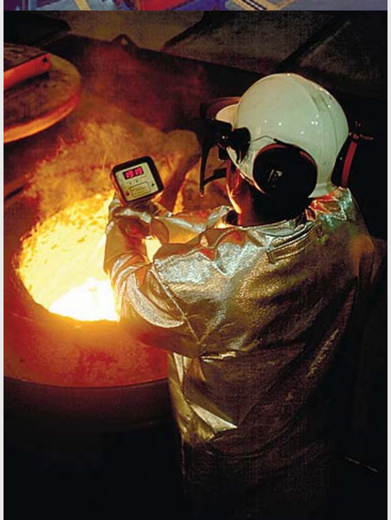
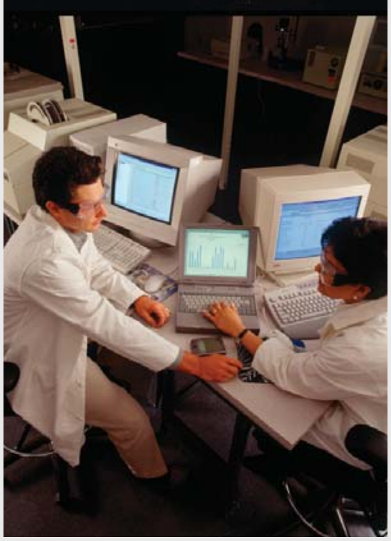
Casting Emission Reduction Program

www.cerp-us.org





Operated by

TECHNIKON

5301 Price Avenue
McClellan, CA 95652
916-929-8001
www.technikonllc.com

US Army Contract W15QKN-05-D-0030
FY2006 Tasks
WBS # 1.1.7

Mix, Make, Storage Emissions, Step Core, Ecolotec® 750

1413-117 NA

April 2007

(Revised for public distribution - August 2007)

CASTING INDUSTRY SUPPLIERS ASSOCIATION

AMERICAN FOUNDRY SOCIETY

ARMAMENT RESEARCH, DEVELOPMENT & ENGINEERING CENTER PICATINNY, NJ

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

DaimlerChrysler Ford GM General Motors

this page intentionally left blank

Mix, Make, Storage Emissions, Step Core, Ecolotec® 750

1413-117 NA

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

Research Scientist	*//Original Signed//* Naomi Goff	Date
V.P. Operations	*//Original signed//* George Crandell	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 were not collected to assess cost or producability.

this page intentionally left blank

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Executive Summary

This report contains the results of emission testing of the mixing, making, and storage segments of the production of step cores made from a chemically bonded dry sand core binder (Ecolotec® 750, Foseco Metallurgical, Inc.) at 2.0% based on sand (BOS) and activated with gaseous carbon dioxide (CO_2). All testing was conducted in the Technikon, LLC Research Foundry.

The specific objective of this test was to determine core process emissions, which encompassed three separate processes: sand mixing, core making (both captured and fugitive emissions) and a period termed “core storage”, which was the time interval between stripping the core out of the core box and mold pouring. All processes were conducted within enclosures meeting the criteria for a temporary total enclosure (TTE) as specified in US EPA Method 204.

All components of the test were conducted in triplicate. All sampling locations were consistent with US EPA Method 1 except for core storage. The storage segment of the test used a laminar flow-through enclosure to sweep all of the emissions to a sampling manifold where they were sampled for speciated target analytes as per US EPA Method 18. One (1) core storage event was monitored.

Four Emission Indicators were measured in addition to selected target analytes. TGOC as Propane is one of these Indicators, and results include all exempted compounds including methane. At present, the methane contribution has not been determined or removed.

Two methods were employed to measure undifferentiated hydrocarbon emissions as Emission Indicators: TGOC as Propane (performed in accordance with EPA Method 25A) and HC as Hexane (performed in accordance with NIOSH Method 1500). US EPA Method 18 was followed for collection procedures using adsorption tubes to collect selected analytes for subsequent laboratory analysis. Sampling was performed using a Volatile Sampling Train (VOST) following EPA, NIOSH, and OSHA methodologies for sampling and analysis of individual analytes. All results are reported in terms of pounds of analyte per pound (lb/lb) of binder.

In data validation, verification, and reporting of results from this test, an analyte is defined as non-detect if its concentration is below a limit of detection (practical quantitation limit, PQL). In individual runs where an analyte is below this limit, the value which is non-detect is substituted by the value of zero. If an analyte average concentration falls below the PQL when all runs are averaged over the course of the test (in this case there are three runs each of sand mixing and core making which are each individually averaged together), the test average for that analyte is shown as ND in the figures and tables of this report.

Table 1 summarizes each test component and shows average test results with units of pounds of pollutant per pound of binder (Lb/Lb Binder. Detailed results may be found in Section 3 of this document and in Appendix B.

Table 1 Average Emissions Indicators Summary - Lb/Lb Binder

	Sand Mixing	Core Making	Core Storage
Segment Duration (min)	30	60	30*
Emission Indicators			
TGOC as Propane	8.07E-04	I	I
HC as Hexane	4.02E-04	3.60E-04	5.26E-05
Sum of Target Analytes	1.08E-04	3.79E-04	8.31E-05
Sum of Target HAPs	3.62E-06	1.47E-04	5.37E-05

I: Invalidated Data

*Note: Although sampling duration 30 minutes for Core Storage, data only taken for 20 minutes for TGOC as Propane Emission Indicator.

The emission results from the testing performed and described herein are unique to the specific 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.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinion of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Destroy this report when no longer needed by the method that will prevent disclosure of its contents or reconstruction of the document. Do not return to the originator.

this page intentionally left blank

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 point source 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 Leadership Council of USCAR, a Michigan partnership of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation; the U.S. Army Research, Development, and Engineering Command (RDECOM-ARDEC); the American Foundry Society (AFS); and the Casting Industry Suppliers Association (CISA). The US Environmental Protection Agency (US EPA) and the California Air Resources Board (CARB) also have been participants in the CERP program and rely on CERP published reports for regulatory compliance data. All published reports are available on the CERP web site at www.cerp-us.org.

1.2. CERP/Technikon Objectives

The primary objective of CERP is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility was designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing facility enables the repeatable collection and evaluation of airborne emissions and associated process data.

1.3. Report Organization

This report has been written to document the methodology and results of a specific test plan that was used to evaluate the core process emissions from the production of step cores. The processes evaluated included 30 minutes of mixing, 60 minutes of core making, and 30 minutes of core storage. Cores were made using a chemically bonded dry sand core binder (Ecolotec® 750, Foseco Metallurgical, Inc.) at 2.0% based on sand (BOS) and activated with gaseous CO_2.

Section 2.0 of this report includes a summary of the methodologies used for data collection and analysis, procedures for 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 archived at the Technikon facility.

1.4. Specific Test Plan and Objectives

This report contains the results of testing performed to provide data on selected HAP and VOC emissions from step cores made with Ecolotec® 750 sand binder manufactured by Foseco Metallurgical, Inc. Table 1-1 provides a summary of the test plan for core making. The details of the approved test plan are included in Appendix A.

Table 1-1 Test Plan Summary

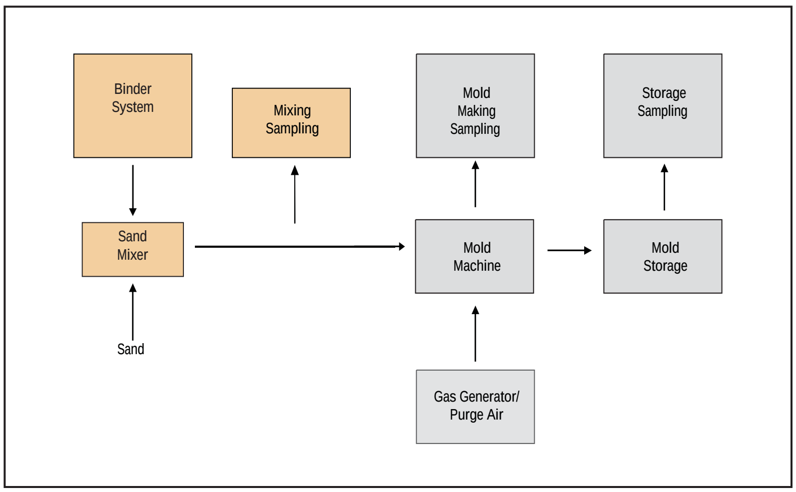
Test Plan Parameter	Parameter Summary
Test Number	1162-0207 (contract number 8500-001)
Test Dates	04-09-02 and 04-10-02
Type of Process Tested	Core mixing, making, and storage
Binder System	Ecolotec® 750 sand binder activated with gaseous CO_2
Number of Test Runs	3 each for sand mixing, core making, and core storage
Emissions Measured	TGOC as propane, HC as hexane, formaldehyde, phenol, cresols, butyl carbitol, ethylene glycol phenyl ether
Process Parameters Measured	Sand and binder weights, incoming sand temperature, sand mixing time, core making cycle time, core loss on ignition (LOI)
Source Parameters Measured	Stack temperature, pressure, moisture content, and volumetric flow rate

2.0 METHODS, ASSUMPTIONS AND PROCEDURES

2.1. Description of Process and Testing Equipment

Figure 2-1 is a diagram of the core/mold making process and testing equipment.

Figure 2-1 Core Making and Testing Process Diagram



2.2. Description of Testing Program

The testing program encompasses the foundry process and emissions testing, both of which are rigorously controlled. Parameters are monitored and recorded prior to and during the emission tests. Process measurements included the weights of the sand and binder, incoming sand temperature, sand mixing time, core making time, and core loss on ignition (LOI) values prior to the test. Measured source parameters included stack temperature, pressure, and volumetric flow rate. All parameters were maintained within prescribed ranges to ensure the reproducibility of the test runs.

Emission testing for hydrocarbons included several methods. Method 18 is one of the US Environmental Agency (EPA) reference methods for volatile compound (VOC) analysis.

The method is a guideline and a system of quality assurance (QA) checks for VOC analysis rather than a rigorous, explicit manual for sampling or analysis. Method 18 is generally used to identify and/or measure as many compounds as possible in order to calculate actual VOC emissions from other measurements.

As described in the method, sampling can be conducted using a Volatile Sampling Train (VOST), which was the technique used for sampling for the tests described in these reports. A sample gas stream was extracted from the source and then routed using the train through tubes containing adsorbents, which were the collection materials upon which the analytes were deposited. Adsorption tube samples were collected and analyzed for six (6) target compounds using procedures based on approved federal methods, including those of the EPA, NIOSH, and OSHA.

Undifferentiated hydrocarbon emissions are represented by the emission indicators TGOC as Propane, performed in accordance with EPA Method 25A, and HC as Hexane.

Method 25A is an instrumental based method in which the stack gas is introduced directly to a flame ionization detector (FID) without first separating the components. In Method 25A, sampling is accomplished by extracting a gas stream from the stack effluent and transferring it via heated non-reactive tubing to the FID analyzer under very controlled temperature and pressure conditions. The FID measures the quantity of carbon containing molecules, and is calibrated by a gas standard, which in this case is the three carbon alkane, propane (C_3H_8). The FID will give a response relative to the calibration standard and results are expressed in terms of the gas used for calibration.

Because the FID responds to all carbon containing compounds, methane (CH_4) and other exempt compounds are included in the results, as per the method design. For this test, the contribution from these compounds has not been determined or removed from the averaged results.

The HC as Hexane method is based on NIOSH methods 1500-1550, and represents the sum of all detected hydrocarbon compounds in the carbon range between C_6 and C_{16}, expressed in terms of the calibration compound, which in this case is the six-carbon alkane, hexane (C_6H_{14}). Results are determined by the summation of all chromatographic peak areas which fall between the elution time of hexane through the elution time of hexadecane ($C_{16}H_{34}$) on the chromatogram. The quantity of hydrocarbons (HC) is determined by dividing the total summed area count by the area of hexane calculated from the initial calibration curve that is derived from a five point calibration.

Mass emission rates for all analytes were calculated using laboratory analytical results, measured source data, and appropriate process data. Detailed emission results are presented in Appendix B. Individual analyte emissions were calculated in addition to four "Emission Indicators": TGOC as Propane, HC as Hexane, Sum of Target Analytes, and Sum of Target Hazardous Air Pollutants (HAPs). Full descriptions of these indicators can be found in Section 3.0 of this report.

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

Figure 2-2 Redford-Carver Core Machine

2.2.1. Test Plan Review and Approval

The proposed test plan was reviewed and approved by the Technikon staff.

2.2.2. Core Preparation

Figure 2-3 Uncoated Step Core

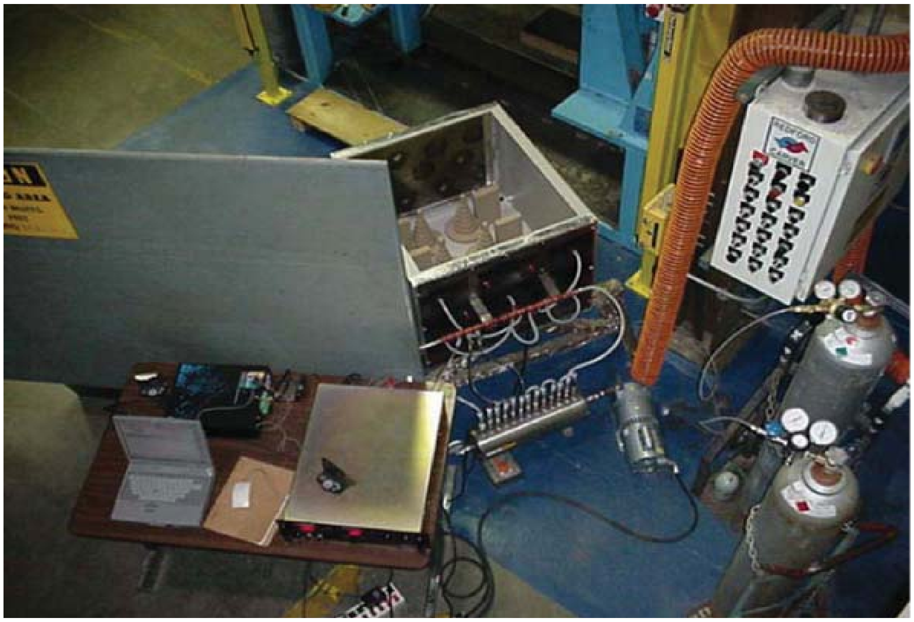
All cores were prepared for this test in the core room area at Technikon LLC. Sand and Ecolotec® 750 binder were weighed and mixed at an amount of 2.0% binder BOS in a sand mixer (Simpson Technologies), and then introduced (blown) into the test tooling in a Redford-Carver core machine (Figure 2-2). An AFS step core was used (Figure 2-3). Following making of the sand/binder mixture into the step core box or hand filling of the core tooling, the sand/binder mixture was gassed with CO_2 for approximately twenty (20) seconds. The step cores were fabricated in single cavity boxes.

2.2.3. Individual Sampling Events

Sampling to determine core process emissions consisted of three (3) segments. Thirty minute mixing emissions were collected from a total temporary enclosure extending from the mixer to, and including, the Redford Carver sand storage hopper. The core and core machine emissions were collected over a one hour period from two (2) locations. One location was in the core box exhaust and collected the emissions from the making events. The other location was in the exhaust duct from the temperature controlled temporary total enclosure. Sampling for the storage event consisted of the collection of integrated thirty (30) minute samples, with the exception of TGOC as Propane which was sampled and an average result computed for a period of twenty (20) minutes. Four fresh cores were placed in a total enclosure storage chamber, the chamber was sealed and rapidly transferred to a temperature and humidity controlled room. Sampling was started immediately and continued for a thirty (30) minute period. Three replicate runs were performed for each segment of the core production process.

All of the enclosures used for the core process emissions measurement segments met the criteria for a total enclosure as specified in US EPA Method 204. Figure 2-4 shows one of the enclosures.

Figure 2-4 Step Core Storage Enclosure and Sampling Train



2.2.4. Process Parameter Measurements

Table 2-1 lists the process parameters that were monitored during each test run. The analytical equipment and methods used are also listed.

Table 2-1 Process Equipment and Methods

Process Parameter	Equipment and Methods
Binder Weight	Mettler PJ8000 Digital Scale
Core Sand Weight	Simpson IQ-800-3A Digital Scale
Core Weight	Cardinal 748 Platform Scale

2.2.5. Air Emissions Analysis

The specific sampling and analytical methods used in the test are based on the reference methods shown in Table 2-2. The details of the specific testing procedures and variance from the reference methods are included in the Technikon Standard Operating Procedures manuals.

Table 2-2 Emission Sampling and Analytical Methods

Emission Measurement Parameter	Test Method
Port location	EPA Method 1
Number of traverse points	EPA Method 1
Gas velocity and temperature	EPA Method 2
Gas moisture	EPA Method 4, gravimetric
Specific HAPs and OAs, HC as Hexane	EPA Method 18, TO-11; NIOSH 1500, NIOSH 2546, OSHA 7
TGOC (THC) as Propane	EPA Method 25A

2.2.6. Data Reduction, Tabulation, and Preliminary Report Preparation

Data calculations for determining emission concentrations resulting from the specific test plan outlined in Appendix A are based on process and emission parameters. 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 the sample volume to the total stack gas volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter, and corrected to standard conditions using the measured stack pressures and temperatures. The total mass of analyte is then divided by the weight of the binder used to provide emissions data in pounds of analyte per pound of binder.

For the storage segment of core making, the stack parameters are replaced by the total volume of gas flowing through the enclosure, corrected to standard conditions. The total mass of the analyte emitted is then calculated by multiplying the measured mass of analyte in the sample times the ratio of sample volume to total gas volume over the same time period. Results are then divided by the weight of the binder used to provide emissions data in pounds of analyte per pound of binder.

Individual concentration and reporting limit results for each analyte for all sampling runs are included in Appendix B of this report. Average results for the test are given in Section 3.0, Table 3-1.

2.2.7. 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 then reviewed by senior management and 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" publication. 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 Process Engineer to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Manager of Process Engineering and the Vice President of 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 Manager of Measurement Technologies reviews and approves the recommendation, if any, that individual sample data should be invalidated. Invalidated data are not used in subsequent calculations.

this page intentionally left blank

3.0 TEST RESULTS

As previously reported, changes from reports prior to July 2006 have been implemented in the text and tables to clarify emission related terminology. The full description of changes may be found in the report for 1412-113, Test HE.

Individual target compounds, in addition to the "Sum of Target Analytes" and the "Sum of Target HAPs" are presented in Table 3-1. The two analyte sums are part of the group termed "Emission Indicators." Also included in this group and reported in the tables are "TGOC as Propane" and "HC as Hexane."

All analytes and sums are reported in units of pounds of emissions per pound of binder. Compounds which were chosen for analysis based on chemical and operational parameters are the target analytes. The emissions indicator called the "Sum of Target Analytes" is the sum of all individual analytes targeted for collection and analysis that were detected at a level above the practical quantitation limit. The sum includes compounds which may also be defined as HAPs. By definition, HAPs are specific compounds listed in the Clean Air Act Amendments of 1990. A subset from the current list of EPA HAPs was targeted for collection and analysis. These individual target HAPs detected in the samples are summed together and defined as the "Sum of Target HAPs."

Appendix B contains the detailed data for the three core making segments including the results for all analytes measured. Integrated adsorption tube samples have not been background corrected with the exception of HC as Hexane.

Table 3-1 Core Process Average Emission Results - Lb/Lb Binder

Analyte Name	Sand Mixing	Core Making (Gassing)	Core Making (Fugtives)	Core Storage	Combined Total
Emission Indicators					
TGOC as Propane	8.07E-04	I	I	I	I
HC as Hexane	4.02E-04	7.32E-05	2.87E-04	5.26E-05	8.14E-04
Sum of Target Analytes	1.08E-04	2.52E-05	3.54E-04	8.31E-05	5.70E-04
Sum of Target HAPs	3.62E-06	1.74E-05	1.30E-04	5.37E-05	2.05E-04
Selected Target HAPs					
Phenol	ND	1.49E-05	1.17E-04	5.16E-05	1.84E-04
Formaldehyde	3.62E-06	2.43E-06	1.28E-05	2.15E-06	2.10E-05
o,m-Cresol	ND	ND	ND	ND	ND
Selected Target Analytes					
Butyl Carbitol	5.94E-05	ND	1.25E-04	1.61E-05	2.01E-04
Ethylene Glycol Phenyl Ether	4.48E-05	ND	9.85E-05	1.32E-05	1.57E-04

I: Invalidated Data
NT = Not tested
ND = Non detect

In the data validation, verification, and reporting of results from this test, an analyte is defined as non-detect if its concentration is below a limit of detection (practical quantitation limit, PQL). The PQL is determined as a minimum reporting limit. In individual runs where an analyte is reported as below this limit, the non-detect value is substituted by the value of zero for calculation purposes. If an analyte average concentration falls below the PQL when all individual runs are averaged over the entire test (in this case there are three runs comprising each segment of core making), the test average for that analyte is shown as ND in the tables and figures of this report.

Figures 3-1a to 3-2e graphically present the data from Table 3-1 for the Technikon Ecolotec® 750 binder core making test of the four emissions indicators as well as individual HAP and target analyte emissions data. All data are reported in units of pound of emissions per pound of binder.

Figure 3-1a Emission Indicators, Combined Total Average Results - Lb/Lb Binder

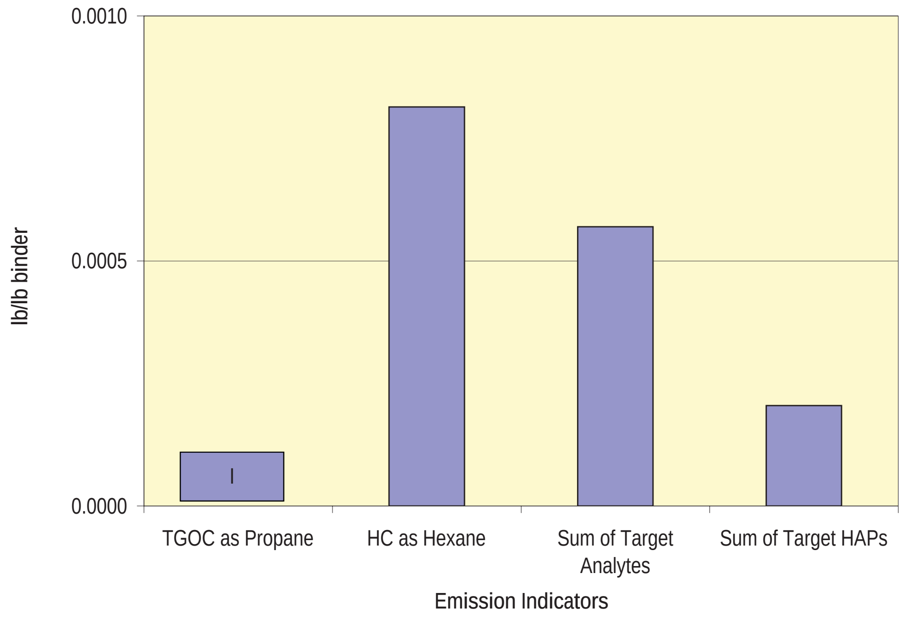


Figure 3-1b Emission Indicators, Sand Mixing Average Results- lb/lb Binder

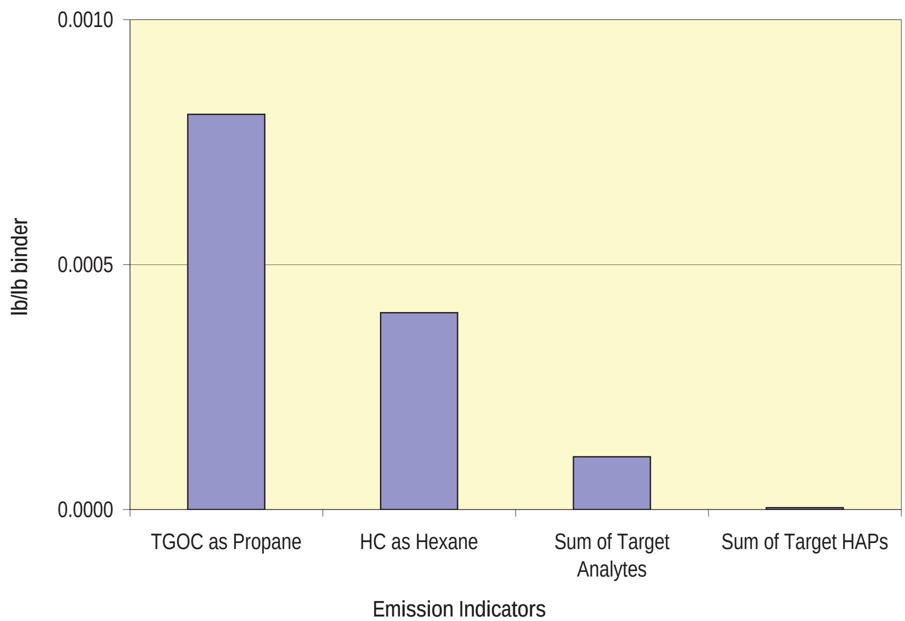


Figure 3-1c **Emission Indicators, Core Making (Gassing), Average Results- Lb/Lb Binder**

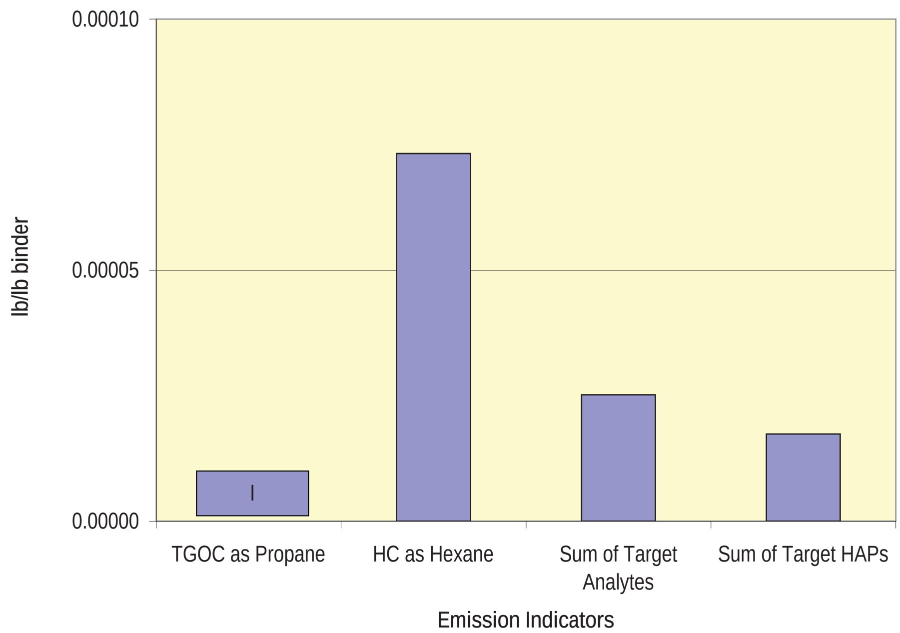


Figure 3-1d **Emission Indicators, Core Making (Fugitives) Average Results- Lb/Lb Binder**

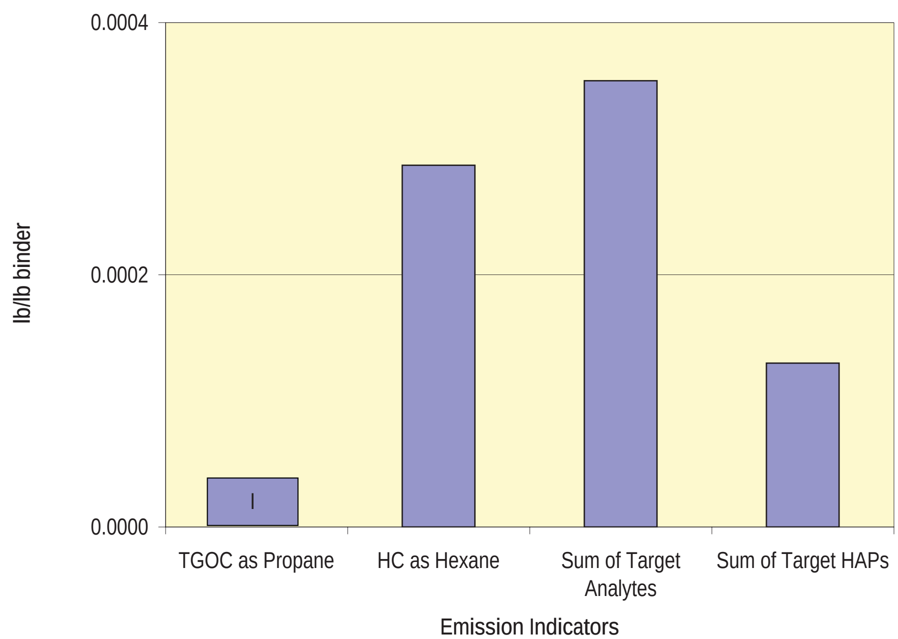


Figure 3-1e ***Emission Indicators, Core Storage Average Results- Lb/Lb Binder***

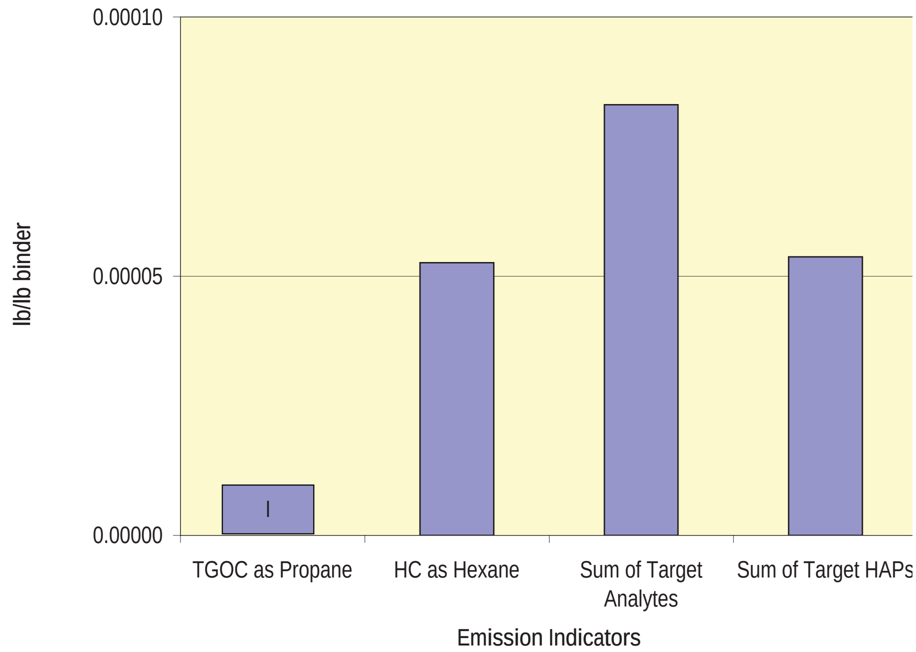


Figure 3-2a ***Selected HAPs, Combined Total Average Results - Lb/Lb Binder***

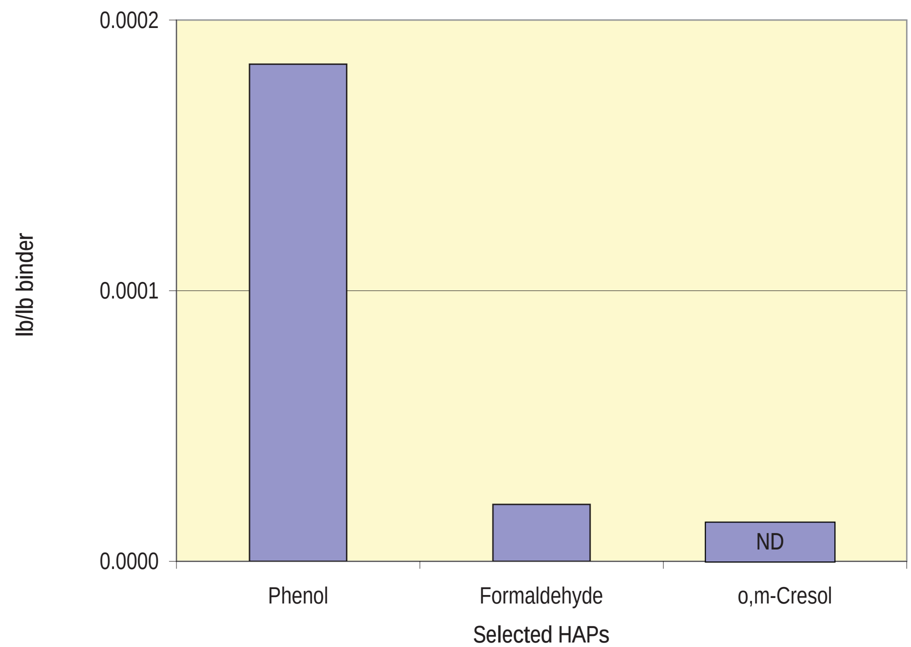


Figure 3-2b Selected HAPs, Sand Mixing Average Results - Lb/Lb Binder

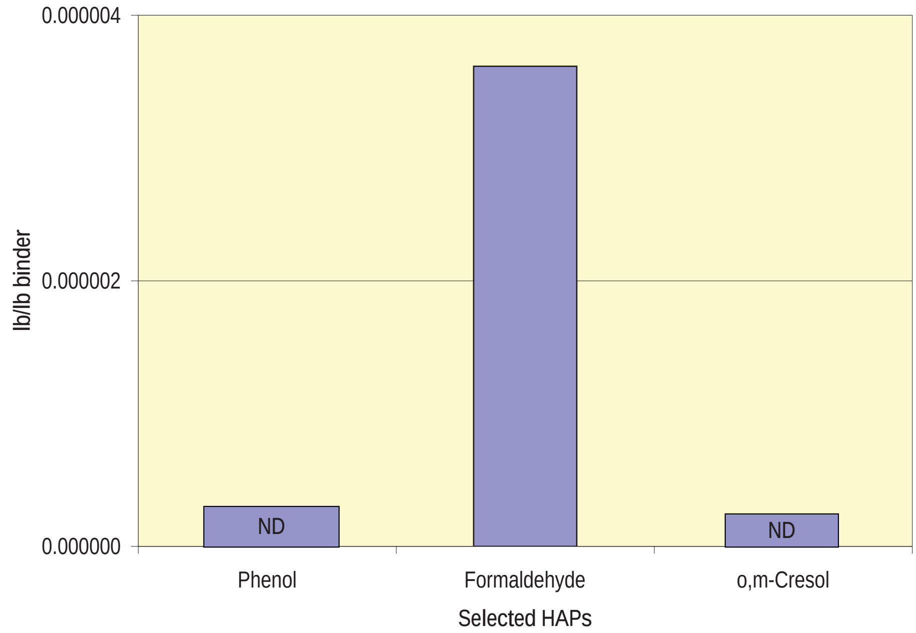


Figure 3-2c Selected HAPs, Core Making (Gassing) Average Results - Lb/Lb Binder

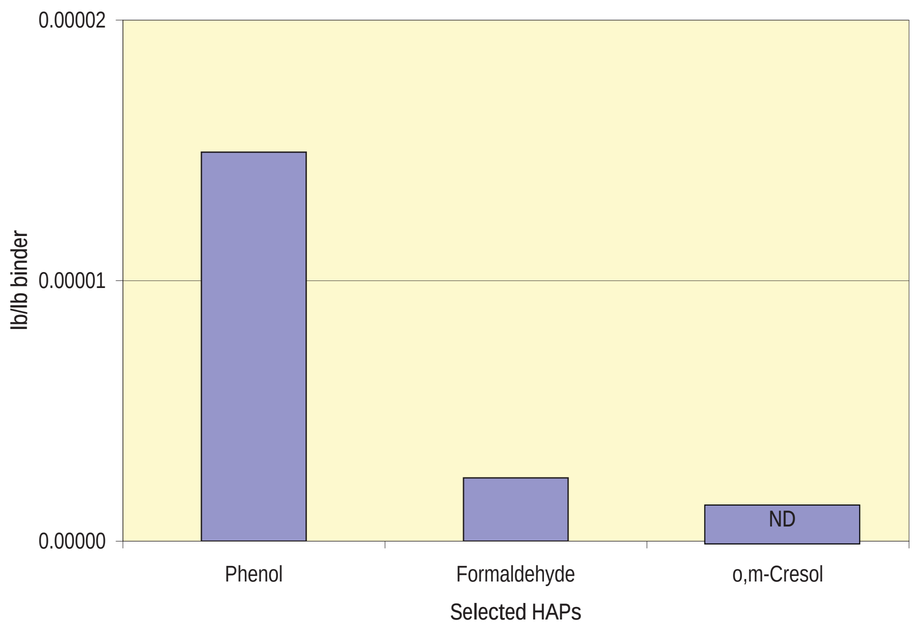


Figure 3-2d Selected HAPs, Core Making (Fugitives) Average Results - Lb/Lb Binder

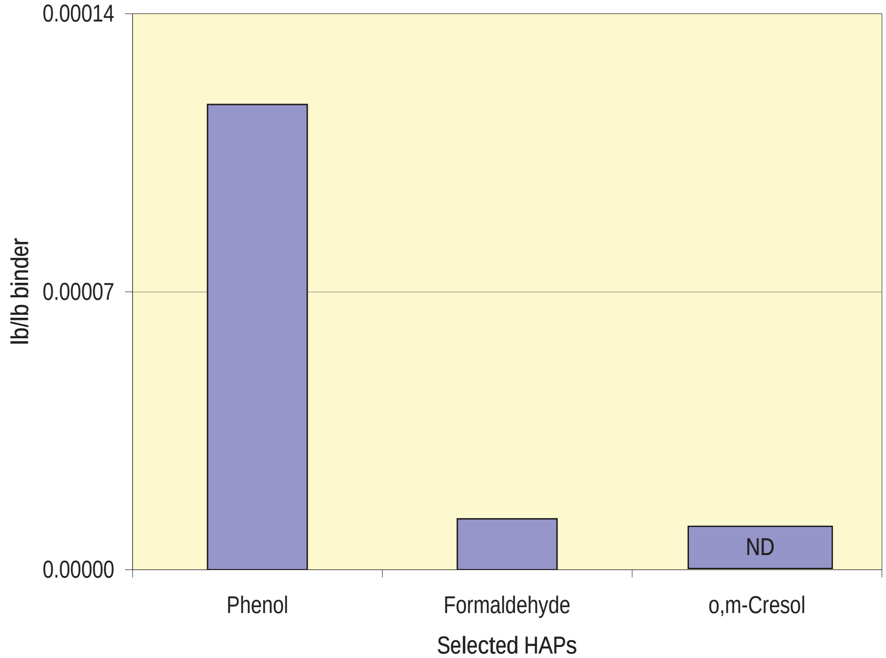
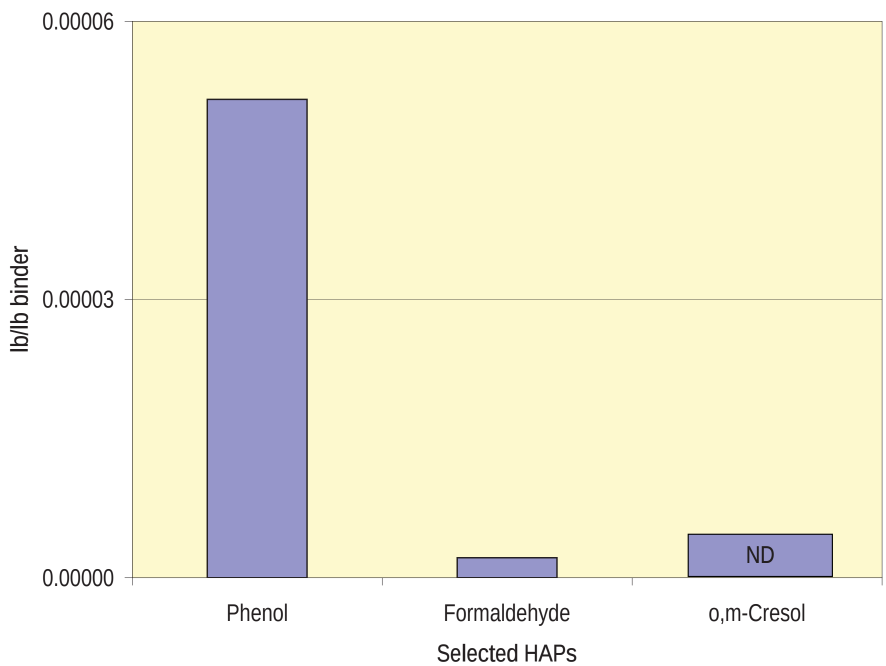


Figure 3-2e Selected HAPs, Core Storage Average Results - Lb/Lb Binder



The average process parameters are reported in Table 3-2 and Appendix C.

Table 3-2 Average Process Parameters and Source Data

Core Sand Mix Test	Averages
Total sand weight, lbs.	107
Binder weight, lbs.	2.20
Calculated % binder	2.01
Sand temperature, °F	75
Test duration, min	30
Volumetric flow rate, ft^3/min	116
Core Make Test	
Total core weight, lbs	265.6
Binder weight, lbs.	5.19
Calculated % binder	1.92
Core or machine cycle count	40
Step core LOI, %	1.39
Test duration, min	60
Volumetric flow rate, ft^3/min	320
Core Storage Test	
Total core weight, lbs.	25.55
Total binder weight, lbs.	0.50
Average core weight, lbs.	6.39
Core machine cycle time, min	1.67
Step core LOI, %	1.28
Test duration, min	30
Volumetric flow rate, ft^3/min	1.5

The four appendices in this report contain detailed information regarding testing, sampling, data collection and results for each sampling event. Appendix A contains test plans, instructions, and the sampling plan for the Ecolotec® 750 Core-Making test. Appendix B contains detailed emissions data and average results for all the targeted analytes. Target analyte practical quantitation reporting limits expressed in lb/lb binder are also shown in Appendix B. Appendix C contains detailed process data. Appendix D contains Method 25A continuous online monitoring charts. Appendix E contains a list of acronyms and abbreviations.

4.0 RESULTS AND CONCLUSIONS

The individual chemical compounds from airborne emissions targeted for collection and analysis for this test were chosen based on the chemistry of the binder under investigation as well as being historically targeted for analysis. Core processing consisted of three segments with four data streams. All of the cores making measurements were conducted within enclosures meeting the criteria for a temporary total enclosure as specified in US EPA Method 204.

Core making emissions were largely comprised of glycol ether solvents. The two glycol ether solvents targeted for analysis, ethylene glycol phenyl ether and butyl carbitol, accounted for 66% of the total emissions measured for core making on a pound of emissions per pound of binder (lb/lb) basis. Formaldehyde and phenol comprised the remainder of the analytes contributing to the sum of targeted analytes, at 3 and 31% respectively. Only four HAPs were targeted for analysis: formaldehyde, phenol, and ortho- and meta-cresols. Ortho- and meta- cresols were not detected in any quantifiable amounts. The highest emitting segment of the core-making process was the 60 minute core making portion, composed of two analyte streams; gassing and fugitive. Together, these streams contributed 66% and 70% to the total targeted analyte and HAP sums, respectively. Detailed results are shown in Appendix B.

this page intentionally left blank

APPENDIX A TEST AND SAMPLE PLANS AND PROCESS INSTRUCTIONS

this page intentionally left blank

Technikon Test Plan

- **CONTRACT NUMBER:** 8500 **TASK NUMBER:** 001
- **WORK ORDER NUMBER:** 1413-117
- **SAMPLE EVENTS:** 001 thru 012
- **SITE:** Pre-Production
- **TEST TYPE:** Core mix, make, & store
- **CORE TYPE:** Chemically bonded dry sand core gaseous CO_2 activated
- **NUMBER OF CORES**: 3
- **CORE TYPE:** Step Core
- **TEST DATE:** **START:** 7 Apr 2002

  FINISHED: 11 Apr 2002

TEST OBJECTIVES:

Measure selected HAP and Targeted Analyte emissions from a Foseco Ecolotec® 750 binder system activated with CO_2. Testing will consist of three tests each of the following: a) Core sand mixing emissions, b) Step-core core making emissions from the Redford Carver core machine, c) Step-core storage emissions.

VARIABLES:

Foseco binder at 2.0 % (BOS), vaporized liquid CO_2 at sufficient flow to set the core. Carbon dioxide is not a hydrocarbon emission and as such is not to be a measured process variable. Process cycle time is 1.5 minutes. Each mix test will consist of one 110 # sand batch mixed for a total of three minutes delivered to the core machine hopper as background. The mix test will then be one (1) 110 # sand batch delivered to the machine hopper. THC and adsorption tube emission sampling will begin when the resin begins to enter the mixer and will end 30 minutes later. The core make test will begin after the core machine has run sufficient time at rate to have the background stabilize. Each core make test will be one hour long with continuous THC and adsorption tube sampling. The storage test will consist of four (4) weighed cores sampled sequentially from the core machine and placed in a sealed sampling box. The box will be placed in a temperature controlled room and sampled continuously with the THC monitor and adsorption tubes for 30 minutes.

BRIEF OVERVIEW:

This process is unique in that while the binder is organic the activator, CO_2, is not and therefore has the potential for lower net emissions.

SPECIAL CONDITIONS:

The sampling environment will be maintained at 75-85°F. Foseco is to supply 10 gallons of core binder and CO_2 vaporizing equipment. Personnel will be supplied by all parties to make cores and provide technical supervision.

SAMPLE PLAN PURGE/GAS

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Core Making**
EVENT 1											**1 Hour**
THC	P/G	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-00101		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 1500	0207-00102				1				0		100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-00103		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-00104				1				0		100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-00105		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-00106				1				0		150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH	0207-00107			1					1000	10	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 1500	0207-00108			1					1000	11	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-00109		1						1100	12	DNPH Cartridge
TO-11	0207-00110				1				0		DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN FUGITIVES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Core Making**
EVENT 1											**1 Hour**
THC	FUG	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-02101		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02102		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-02103		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	0207-02104			1					1000	10	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02105			1					1000	11	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-02106		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN STORAGE

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Storage**
EVENT 1											**30 Minutes**
THC	Storage	X									
	Blocked								32000	1	Blocked
	Blocked								20	2	Blocked
	Blocked								20	3	Blocked
	Blocked								40	4	Blocked
Modified NIOSH 1500	0207-03101		1						900	5	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-03102		1						900	6	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-03103		1						900	7	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	0207-03104			1					1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-03105			1					1000	9	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-03106		1						1000	10	DNPH Cartridge
	Blocked								5000	11	Blocked
	Excess								5000	12	Excess
	Blocked								22000	13	Blocked

SAMPLE PLAN MIXING

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Mixing**
EVENT 1											**30 Minutes**
THC	Mixing	1									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-04101		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-04102		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-04103		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	0207-04104			1					1000	10	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-04105			1					1000	11	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-04106		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN PURGE/GAS

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 2											**1 Hour**
THC	P/G	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-00201		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-00202		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-00203		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-00204			1					1000	10	150/75 mg Silica Gel (SKC 226-10)
TO-11	0207-00205			1					1000	11	DNPH Cartridge
TO-11	0207-00206		1						1100	12	DNPH Cartridge
	Excess									13	Excess

SAMPLE PLAN FUGITIVES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 2											**1 Hour**
THC	FUG	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-02201		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02202		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-02203		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-02204		1						1000	10	150/75 mg Silica Gel (SKC 226-10)
TO-11	0207-02205			1					1000	11	DNPH Cartridge
TO-11	0207-02206		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN STORAGE

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Storage**
EVENT 2											**30 Minutes**
THC	FUG	X									
	Blocked								32000	1	Blocked
	Blocked								20	2	Blocked
	Blocked								20	3	Blocked
	Blocked								40	4	Blocked
Modified NIOSH 1500	0207-03201		1						900	5	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-03202		1						900	6	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-03203		1						900	7	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-03204			1					1000	8	150/75 mg Silica Gel (SKC 226-10)
TO-11	0207-03205			1					1000	9	DNPH Cartridge
TO-11	0207-03206		1						1000	10	DNPH Cartridge
	Blocked								5000	11	Blocked
	Excess								5000	12	Excess
	Blocked								22000	13	Blocked

SAMPLE PLAN MIXING

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Mixing**
EVENT 2											**30 Minutes**
THC	Mixing	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-04201		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-04202		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-04203		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-04204			1					1000	10	150/75 mg Silica Gel (SKC 226-10)
TO-11	0207-04205			1					1000	11	DNPH Cartridge
TO-11	0207-04206		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN PURGE/GAS

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 3											**1 Hour**
THC	P/G	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-00301		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-00302		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-00303		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
	Blocked								1000	10	Blocked
	Blocked								1000	11	Blocked
TO-11	0207-00304		1						1100	12	DNPH Cartridge
TO-11	0207-00305					1			1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN FUGITIVES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 3											**1 Hour**
THC	FUG	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-02301		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02302		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-02303		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
	Blocked								1000	10	Blocked
	Blocked								1000	11	Blocked
TO-11	0207-02304		1						1100	12	DNPH Cartridge
TO-11	0207-02305					1			1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN STORAGE

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Storage**
EVENT 3											**30 Minutes**
THC	Storage	X									
	Blocked								32000	1	Blocked
	Blocked								20	2	Blocked
	Blocked								20	3	Blocked
	Blocked								40	4	Blocked
Modified NIOSH 1500	0207-03301		1						900	5	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-03302		1						900	6	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-03303		1						900	7	150/75 mg Silica Gel (SKC 226-10)
	Blocked								1000	8	Blocked
	Blocked								1000	9	Blocked
TO-11	0207-03304		1						1000	10	DNPH Cartridge
TO-11	0207-03305					1			1000	10	DNPH Cartridge
	Blocked								5000	11	Blocked
	Excess								5000	12	Excess
	Blocked								22000	13	Blocked

SAMPLE PLAN MIXING

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/9/2002											**Solvent - Mixing**
EVENT 3											**30 Minutes**
THC	Mixing	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-04301		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-04302		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-04303		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
	Blocked								1000	10	Blocked
	Blocked								1000	11	Blocked
TO-11	0207-04304		1						1100	12	DNPH Cartridge
TO-11	0207-04305					1			1100	12	DNPH Cartridge
	Excess									13	Excess

SAMPLE PLAN PURGE/GAS

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 4											**1 Hour**
THC	P/G	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-00401		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-00402		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-00403		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH	0207-00404			1					1000	10	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 1500	0207-00405			1					1000	11	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-00406		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN FUGITIVES

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Core Making**
EVENT 4											**1 Hour**
THC	FUG	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-02401		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02402		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-02403		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 1500	0207-02404			1					1000	10	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-02405			1					1000	11	100/50 mg Coconut Charcoal (SKC 226-01)
TO-11	0207-02406		1						1100	12	DNPH Cartridge
	Excess								1600	13	Excess

SAMPLE PLAN STORAGE

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
4/10/2002											**Solvent - Storage**
EVENT 4											**30 Minutes**
THC	FUG	X									
	Blocked								32000	1	Blocked
	Blocked								20	2	Blocked
	Blocked								20	3	Blocked
	Blocked								40	4	Blocked
Modified NIOSH 1500	0207-03401		1						900	5	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-03402		1						900	6	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-03403		1						900	7	150/75 mg Silica Gel (SKC 226-10)
Modified NIOSH 2002	0207-03404			1					1000	8	150/75 mg Silica Gel (SKC 226-10)
TO-11	0207-03405			1					1000	9	DNPH Cartridge
TO-11	0207-03406		1						1000	10	DNPH Cartridge
	Blocked								5000	11	Blocked
	Excess								5000	12	Excess
	Blocked								22000	13	Blocked

SAMPLE PLAN MIXING

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Duplicate	Flow (ml/min)	Train Channel	Comments
NOT PERFORMED											**Solvent - Mixing**
EVENT 4											**30 Minutes**
THC	Mixing	X									
	Blocked								20	1	Blocked
	Blocked								20	2	Blocked
	Blocked								60	3	Blocked
	Blocked								60	4	Blocked
	Blocked								80	5	Blocked
	Blocked								80	6	Blocked
Modified NIOSH 1500	0207-04401		1						1000	7	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH	0207-04402		1						1000	8	100/50 mg Coconut Charcoal (SKC 226-01)
Modified NIOSH 2002	0207-04403		1						1000	9	150/75 mg Silica Gel (SKC 226-10)
	Blocked								1000	10	Blocked
	Blocked								1000	11	Blocked
TO-11	0207-04404		1						1100	12	DNPH Cartridge
TO-11	0207-04405					1			1100	12	DNPH Cartridge
	Excess									13	Excess

Series 1162-0207

Core Mixing, Making, Storage,
Process Instructions

A. Experiment

1. Measure selected HAPs and VOCs from the mixing, core making, and storage of step cores made form 2.0% Foseco binder gassed with CO_2.

B. Materials:

1. Wexford 450W Lake sand.
2. Foseco Ecolotec® core binder.
3. Vaporized liquid carbon dioxide.

C. Core sand mixing tests.

1. Prepare the sand mixing, transport, and bulk sand storage environmental enclosure.
2. Set up the sampling trains.
3. Weigh 110 pounds of lake sand on the Simpson mixer batch scale.
4. Pre-weigh 2.0% binder (BOS); 998.1 gms.
5. Verify that the sand is 75-85^{o}F.
6. Turn on the sand conveyor.
7. Move the emission sampling hose away from the mixer charging port.
8. Place the sand funnel over the mixer charging port.
9. When all parties are ready and the THC is running charge sand to muller.
10. Move the sand funnel away and return the emission sampling hose to the mixer charging port.
11. Start the test clock and turn on the sample tubes.
12. Pour the binder into the mixer over a one (1) minute period.
13. Continue mixing for a total of three (3) minutes from the start of adding the binder.
14. Discharge the sand to the sand conveyor and close the mixer door.
15. Sample for a total of 30 minutes.
16. Repeat this procedure three (3) times, constituting three (3) tests, alternating with the core storage tests.

D. Core storage tests.

1. Verify that the heated core test room is 75-85^{o}F.
2. Prepare the core storage emission enclosure.
3. Set up the sampling trains and calibrate.
4. Set up the Redford/Carver core machine with the step core box.
5. Set machine to gas for 30 seconds with zero (0) second delay after gassing and zero

second (0) purge. Set the cycle counter to zero (0). Total cycle time to be two (2) minutes.

6. Start and calibrate the Foseco CO_2 vaporizer.
7. Set the CO_2 gas flow rate according to the customer's instruction and record the value.
8. Make core from the sand accumulated in the previous core mixing test.
9. Number, weigh, and record each core.
10. When good cores are being made sample four (4) cores consecutively for the storage test. Place these cores in the core storage emission enclosure.
11. Close the enclosure lid and seal with duct tape.
12. Wheel the enclosure into the heated core test room.
13. Connect the sample train and THC.
14. Start the test clock, open the sample train and begin the emission sampling. Continue sampling for 30 minutes then close the sample train.
15. Repeat this procedure three (3) times, constituting three (3) tests, alternating with the sand mixing tests.

E. Core making

1. Upon conclusion of the last storage test make new sand as required in 110 pound batches to assure continuity of production for 3 hours.
2. Record the number and weight of each core throughout the test.
3. When everybody is ready, start the emission sampling clock and open the sample train. Sample continuously for one (1) hour then close the sample train.
4. Do not stop making cores.
5. Set up the sample train again and repeat the test for a second and third hour. A total of three (3) one (1) hour tests are to be performed.
6. Empty and clean the core machine and core sand mixer.
7. Shut down non-essential electrical devices.

F. Making cores.

1. Remove the CO_2 vaporizer discharge hose from the core machine and attach it to a portable gassing head.
2. Use the portable Redford/Carver core mixer to mix 110 pound batches of core sand as above.
3. Make a drag half core by hand placing the sand, screeding and tamping with the screed bar. Clean the parting surface and place the gassing head on top of the half core box. Gas for 20-30 seconds with CO_2 per customer instructions.
4. Strip the drag half core and place it on a flat surface.
5. In like manner make a cope half core.
6. Make a pour basin.
7. Assemble the core halves and pour basin using inorganic ceramic adhesive.
8. Repeat the procedure for as many cores as are required.

9. Wrap the cores with polyethylene film to preserve volatiles.

Steven M. Knight
Mgr. Process Engineering

this page intentionally left blank

APPENDIX B DETAILED EMISSION DATA AND REPORTING LIMITS

this page intentionally left blank

Test 1162-0207 - Detailed Emission Data - Mix - Lb/Lb

TA	HAP	Run Number	0207-041	0207-042	0207-043	Average	Standard Deviation
		Test Dates	9-Apr-02	9-Apr-02	9-Apr-02	-	-
Emission Indicators							
		TGOC as Propane	7.70E-04	7.74E-04	8.76E-04	8.07E-04	6.04E-05
		HC as Hexane	4.76E-04	3.66E-04	3.63E-04	4.02E-04	6.47E-05
		Sum of Target Analytes	8.05E-05	1.12E-04	1.31E-04	1.08E-04	2.55E-05
		Sum of Target HAPs	3.88E-06	5.30E-06	1.66E-06	3.62E-06	1.83E-06
Selected Target HAPs							
TA	H	Formaldehyde	3.88E-06	5.30E-06	1.66E-06	3.62E-06	1.83E-06
TA	H	Phenol	ND	ND	ND	ND	NA
TA	H	o,m-Cresol	ND	ND	ND	ND	NA
Additional Selected Target Analytes							
TA		Butyl Carbitol	4.41E-05	6.07E-05	7.33E-05	5.94E-05	1.46E-05
TA		Ethylene glycol phenyl ether	3.24E-05	4.58E-05	5.61E-05	4.48E-05	1.18E-05

Test 1162-0207 - Detailed Emission Data - Making (Gassing) - Lb/Lb

TA	HAP	Run Number	0207-002	0207-003	0207-004	Average	Standard Deviation
		Test Dates	10-Apr-02	10-Apr-02	10-Apr-02	-	-
Emission Indicators							
		TGOC as Propane	I	I	I	I	NA
		HC as Hexane	5.23E-05	8.44E-05	8.29E-05	7.32E-05	1.81E-05
		Sum of Target Analytes	8.82E-06	4.47E-05	2.20E-05	2.52E-05	1.81E-05
		Sum of Target HAPs	1.75E-06	2.83E-05	2.20E-05	1.74E-05	1.39E-05
Selected Target HAPs							
TA	H	Phenol	ND	2.43E-05	2.05E-05	1.49E-05	1.31E-05
TA	H	Formaldehyde	1.75E-06	4.03E-06	1.52E-06	2.43E-06	1.39E-06
TA	H	o,m-Cresol	ND	ND	ND	ND	NA
Additional Selected Target Analytes							
TA		Ethylene glycol phenyl ether	7.07E-06	1.64E-05	ND	7.81E-06	8.21E-06
TA		Butyl Carbitol	ND	ND	ND	ND	NA

ND=Not Detected
NT=Not Tested
NA=Not Applicable
I=Invalidated Data
TA=Target Analyte

Test 1162-0207 - Detailed Emission Data - Making (Fugitives) - Lb/Lb

TA	HAP	Run Number	0207-022	0207-023	0207-024	Average	Standard Deviation
		Test Dates	10-Apr-02	10-Apr-02	10-Apr-02	-	-
Emission Indicators							
		TGOC as Propane	I	I	I	I	3.23E-04
		HC as Hexane	2.88E-04	2.86E-04	2.87E-04	2.87E-04	8.42E-07
		Sum of Target Analytes	2.68E-04	4.21E-04	3.72E-04	3.54E-04	7.81E-05
		Sum of Target HAPs	1.04E-04	1.56E-04	1.30E-04	1.30E-04	2.61E-05
Selected Target HAPs							
TA	H	Phenol	8.95E-05	1.38E-04	1.24E-04	1.17E-04	2.50E-05
TA	H	Formaldehyde	1.44E-05	1.82E-05	5.95E-06	1.28E-05	6.27E-06
TA	H	o,m-Cresol	ND	ND	ND	ND	NA
Additional Selected Target Analytes							
TA		Butyl Carbitol	7.14E-05	1.60E-04	1.45E-04	1.25E-04	4.74E-05
TA		Ethylene glycol phenyl ether	9.31E-05	1.05E-04	9.76E-05	9.85E-05	6.02E-06

Test 1162-0207 - Detailed Emission Data - Storage - Lb/Lb

TA	HAP	Run Number	0207-031	0207-033	0207-034	Average	Standard Deviation
		Test Dates	9-Apr-02	10-Apr-02	10-Apr-02	-	-
Emission Indicators							
		TGOC as Propane	I	I	I	I	NA
		HC as Hexane	3.35E-05	5.72E-05	6.70E-05	5.26E-05	1.72E-05
		Sum of Target Analytes	5.18E-05	9.08E-05	1.07E-04	8.31E-05	2.82E-05
		Sum of Target HAPs	3.62E-05	5.76E-05	6.75E-05	5.37E-05	1.60E-05
Selected Target HAPs							
TA	H	Phenol	3.33E-05	5.59E-05	6.56E-05	5.16E-05	1.66E-05
TA	H	Formaldehyde	2.91E-06	1.69E-06	1.86E-06	2.15E-06	6.62E-07
TA	H	o,m-Cresol	ND	ND	ND	ND	NA
Additional Selected Target Analytes							
TA		Butyl Carbitol	8.74E-06	1.81E-05	2.16E-05	1.61E-05	6.63E-06
TA		Ethylene glycol phenyl ether	6.87E-06	1.51E-05	1.76E-05	1.32E-05	5.63E-06

Test 1162-0207 - Practical Reporting limits

Analyte	Mixing	Making		Storage
		Gassing	Fugitives	
Butyl Carbitol	1.69E-05	1.98E-05	1.92E-05	1.05E-06
Ethylene glycol phenyl ether	1.36E-05	1.58E-05	1.53E-05	8.37E-07
Formaldehyde	1.12E-06	2.10E-05	1.29E-06	7.64E-08
HC as Hexane	3.56E-05	4.07E-05	4.04E-05	2.11E-06
o,m-Cresol	7.10E-06	8.40E-06	8.12E-06	4.31E-07
Phenol	1.78E-05	1.34E-06	2.03E-05	1.08E-06

All reporting limits values are expressed in terms of lb/lb binder

ND=Not Detected
NT=Not Tested
NA=Not Applicable
I=Invalidated Data
TA=Target Analyte

APPENDIX C DETAILED PROCESS DATA

this page intentionally left blank

Test 1162-0207 - Detailed Process Data

Sand Mixing	Background	1	2	3	Averages
Emission No. Purge & Gas		----	----	----	
Emission No. Mix/Fugitives		0207-041	0207-042	0207-043	
Total sand or core weight, Lbs.	111	100	111	111	107
Binder weight, Lbs.	2.20	2.20	2.20	2.20	2.20
Calculated % binder	1.94	2.15	1.94	1.94	2.01
Sand temperature, °F	75	75	----	----	75
Core or machine cycle count	----	----	----	----	----
Step core LOI, average % (Note 5)	----	----	----	----	----
	Note 1	Note 2			

Mold Making	1	2	3	4	Averages
Emission test no. Purge &Gas	0207-001	0207-002	0207-003	0207-004	
Emission test no. Mix/Fugitives	0207-021	0207-022	0207-023	0207-024	
Total sand or core weight, Lbs.	57.9	235.3	263.6	298.0	265.6
Binder weight, Lbs. (Note 4)	1.12	4.61	5.11	5.84	5.19
Calculated % binder	1.90	1.92	1.90	1.92	1.92
Sand temperature, °F	----	----	----	----	----
Core or machine cycle count	15	38	40	43	40
Step core LOI, average % (Note 5)	----	1.33	1.36	1.47	1.39
	Note 3				

Mold Storage	1	2	3	4	Averages
Emission No.storage	0207-031	0207-032	0207-033	0207-034	
Core weights, 1st in box	6.68	6.83	6.71	5.63	6.34
2nd in box	6.77	6.83	6.22	5.81	6.27
3rd in box	6.76	6.58	5.70	6.90	6.45
4th in box	6.74	---	5.84	6.91	6.50
Total core weight, Lbs.	26.95	20.24	24.47	25.24	25.55
Total binder weight, Lbs.	0.52	0.39	0.48	0.49	0.50
Average core weight, Lbs.	6.74	6.75	6.12	6.31	6.39
Core machine cycle time, Min.	2.00	2.00	1.50	1.50	1.67
Step core/mold LOI, %	1.28	----	----	----	1.28
		Note 6			

Note 1: The background batch was sent to the core machine hopper to make the first batch appear as a continuation of an ongoing process. The other batches for the mix test were batches of an ongoing process.

Note 2: Sand batch 0207-041 is not rejected as out of tolerance because the correct amount of binder existed in the test enclosure. The sand is merely a carrier for the purposes of this test.10 pounds of dry sand leaked through mixer before the binder addition.

Note 3: A feature of this chemical system is that the activator, CO_2, exists as a component of the atmosphere. With the 1.5-2.0 minute cycle time during this test the top of the sand in the hopper would crust over and the crust would break into many pieces. When forced into the blow magazine these particle would plug the blow head causing incomplete cores and stop the test. Test 0207-001/021 aborted. Not used in report

Note 4: Sand mixed for mix test was subsequently used in make core and corestorage tests therefore binder content is defined as core weight (lbs) x % binder (mix test) / 100

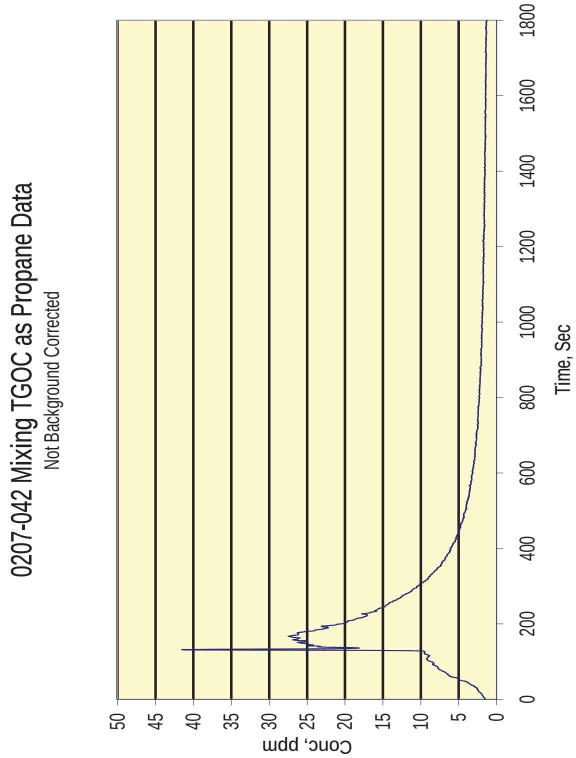
Note 5: The sand mixed for the mix test carried to the core machine and was consumed in the make test. The make test LOIs therefore also represent the mix test.

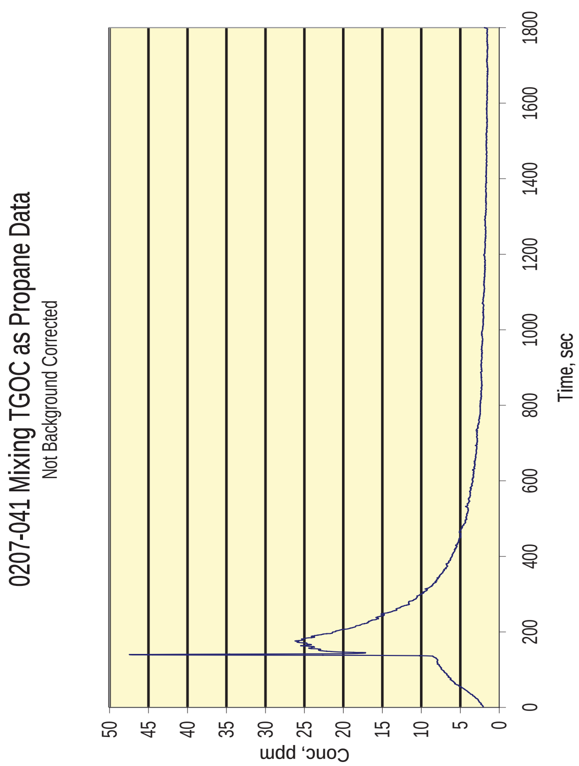
Note 6: Test 0207-032 voided , only three cores vs four and then process failed completely. Not used in report.

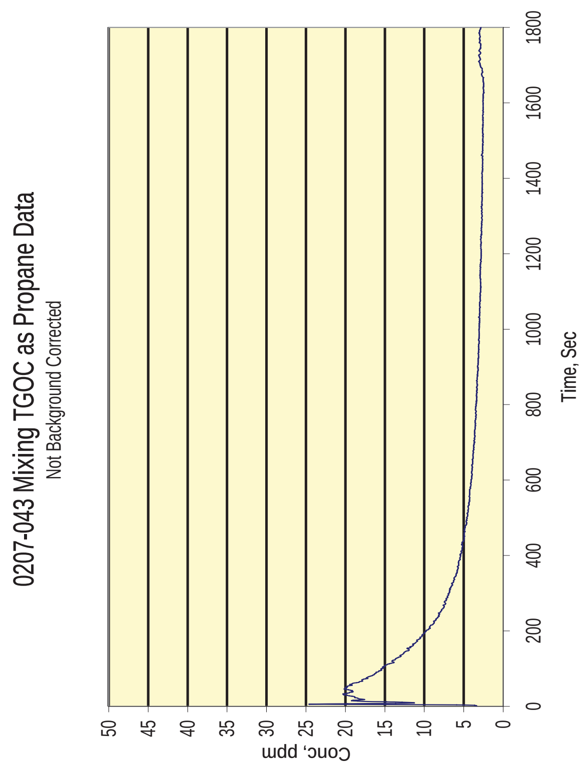
this page intentionally left blank

APPENDIX D CONTINUOUS EMISSION CHARTS

this page intentionally left blank


0207-042 Mixing TGOC as Propane Data
Not Background Corrected
Conc, ppm
0
5
10
15
20
25
30
35
40
45
50
Time, Sec
0
200
400
600
800
1000
1200
1400
1600
1800


0207-041 Mixing TGOC as Propane Data
Not Background Corrected
Conc, ppm
0
5
10
15
20
25
30
35
40
45
50
Time, sec
0
200
400
600
800
1000
1200
1400
1600
1800


0207-043 Mixing TGOC as Propane Data
Not Background Corrected
Conc, ppm
0
5
10
15
20
25
30
35
40
45
50
Time, Sec
0
200
400
600
800
1000
1200
1400
1600
1800

this page intentionally left blank

APPENDIX E ACRONYMS AND ABBREVIATIONS

this page intentionally left blank

ACRONYMS & ABBREVIATIONS

AFS	American Foundry Society
ARDEC	(US) Army Armament Research, Development and Engineering Center
BO	Based on ( ).
BOS	Based on Sand.
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CERP	Casting Emission Reduction Program
CFR	Code of Federal Regulations
CISA	Casting Industry Suppliers Association
CRADA	Cooperative Research and Development Agreement
DOD	Department of Defense
DOE	Department of Energy
EEF	Established Emission Factors
EPA	Environmental Protection Agency
ERC	Environmental Research Consortium
FID	Flame Ionization Detector
HAP	Hazardous Air Pollutant defined by the 1990 Clean Air Act Amendment
HC	Hydrocarbon
I	Invalidated Data
Lb/Lb	Pound per Pound of Binder
LOI	Loss on Ignition
MB	Methylene Blue
NA	Not Applicable; Not Available
ND	Non-Detect; Not detected below the practical quantitation limit
NT	Not Tested - Lab testing was not done
POM	Polycyclic Organic Matter
QA/QC	Quality Assurance/Quality Control
TGOC	Total Gaseous Organic Concentration
THC	Total Hydrocarbon Concentration
US EPA	United States Environmental Protection Agency
USCAR	United States Council for Automotive Research

VOST	Volatile Sampling Train
WBS	Work Breakdown Structure