73E-03	1.15E-04
x		**m,p-Cresol**	I	2.56E-03	2.92E-03	I	3.09E-03	4.40E-03	3.65E-03	3.37E-03	3.61E-03	3.37E-03	5.97E-04
x	z	**1,3-Dimethylnaphthalene**	I	2.39E-03	3.03E-03	I	3.08E-03	4.13E-03	3.48E-03	3.39E-03	3.13E-03	3.23E-03	5.29E-04
x		**o-Toluidine**	I	1.50E-03	2.89E-03	I	2.77E-03	3.87E-03	3.86E-03	2.87E-03	3.06E-03	2.97E-03	7.97E-04
x	z	**2,6-Dimethylnaphthalene**	I	1.57E-03	1.97E-03	I	1.99E-03	2.69E-03	2.25E-03	2.21E-03	2.05E-03	2.10E-03	3.41E-04
x	z	**1,6-Dimethylnaphthalene**	I	9.57E-04	1.22E-03	I	1.21E-03	1.61E-03	1.36E-03	1.33E-03	1.23E-03	1.27E-03	1.98E-04
x		**o-Xylene**	I	1.24E-03	1.11E-03	I	1.14E-03	1.13E-03	1.10E-03	1.19E-03	1.11E-03	1.15E-03	5.06E-05
x		**Formaldehyde**	I	1.06E-03	9.82E-04	I	8.19E-04	7.77E-04	6.41E-04	7.20E-04	6.84E-04	8.11E-04	1.55E-04
x		**Ethylbenzene**	I	7.51E-04	6.52E-04	I	7.08E-04	6.74E-04	6.73E-04	7.30E-04	6.93E-04	6.97E-04	3.49E-05
x		**Hexane**	I	6.48E-04	6.28E-04	I	5.89E-04	6.33E-04	I	6.55E-04	6.22E-04	6.29E-04	2.32E-05
x	z	**2,3-Dimethylnaphthalene**	I	ND	9.45E-04	I	ND	ND	1.06E-03	1.11E-03	1.01E-03	5.88E-04	5.52E-04
x		**Styrene**	I	5.23E-04	4.71E-04	I	5.47E-04	5.63E-04	5.39E-04	6.09E-04	5.14E-04	5.38E-04	4.29E-05
x	z	**1,2-Dimethylnaphthalene**	I	ND	6.16E-04	I	ND	7.86E-04	6.50E-04	6.38E-04	0.00E+00	3.84E-04	3.63E-04
x		**Propionaldehyde**	I	3.18E-04	3.34E-04	I	2.70E-04	2.63E-04	2.61E-04	2.89E-04	2.60E-04	2.85E-04	2.98E-05
x		**2-Butanone**	I	2.06E-04	2.38E-04	I	2.23E-04	2.27E-04	2.03E-04	2.27E-04	2.25E-04	2.21E-04	1.23E-05
x		**N,N-Dimethylaniline**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**1,5-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**1,8-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**2,3,5-Trimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**2,7-Dimethylnaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x	z	**Acenaphthalene**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x		**Biphenyl**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
x		**Acrolein**	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA

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

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	12/17/03	12/18/03	12/18/03	12/19/03	12/22/03	12/22/03	12/22/03	12/23/03	12/23/04		
			Other VOCs										
		1,2,4-Trimethylbenzene	I	I	3.05E-03	I	3.08E-03	3.12E-03	3.06E-03	3.17E-03	3.01E-03	3.08E-03	5.70E-05
		1,2,3-Trimethylbenzene	I	1.09E-03	1.16E-03	I	1.24E-03	1.33E-03	1.17E-03	1.24E-03	1.10E-03	1.19E-03	8.63E-05
		3-Ethyltoluene	I	1.12E-03	1.06E-03	I	1.05E-03	1.14E-03	1.22E-03	1.12E-03	1.13E-03	1.12E-03	5.75E-05
		Indene	I	9.33E-04	1.03E-03	I	1.14E-03	1.23E-03	1.08E-03	1.14E-03	9.95E-04	1.08E-03	9.92E-05
		2,4-Dimethylphenol	I	1.15E-03	7.47E-04	I	9.29E-04	1.17E-03	7.31E-04	7.36E-04	6.99E-04	8.80E-04	2.05E-04
		2-Ethyltoluene	I	8.00E-04	7.12E-04	I	6.49E-04	8.50E-04	7.43E-04	8.98E-04	7.34E-04	7.69E-04	8.56E-05
		Undecane	I	I	6.58E-04	I	7.14E-04	6.98E-04	6.21E-04	6.09E-04	5.74E-04	6.46E-04	5.42E-05
		Dodecane	I	ND	6.70E-04	I	1.01E-03	6.45E-04	6.38E-04	5.80E-04	ND	5.06E-04	3.74E-04
		Butyraldehyde/Methacrolein	I	4.42E-04	5.09E-04	I	4.83E-04	4.80E-04	5.18E-04	4.77E-04	4.23E-04	4.76E-04	3.39E-05
		1,3-Diethylbenzene	I	7.33E-04	ND	I	1.05E-03	1.05E-03	ND	ND	ND	4.05E-04	5.16E-04
		Crotonaldehyde	I	ND	ND	I	ND	ND	9.13E-04	6.53E-04	6.29E-04	3.14E-04	4.02E-04
		Benzaldehyde	I	1.83E-04	2.03E-04	I	1.95E-04	1.94E-04	1.88E-04	1.86E-04	1.75E-04	1.89E-04	9.12E-06
		1,3,5-Trimethylbenzene	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		2,6-Dimethylphenol	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Cyclohexane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Decane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Heptane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Indan	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Nonane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		n-Propylbenzene	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Octane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Tetradecane	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Hexaldehyde	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		Pentanal	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA
		o,m,p-Tolualdehyde	I	ND	ND	I	ND	ND	ND	ND	ND	ND	NA

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

HAPs	POMs	COMPOUND / SAMPLE NUMBER	FQ001	FQ002	FQ003	FQ004	FQ005	FQ006	FQ007	FQ008	FQ009	Average	STDEV
		Test Dates	**12/17/03**	**12/18/03**	**12/18/03**	**12/19/03**	**12/22/03**	**12/22/03**	**12/22/03**	**12/23/03**	**12/23/04**		
			Other Analytes										
		Acetone	I	1.78E-03	1.83E-03	I	1.75E-03	1.77E-03	1.89E-03	I	1.77E-03	1.80E-03	5.12E-05
		Carbon Dioxide	I	1.93E+01	2.24E+01	I	1.99E+01	1.95E+01	1.85E+01	1.90E+01	NA	1.98E+01	1.39E+00
		Carbon Monoxide	I	ND	2.80E-01	I	3.09E-01	ND	ND	2.81E-01	NA	2.90E-01	1.66E-02
		Methane	I	5.00E-04	5.55E-04	I	4.93E-04	4.84E-04	4.37E-04	4.93E-04	NA	4.94E-04	3.75E-05
		Ethane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Propane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Isobutane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Butane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Neopentane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Isopentane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA
		Pentane	I	ND	ND	I	ND	ND	ND	ND	NA	ND	NA

I: Data rejected based on data validation considerations.

ND: Non Detect; NA: Not Applicable

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

Test FQ Quantitation Limits – Lb/Lb Binder

Analytes	Lb/Lb Binder
1,2,3-Trimethylbenzene	1.59E-05
1,2,4-Trimethylbenzene	1.59E-05
1,3,5-Trimethylbenzene	1.59E-05
1,3-Dimethylnaphthalene	1.59E-05
1-Methylnaphthalene	1.59E-05
2-Ethyltoluene	1.59E-05
2-Methylnaphthalene	1.59E-05
Benzene	1.59E-05
Ethylbenzene	1.59E-05
Hexane	1.59E-05
m,p-Xylene	1.59E-05
Naphthalene	1.59E-05
o-Xylene	1.59E-05
Styrene	1.59E-05
Toluene	1.59E-05
Undecane	1.59E-05
1,2-Dimethylnaphthalene	7.95E-05
1,3-Diethylbenzene	7.95E-05
1,5-Dimethylnaphthalene	7.95E-05
1,6-Dimethylnaphthalene	7.95E-05
1,8-Dimethylnaphthalene	7.95E-05
2,3,5-Trimethylnaphthalene	7.95E-05
2,3-Dimethylnaphthalene	7.95E-05
2,4-Dimethylphenol	7.95E-05

Analytes	Lb/Lb Binder
2,6-Dimethylnaphthalene	7.95E-05
2,6-Dimethylphenol	7.95E-05
2,7- Dimethylnaphthalene	7.95E-05
3-Ethyltoluene	7.95E-05
Acenaphthalene	7.95E-05
Biphenyl	7.95E-05
Cyclohexane	7.95E-05
Decane	7.95E-05
Dodecane	7.95E-05
Heptane	7.95E-05
Indan	7.95E-05
Indene	7.95E-05
m,p-Cresol	7.95E-05
Nonane	7.95E-05
o-Cresol	7.95E-05
Octane	7.95E-05
Phenol	7.95E-05
Propylbenzene	7.95E-05
Tetradecane	7.95E-05
HC as Hexane	4.80E-04
2-Butanone (MEK)	1.41E-05
Acetaldehyde	1.41E-05
Acetone	1.41E-05
Acrolein	1.41E-05

Analytes	Lb/Lb Binder
Benzaldehyde	1.41E-05
Butyraldehyde	1.41E-05
Crotonaldehyde	1.41E-05
Formaldehyde	1.41E-05
Hexaldehyde	1.41E-05
Butyraldehyde/Methacrolein	2.35E-05
o,m,p-Tolualdehyde	3.76E-05
Pentanal (Valeraldehyde)	1.41E-05
Propionaldehyde (Propanal)	1.41E-05
Aniline	9.58E-05
Dimethylaniline	9.58E-05
o-Toluidine	4.79E-05
Carbon Monoxide	3.76E-02
Methane	2.15E-03
Carbon Dioxide	5.90E-02
Ethane	4.02E-02
Propane	5.90E-02
Isobutane	7.78E-02
Butane	7.78E-02
Neopentane	9.66E-02
Isopentane	9.66E-02
Pentane	9.66E-02

Test FQ Quantitation Limits – Lb/Tn Metal

Analytes	Lb/Tn Metal
1,2,3-Trimethylbenzene	1.18E-04
1,2,4-Trimethylbenzene	1.18E-04
1,3,5-Trimethylbenzene	1.18E-04
1,3-Dimethylnaphthalene	1.18E-04
1-Methylnaphthalene	1.18E-04
2-Ethyltoluene	1.18E-04
2-Methylnaphthalene	1.18E-04
Benzene	1.18E-04
Ethylbenzene	1.18E-04
Hexane	1.18E-04
m,p-Xylene	1.18E-04
Naphthalene	1.18E-04
o-Xylene	1.18E-04
Styrene	1.18E-04
Toluene	1.18E-04
Undecane	1.18E-04
1,2-Dimethylnaphthalene	5.92E-04
1,3-Diethylbenzene	5.92E-04
1,5-Dimethylnaphthalene	5.92E-04
1,6-Dimethylnaphthalene	5.92E-04
1,8-Dimethylnaphthalene	5.92E-04
2,3,5-Trimethylnaphthalene	5.92E-04
2,3-Dimethylnaphthalene	5.92E-04
2,4-Dimethylphenol	5.92E-04

Analytes	Lb/Tn Metal
2,6-Dimethylnaphthalene	5.92E-04
2,6-Dimethylphenol	5.92E-04
2,7- Dimethylnaphthalene	5.92E-04
3-Ethyltoluene	5.92E-04
Acenaphthalene	5.92E-04
Biphenyl	5.92E-04
Cyclohexane	5.92E-04
Decane	5.92E-04
Dodecane	5.92E-04
Heptane	5.92E-04
Indan	5.92E-04
Indene	5.92E-04
m,p-Cresol	5.92E-04
Nonane	5.92E-04
o-Cresol	5.92E-04
Octane	5.92E-04
Phenol	5.92E-04
Propylbenzene	5.92E-04
Tetradecane	5.92E-04
HC as Hexane	3.57E-03
2-Butanone (MEK)	1.05E-04
Acetaldehyde	1.05E-04
Acetone	1.05E-04
Acrolein	1.05E-04

Analytes	Lb/Tn Metal
Benzaldehyde	1.05E-04
Butyraldehyde	1.05E-04
Crotonaldehyde	1.05E-04
Formaldehyde	1.05E-04
Hexaldehyde	1.05E-04
Butyraldehyde/Methacrolein	1.75E-04
o,m,p-Tolualdehyde	2.80E-04
Pentanal (Valeraldehyde)	1.05E-04
Propionaldehyde (Propanal)	1.05E-04
Aniline	7.13E-04
Dimethylaniline	7.13E-04
o-Toluidine	3.57E-04
Carbon Monoxide	2.80E-01
Methane	1.60E-02
Carbon Dioxide	4.40E-01
Ethane	3.00E-01
Propane	4.40E-01
Isobutane	5.79E-01
Butane	5.79E-01
Neopentane	7.19E-01
Isopentane	7.19E-01
Pentane	7.19E-01

APPENDIX C TEST SERIES FQ DETAILED PROCESS DATA

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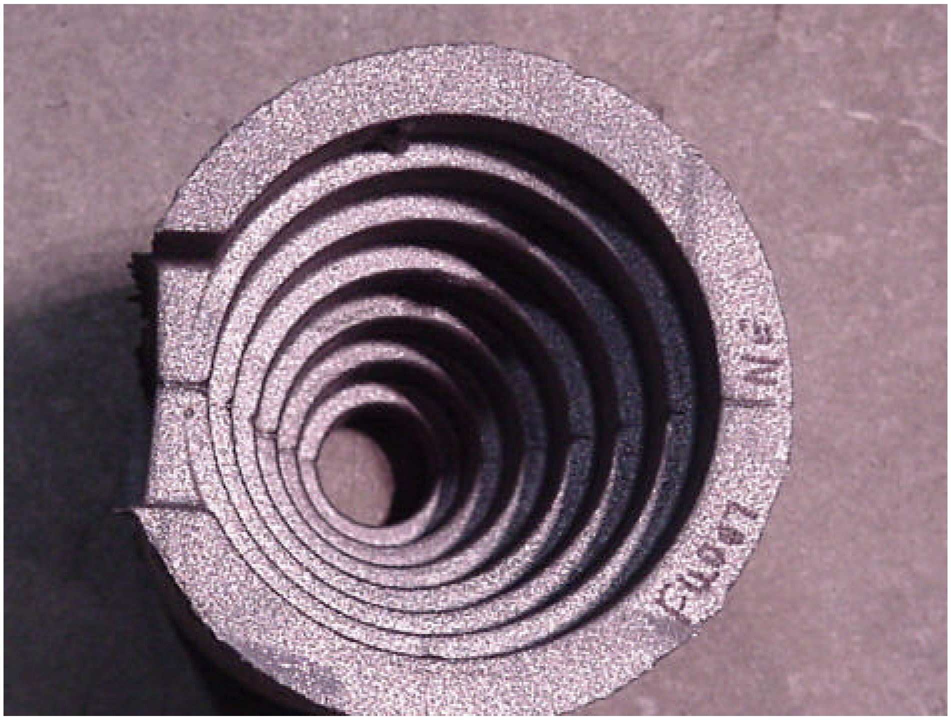
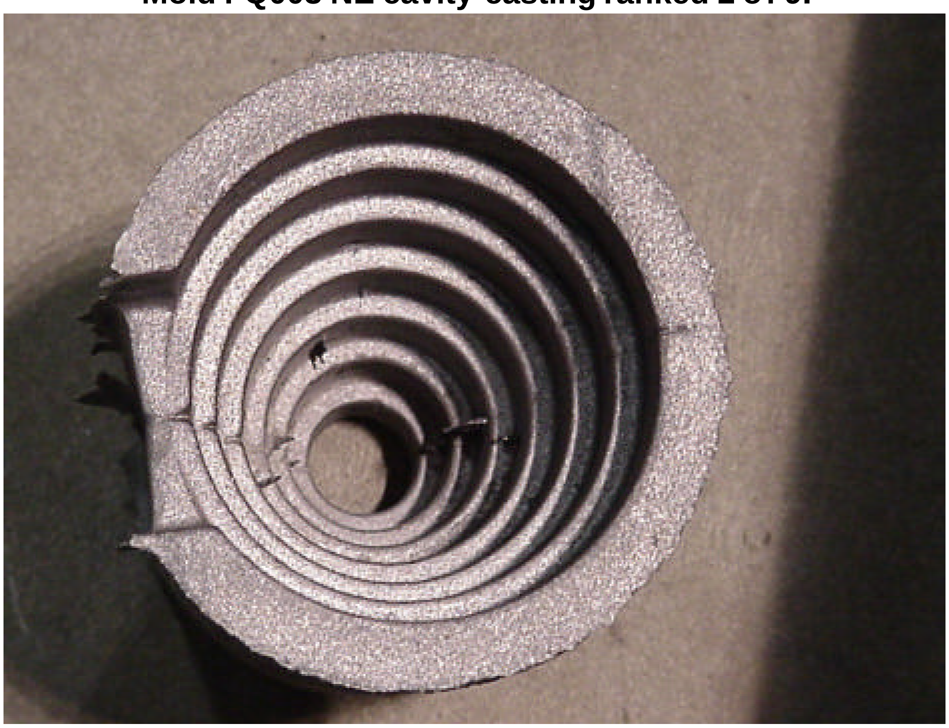
Test FQ Detailed Process Data

Greensand PCS										
Test Dates	**12/17/2003**	**12/18/2003**	**12/18/2003**	**12/19/2003**	**12/22/2003**	**12/22/2003**	**12/22/2003**	**12/23/2003**	**12/23/2004**	**Averages**
Emissions Sample # Production Sample #	**FQ001**	**FQ002**	**FQ003**	**FQ004**	**FQ005**	**FQ006**	**FQ007**	**FQ008**	**FQ009**	
Cast Weight (all metal inside mold), Lbs.	108.30	106.30	107.15	106.80	106.70	106.70	107.45	105.85	106.95	**106.91**
Pouring Time, sec.	21	24	27	27	25	23	26	31	24	**25**
Pouring Temp ,°F	2635	nd	2626	2640	2622	2632	2626	2620	2636	**2630**
Pour Hood Process Air Temp at Start of Pour, °F	86	85	86	87	87	88	87	88	89	**87**
Mixer auto dispensed batch weight, Lbs	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.55	**51.40**
Calibrated auto dispensed binder weight, Lbs	0.728	0.728	0.728	0.728	0.728	0.728	0.728	0.728	0.719	**0.727**
Core binder calibrated weight, %BOS	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.40	**1.41**
Core binder calibrated weight, %	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.38	**1.39**
Total uncoated core weight in mold, Lbs.	28.45	28.30	28.55	28.65	28.60	28.60	28.40	28.30	28.85	**28.52**
Total binder weight in mold, Lbs.	0.397	0.395	0.399	0.400	0.399	0.399	0.397	0.395	0.397	**0.398**
Core LOI, %	1.33	1.32	1.41	1.32	1.31	1.32	1.38	1.46	1.49	**1.37**
Total dried core coating weight in mold, Lbs	0.20	0.40	0.40	0.40	0.35	0.30	0.35	0.40	0.20	**0.33**
Core age, hrs.	70	72	91	106	164	168	171	188	171	**133**
Muller Batch Weight, Lbs.	900	900	900	900	900	900	900	900	900	**900**
GS Mold Sand Weight, Lbs.	620	617	613	609	610	612	613	610	609	**613**
Mold compactability, %	48	51	57	57	56	57	59	58	55	**55**
Mold Temperature, °F	90	70	88	78	67	72	74	71	76	**76**
Average Green Compression , psi	11.93	13.77	12.38	13.22	12.27	12.51	12.57	16.36	15.93	**13.44**
GS Compactability, %	26	40	42	47	52	53	55	44	45	**45**
GS Moisture Content, %	1.34	1.68	1.78	2.06	2.28	2.04	2.26	1.92	2.06	**1.94**
GS MB Clay Content, %	6.09	6.09	5.62	5.97	6.21	6.21	6.21	6.68	6.56	**6.18**
MB Clay reagent, ml	26.0	26.0	24.0	25.5	26.5	26.5	26.5	28.5	28.0	**26.4**
1800°F LOI - Mold Sand, %	0.76	0.75	0.93	0.88	0.83	0.74	0.90	0.85	0.79	**0.83**
900°F Volatiles , %	0.52	0.26	0.28	0.40	0.34	0.40	0.44	0.44	0.34	**0.38**
Appearance ranking: 1 = best, 9 = worst	4	6	2	9	5	7	1	3	8	

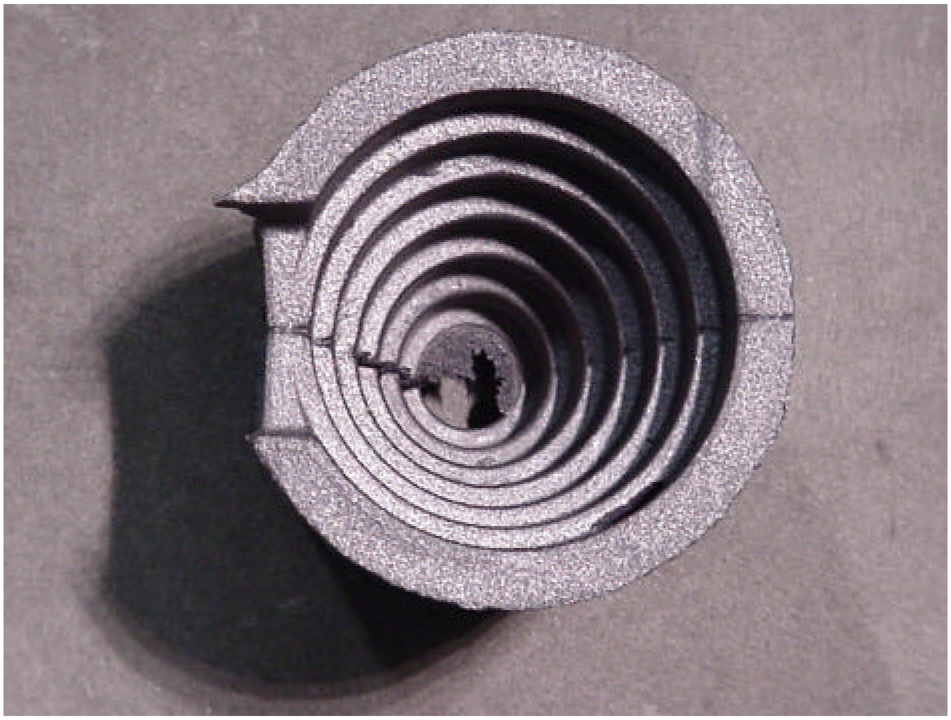
Mold FQ007 NE cavity casting ranked 1 of 9.



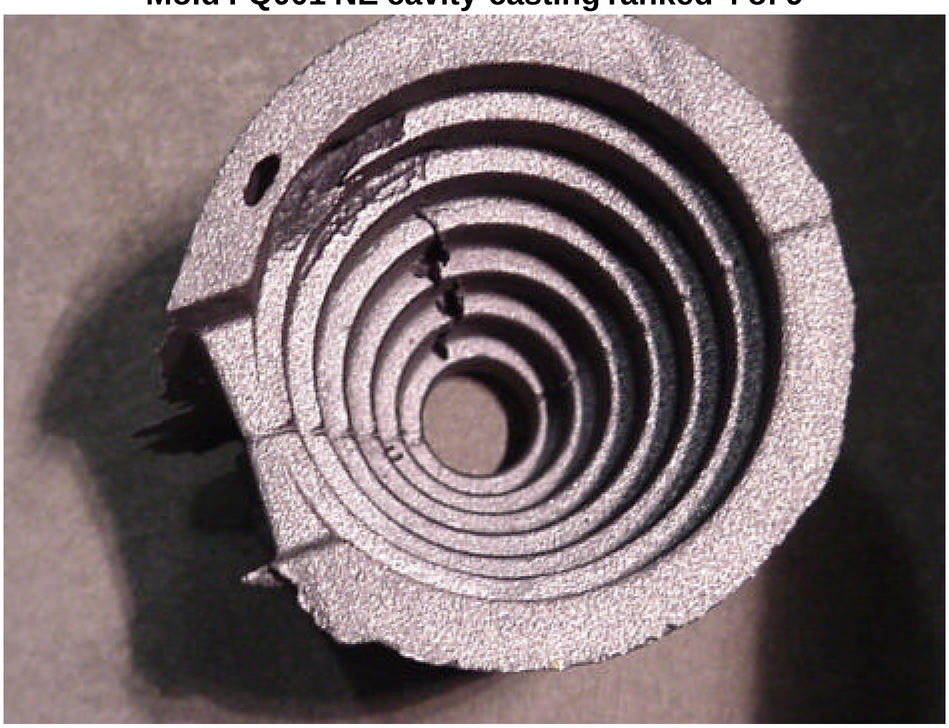
Mold FQ003 NE cavity casting ranked 2 of 9.



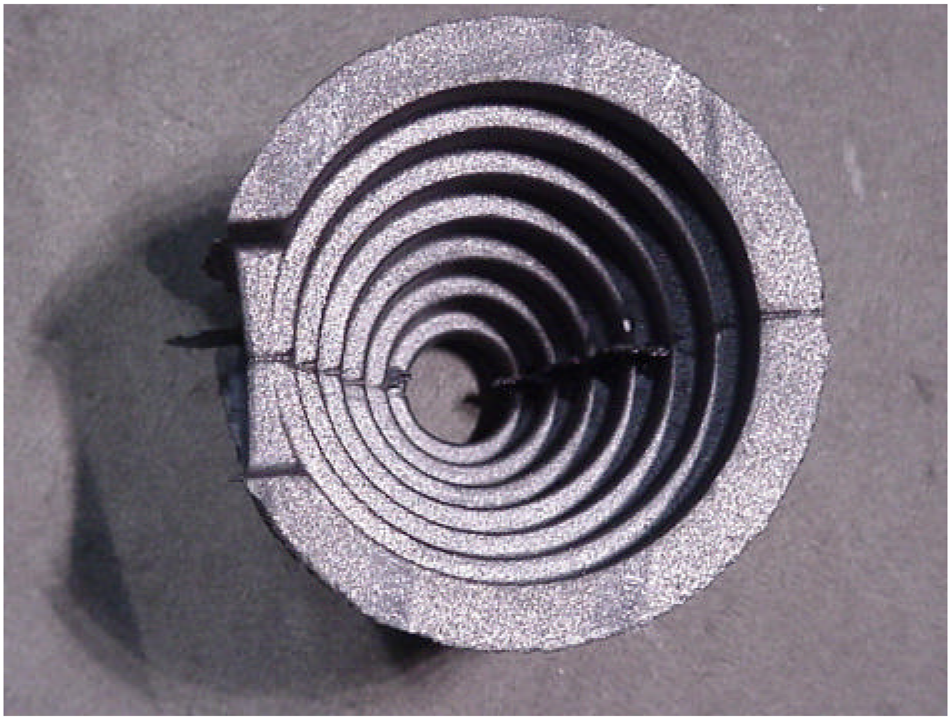
Mold FQ008 NE cavity casting ranked 3 of 9



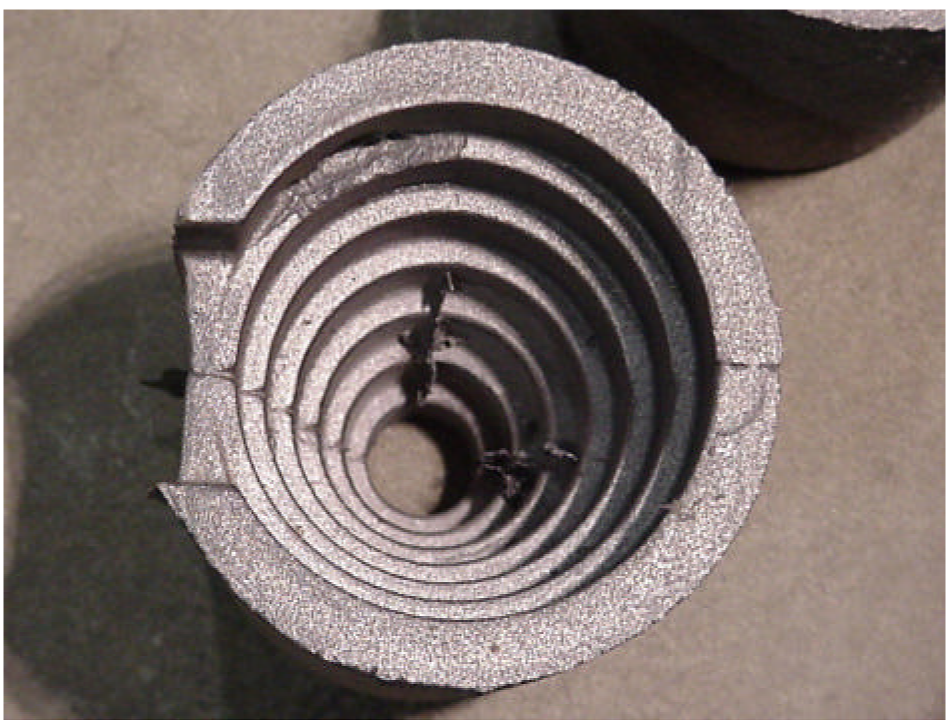
Mold FQ001 NE cavity casting ranked 4 of 9



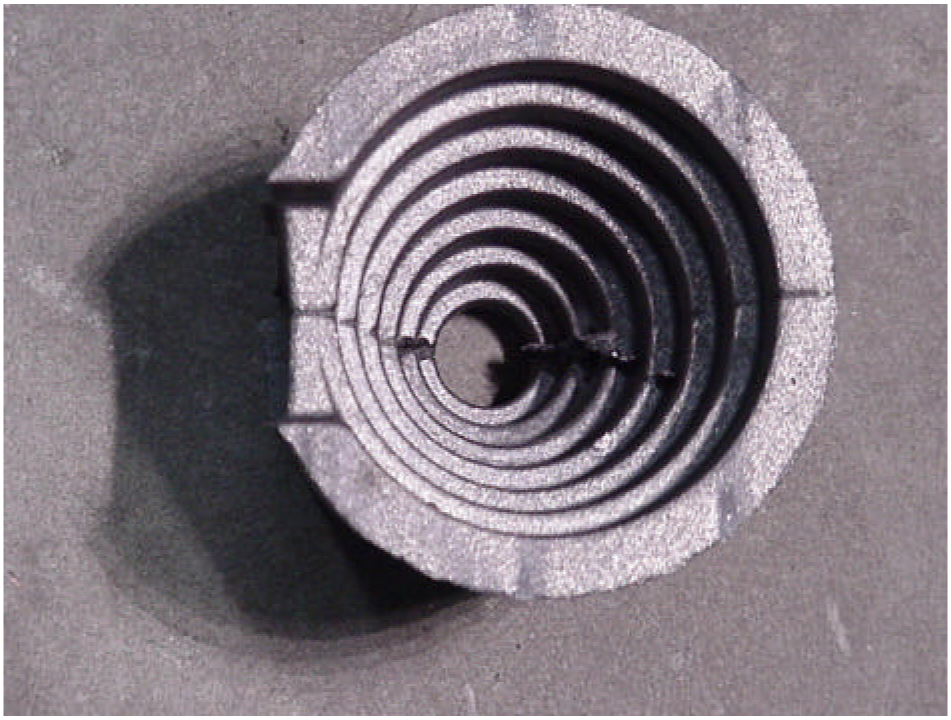
Mold FQ005 NE cavity casting ranked 5 of 9



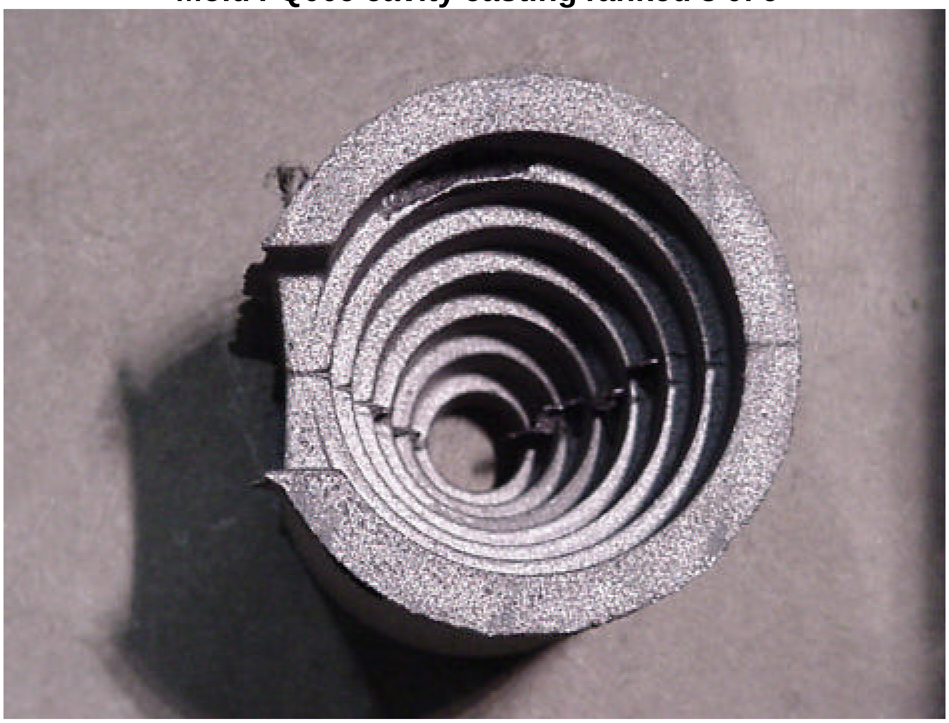
Mold FQ002 NE cavity casting ranked 6 of 9



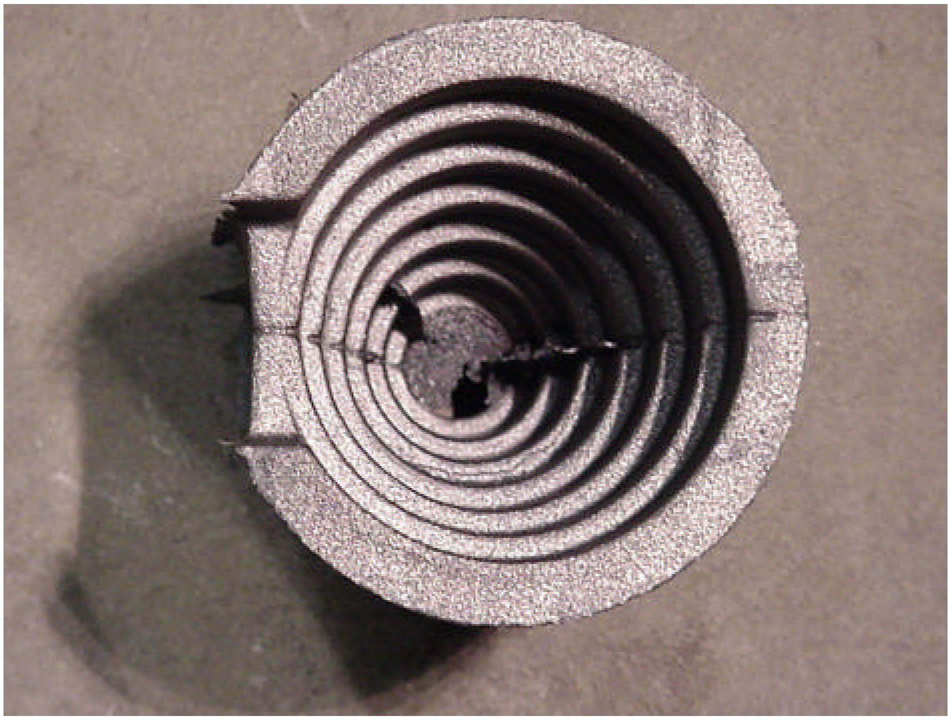
Mold FQ006 NE cavity casting ranked 7 of 9



Mold FQ009 cavity casting ranked 8 0f 9



Mold FQ004 cavity casting ranked 9 of 9



APPENDIX D METHOD 25A CHARTS

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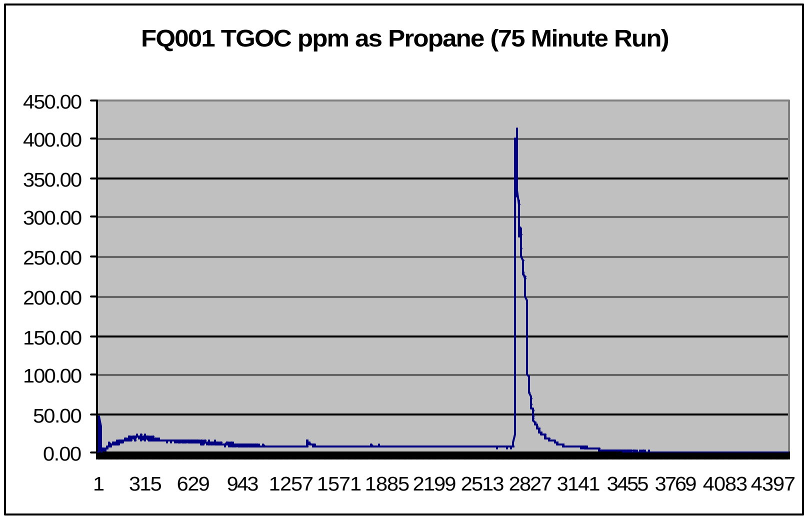
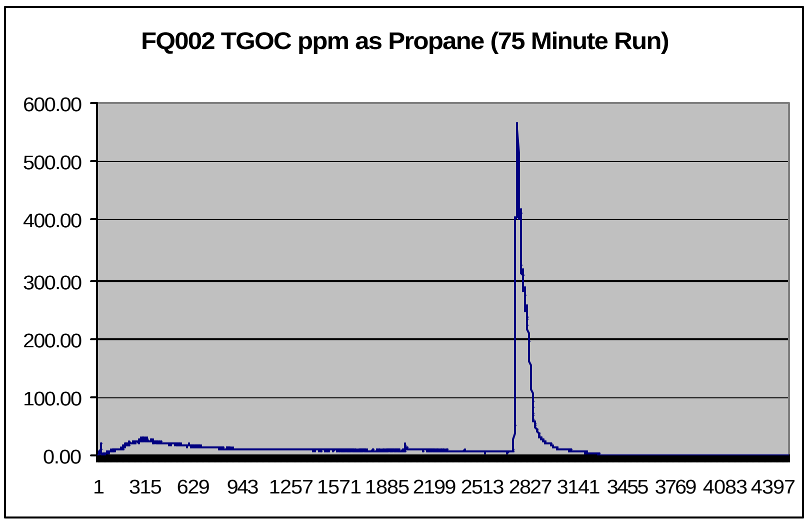

FQ001 TGOC ppm as Propane (75 Minute Run)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FQ002 TGOC ppm as Propane (75 Minute Run)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
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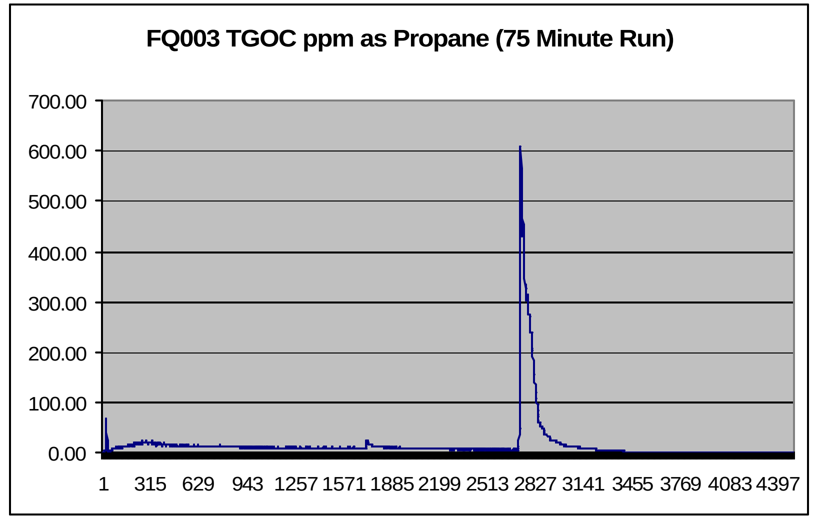
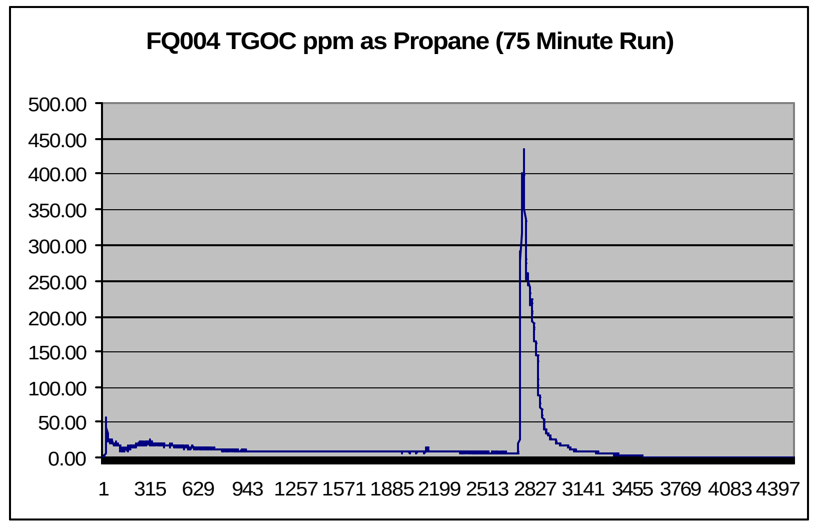
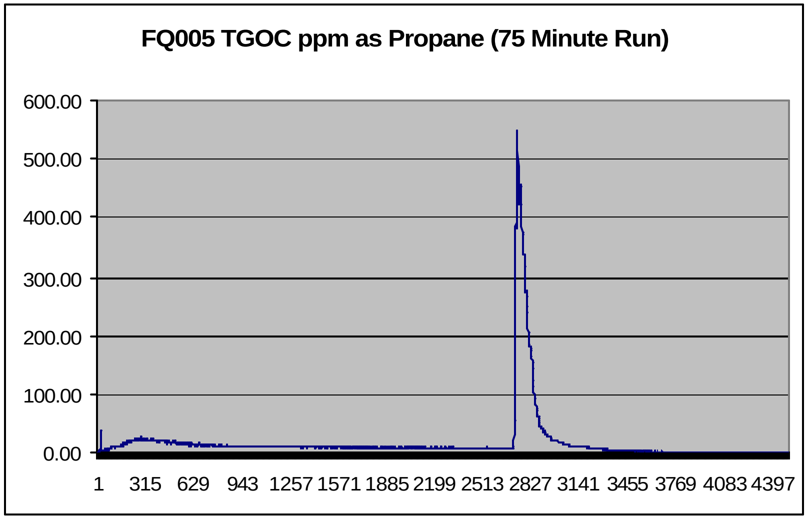
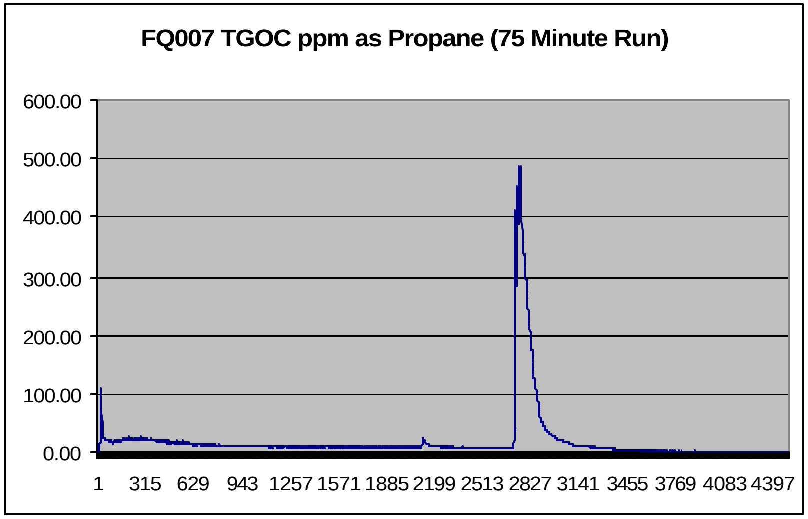
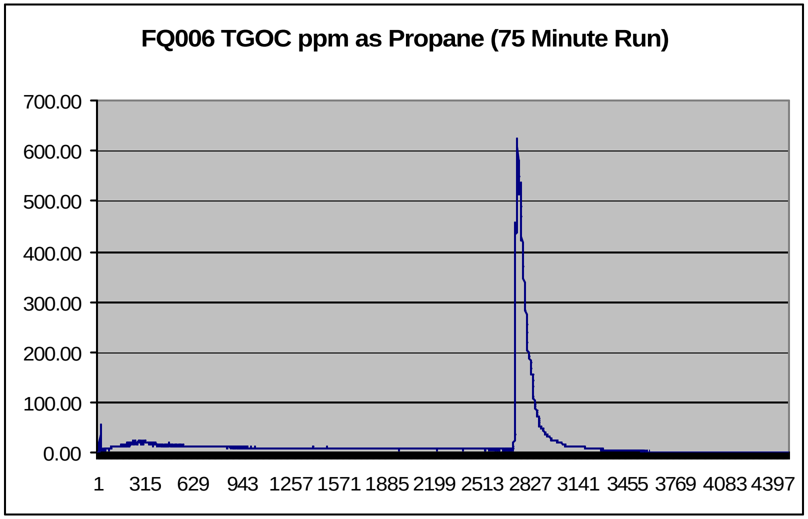
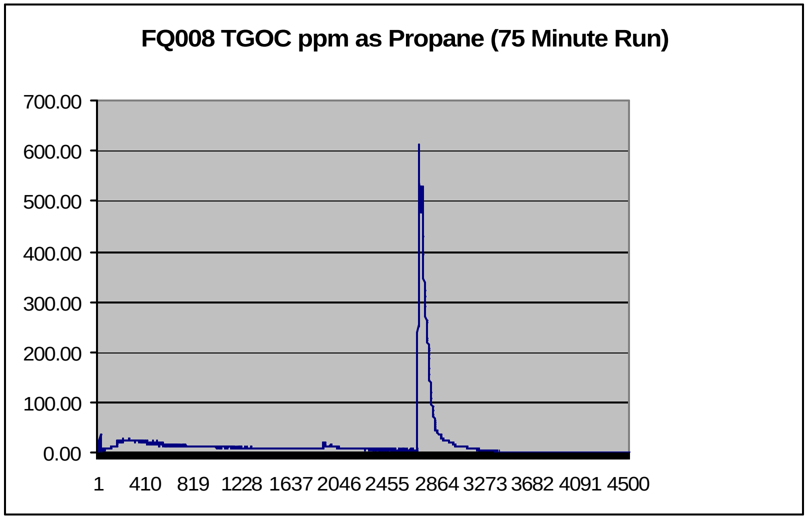

FQ003 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397

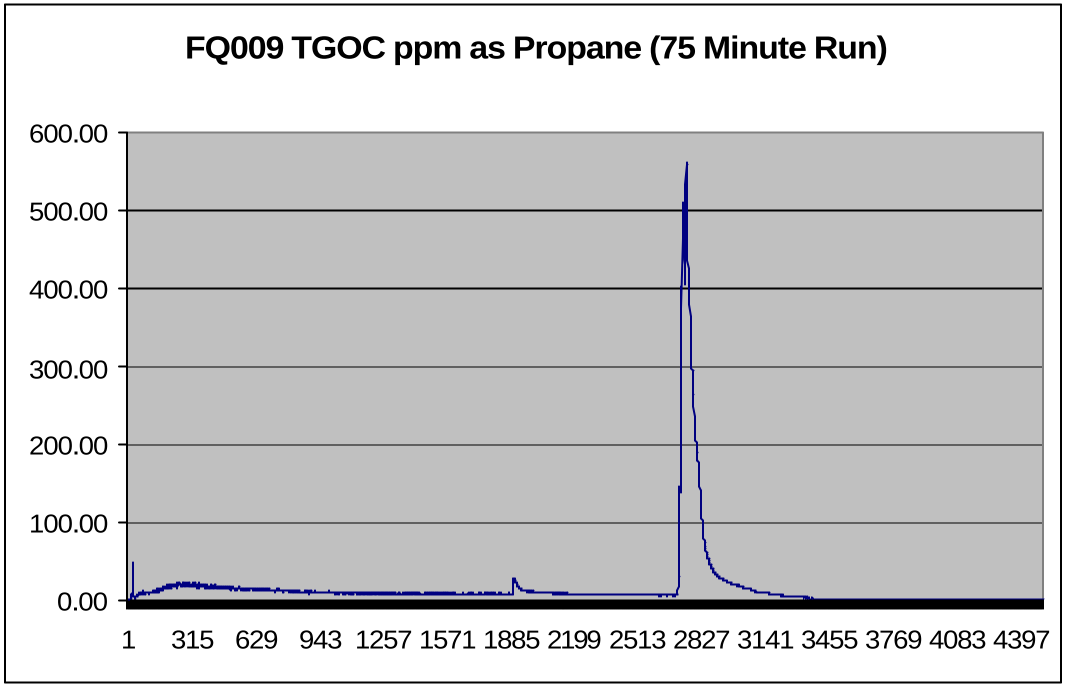

FQ004 TGOC ppm as Propane (75 Minute Run)
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FQ005 TGOC ppm as Propane (75 Minute Run)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FQ007 TGOC ppm as Propane (75 Minute Run)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FQ006 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 315 629 943 1257 1571 1885 2199 2513 2827 3141 3455 3769 4083 4397


FQ008 TGOC ppm as Propane (75 Minute Run)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1 410 819 1228 1637 2046 2455 2864 3273 3682 4091 4500


FQ009 TGOC ppm as Propane (75 Minute Run)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1
315
629
943
1257
1571
1885
2199
2513
2827
3141
3455
3769
4083
4397

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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