Casting Emission Reduction Program

Prepared by:

TECHNIKON LLC

5301 Price Avenue ▼ McClellan, CA, 95652 ▼ (916) 929-8001

www.technikonllc.com

US Army Task N256

Core Making Emissions Pre and Post Scrubber

Technikon #RE100124 EC

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United States Environmental Protection Agency

CISA

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UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

USCAR

DaimlerChrysler Ford Motor Company General Motors

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Production
Core Making Emissions Study

Core Making Emissions Study Test Report

RE199124EC

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

Prepared by:	*Original Signed* Carmen Hornsby	6/27/01 Date
Process Engineering Manager:	*Original Signed* Steven Knight	6/26/01 Date
VP Measurement Technologies:	*Original Signed* Clifford Glowacki, CIH	6/26/01 Date
VP Operations:	*Original Signed* George Crandell	6/26/01 Date
President:	*Original Signed* William Walden	6/26/01 Date

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

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Executive Summary

This report contains the results of emission testing at sampling locations before and after the core machine exhaust gas scrubber as part of a Core Making Emissions Study. All testing was conducted in the CERP Production foundry core making facility, operated by Technikon, LLC.

The testing was conducted under the Casting Emission Reduction Program (CERP) as a cooperative initiative between the Department of Defense (U.S. Army) and the United States Council for Automotive Research (US CAR). CERP's mission is to evaluate alternative casting materials and processes that are designed to reduce air emissions from foundries and/or improve the efficiency of casting processes. Other technical partners directly supporting the CERP 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).

The specific objective of this test was to determine the emission levels of a selected group of Hazardous Air Pollutants (HAPs) and Volatile Organic Compounds (VOCs) produced during core making and to evaluate the impact of the acid scrubbers on those emissions. The resultant emissions are expressed as pounds of emission per pound of resin (Lb/Lb) as well as parts per million (v/v).

The testing performed involved the collection of air samples during the sand and binder mixing, core blowing, and catalyst addition processes. Process and stack parameters were measured and include: the weights of the sand and binder; stack temperature, pressure, volumetric flow rate and moisture content. The process parameters were maintained within prescribed ranges in order to ensure the reproducibility of the tests. Three sixty-minute sampling periods were performed for this test at both the inlet and at the outlet stack of the gas scrubber. Samples were collected and analyzed for selected target compounds using procedures based on US EPA Method 18.

The mass emission rate of each parameter or target compound was calculated, in pounds per pound of resin and part per million, using the Method 25A data or the laboratory analytical results, the measured source data, and the collective weight of the cores produced during each test. The HC as Hexane results represent the sum of all organic compounds detected and expressed as Hexane. Triethylamine (TEA) results expressed as parts of TEA per million parts of air are reported for results from the outlet stack of the scrubber.

Results from Test EC for the measured analytes are shown in the following table.

Analyte	Pre-Scrubber	Post Scrubber
HC as Hexane (Lb/Lb Resin)	0.045	0.037
Triethylamine (ppm, v/v)	I	<0.041

I: Data rejected based on data validation considerations.

The results from the above table show a decrease in emissions comparing the inlet to the outlet stack for HC as Hexane. The concentration of triethylamine was found to be below the method quantitation limit at the post scrubber position.

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

1.0 Introduction

1.1 Background

Technikon LLC is a privately held contract research organization located in McClellan, California, a suburb of Sacramento. Technikon offers emissions research services to industrial and government clients specializing in the metal casting and mobile emissions areas. Technikon operates the Casting Emission Reduction Program (CERP). CERP is a cooperative initiative between the Department of Defense (US Army) and the United States Council for Automotive Research (US CAR). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes. Other technical partners directly supporting the project include: the American Foundry Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (US EPA); and the California Air Resources Board (CARB).

1.2 CERP Objectives

The primary objective of CERP is to evaluate 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 data collected during the various testing projects are evaluated to determine both the airborne emissions impact of the materials and/or process changes, and their stability and impact upon the quality and economics of casting and core manufacture. The materials, equipment, and processes may need to be further adapted and defined so that they will integrate into current casting facilities smoothly and with minimum capital expenditure.

Normally, Pre-Production testing is conducted first in order to evaluate the air emissions impact of a proposed alternative material, equipment, or process in the most cost effective manner. The Pre-Production Foundry is a simple general purpose manual foundry that was adapted and instrumented to make detailed emission measurements using methods based on EPA protocols for pouring, casting cooling, and shakeout processes on <u>discrete</u> molds under tightly controlled conditions not practical in a commercial foundry.

The Production Foundry's design as a basic greensand foundry was deliberately chosen so that whatever is tested in this facility will also be convertible to existing mechanized commercial foundries. The type and size of equipment, materials, and processes used emulate an automotive foundry. This facility is used to evaluate materials, equipment, and processes in a <u>continuous</u> process that is allowed to vary to the limits of commercial experience in a controlled manner. The Production Foundry provides simultaneous detailed individual emission measurements using methods based on USEPA protocols of the melting, pouring, sand preparation, mold making, and core making processes. It is instrumented so that the data on all activities of the metal casting process can be simultaneously and continuously collected, in order to completely evaluate the economic impact of the prospective emission reducing strategy. The Production Foundry's test casting is a single cavity Ford Motor Company I-4 engine block. Castings are randomly selected to evaluate the impact of the material, equipment, or process on casting quality. Alternative materials, equipment, and processes that demonstrate significant air emission reduction potential, preserve casting quality parameters, and that are economically viable based on the Pre-Production testing, may be further evaluated in the Production Foundry.

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

1.3 Report Organization

This report has been designed to document the methodology and results of a specific test plan that was used to evaluate the performance of an alternative material, equipment, or process of core making. Section 2 of this report includes a summary of the methodologies used for data collection and analysis, emission calculations, QA/QC procedures, and data management and reduction methods. Specific data collected during this test are summarized in Section 3 of this report, with detailed data included in Appendix B of this report. Section 4 of this report contains a discussion of the results.

The raw data for this test series are included in a data binder that is maintained at the Technikon facility. There are several support documents that provide details regarding the testing and analytical procedures used. Appendix F contains a listing of these support documents.

1.4 Specific Test Plan and Objectives

This report contains the results of testing performed to provide data on selected VOC and HAP emissions from the core making process. 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	Core Making Emissions Study - Pre/Post Scrubber
Test Plan Number	RE100124EC
Binder System	Ashland Isocure® 305/904
Number of tests	3
Test Date	3-13-01
Emissions Measured	Selected Analytes
Process Parameters Measured	Sand and Binder Weights; Stack Temperature, Moisture Content, 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 core making process and testing equipment.

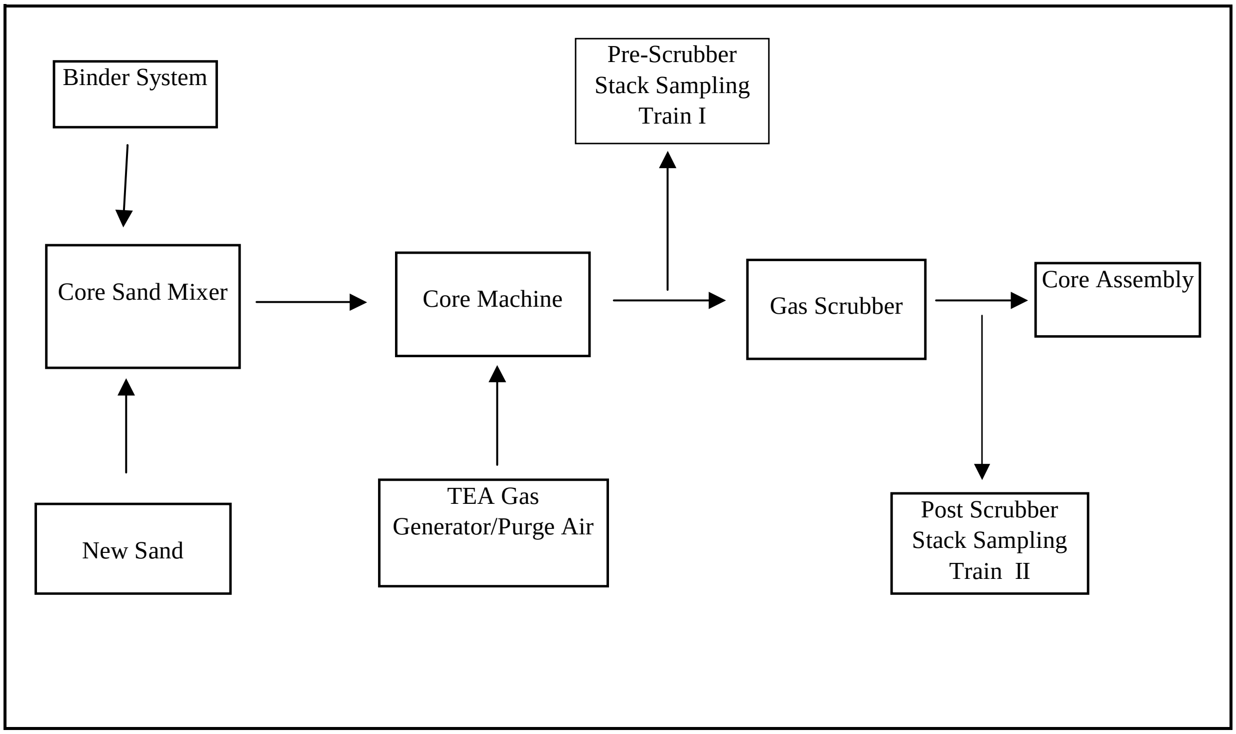


Figure 2-1. Core Making and Testing Process

2.2 Description of Testing Program

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

1. **Test Plan Review and Approval:** The proposed test plan was reviewed by the Technikon staff and CTC Program Manager, and approved.

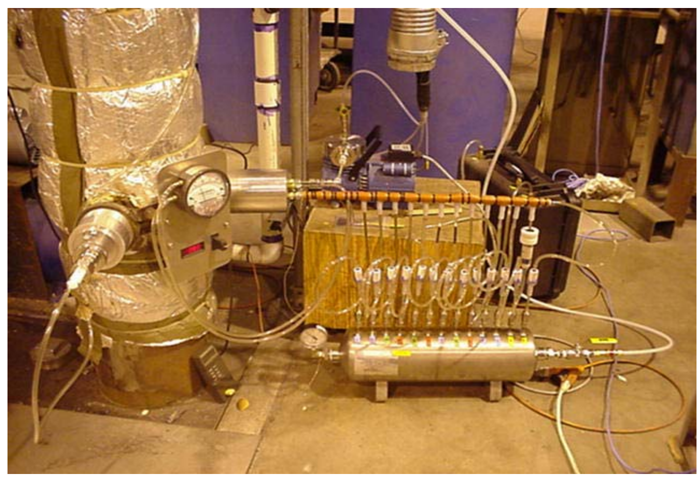
2. **Core Preparation**: Ford automotive I-4 engine block cores were prepared using a multi-cavity corebox on the George Fischer core machine in the Production foundry. Sand and Ashland 305/904 core binder were weighed and mixed at a rate of 1.75% binder based on sand in a Simpson Technologies core sand mixer above the core machine. The sand/resin mixture is introduced (blown) into the core tooling in the core machine. Next, a measured amount of the catalyst triethylamine (TEA) gas is heated to 84^{o}F and allowed to expand into the sand in the core box to cure the core, finally purge air is heated to 84^{o}F and blown

GF Core Machine and Headslab & Water jacket tooling

through the sand mixture in the core box. All these gases are exhausted to the wet gas scrubber charged with sulfuric acid at pH 2 or less.

Engine block cores consist of four parts, crankcase, Journal, Headslab, & Water Jacket. In one blow, either two each of the crankcase and journal cores or three each of the Headslab & Water jacket cores are produced.

3. **Individual Sampling Events:** Sampling at each of the sampling points (pre and post scrubber) was conducted over three (3) individual one-hour test runs. The number of cores produced and the weight of the resin used during each test hour was determined from the sand mixing and core making logs. Air samples were collected continuously during each one-hour test run at each of the sampling points. The total binder weight was used in order to correlate the emissions measurements with the resin weight processed.



Volatiles and Condensables Sampling

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
Binder Weight	Mettler PJ8000 Digital Scale (Gravimetric)
Core Sand Weight	Simpson IQ-800-3A Digital Scale

5. **Air Emissions Analysis:** The specific sampling and analytical methods used in the core making tests are based on the USEPA 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 CERP Testing, Quality Assurance /Quality Control Procedures Manual.

Table 2-2. Sampling and Analytical Methods

Measurement Parameter	Test Method
Port location	EPA Method 1
Number of traverse points	EPA Method 1
Gas velocity and temperature	EPA Method 2
Gas density and molecular weight	EPA Method 3a
Gas moisture	EPA Method 4, gravimetric
TEA concentration	EPA Method 18, NIOSH 2002*
HC as Hexane concentration	EPA Method 18, NIOSH 1500*

*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 resin used to provide emissions data in pounds of analyte per pound of resin.

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, 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 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 parts per million, are presented in Table 3-1 for the test reported in this document. This table includes the results for the measurement of triethylamine and HC as Hexane at the pre and post stack positions to the scrubber. Appendix B contains the detailed data including the results for all analytes measured. All emission results are presented without blank or background correction.

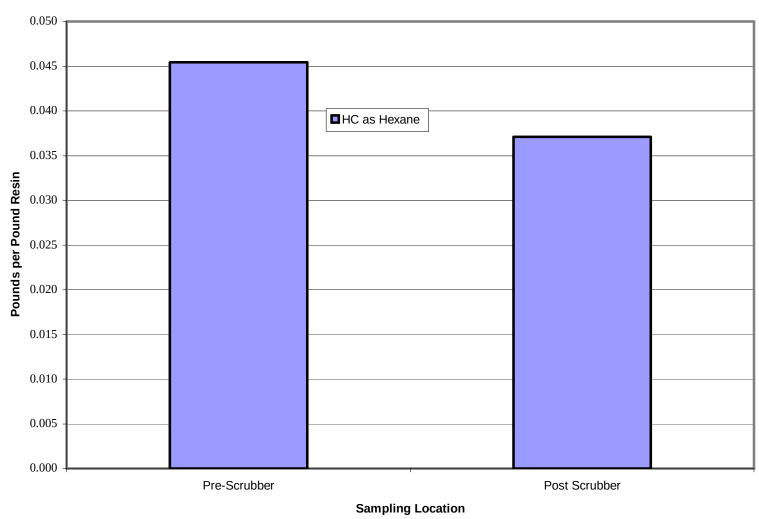
A laboratory analytical data validation log is included in Appendix C of this report.

Table 3-1. Summary of Test Plan EC Average Results

Analyte/Sampling Location	Test EC (Lb/Lb)
HC as Hexane - Pre-Scrubber	0.045
HC as Hexane - Post Scrubber	0.037
Analyte/Sampling Location	**Test EC (ppm, v/v)**
Triethylamine - Post Scrubber	<0.041*

* Based on the method quantitation limit

Figure 3-1. Test EC HC as Hexane Results Pre and Post Scrubber



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4.0 Discussion of Results

The results presented in this document show a decrease in the HC as Hexane when comparing the pre-scrubber to the post scrubber sampling locations. Triethylamine was found to be below the method quantitation limit at the post scrubber position (Table 3-1). Triethylamine was detected at the pre-scrubber sampling location; however, the results were inconsistent and all values invalidated. Detailed results may be found in Appendix B of this report.

The HC as hexane method detects hydrocarbon compounds in the alkane range between C6 and C16, with results calibrated against a six-carbon alkane (hexane).

Observation of measured process parameters indicates that the test was run within an acceptable range. Supporting data are available in the Technikon offices.

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APPENDIX A APPROVED TEST PLAN FOR TEST SERIES EC

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TECHNIKON TEST PLAN

> **CONTRACT NUMBER:** 1256 **TASK NUMBER:** 130

> **CONTROL NUMBER:** RE 100124

> **SAMPLE FAMILY:** EC

> **SAMPLE EVENTS:** 001 thru 005 Core Making Stack "In" 021 thru 025 Core Making Stack "Out"

> **SITE: ___PRE-PRODUCTION (243)__X__CERP FOUNDRY (238)**

> **TEST TYPE:** Core Making Emissions Study before and after the Scrubbers

> **MOLD TYPE**: N/A

> **NUMBER OF MOLDS:** N/A

> **CORE TYPE:** Ashland Cores with Standard 1.75 ISOCURE® 305/904 Resin

> **TEST DATE: START:** 12 Mar 01
> **FINISH:** 14 Mar 01

TEST OBJECTIVES:

Primary: To measure emissions from the core making process before and after the scrubbers. Critical Orifice Sample trains will be used to monitor the test and sample tubes will be collected for analysis by an outside laboratory.

VARIABLES: The core machine cycle time, incoming sand temperature, core resin content, sand mixing time, and TEA catalyzing cycles will be held constant during the emission testing periods.

BRIEF OVERVIEW: In prior tests emissions from stored cores of the type being tested here were measured. In this test we will measure the emissions that come from core making process itself. The emission testing will be done during standard I-4 engine block core manufacture for test EA. All core machine cycle times and settings will be recorded.

SPECIAL CONDITIONS:

*Original Signed*______________ ____*6/26/01*___
Manager Process Engineering (Technikon) **Date**

*Original Signed*______________ ____*6/26/01*___
V.P. Measurement Technology (Technikon) **Date**

*Original Signed*______________ ____*6/26/01*___
V.P. Operations (Technikon) **Date**

*Original Signed*______________ ____*6/26/01*___
Emissions Team (USCAR) **Date**

*Original Signed*______________ ____*6/26/01*___
Process and Facilities Team (USCAR) **Date**

*Original Signed*______________ ____*6/26/01*___
Project Manager (CTC) **Date**

Series EC

PILOT FOUNDRY PUA CORE MANUFACTURING PROCESS REFERENCE BASELINE INSTRUCTIONS

A. Experiment:

1. Measure the dynamic emissions from the +GF+ core machine operating the Phenolic Urethane Amine (PUA) core process

B. Introduction:

1. Prior studies looked at the emissions from PUA cores accumulated into a closed core storage area. This study will sample the emissions from the core machine purge air containing the amine catalyst. As the machine is operated though its full cycle, at about 40 cycles per hour with a multi-cavity core box, the purge air will be sampled before and after the acid scrubber.

C. Materials:

1. Wexford W450 Lake sand**,** Ashland Isocure ® LF305 Part I (55%), 904GR Part II (45%), & TEA gas.

D. Equipment:

1. Start and operate the +GF+ core machine and ancillary equipment only according to the Production Foundry Operating and Safety Manual.

E. Core manufacture

1. Cores shall be made in at least two sessions. The first is to allow the emission team to assess the flow rates and determine the collection requirements for the emission measurement session. The second will be the emission measurement session done during the manufacture of core for test EA.
2. It is important that during the assessment session that the TEA level be set at the minimum to cure the core and that the flow rates used are readable on a scaled part of the TEA flow meter.
3. Standard uncoated banded Isocure ® I-4 engine block cores shall be used.
4. Mix the core sand using Wexford W-450 Lake sand with 1.75% total resin BOS. The resin shall be Ashland Isocure ® LF305 Part I (55%) and 904GR Part II (45%).
5. Manufacture 500 sets of cores on the Georg Fisher core machine for test EA.
6. Use the Core Process Machine Parameters- George Fischer Core Machine, affectivity date 1 Jan 2000, to setup the core machine.
7. 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 50 shall be marked with a hold tag until they can be 100-scratch hardness tested to re-qualify. Scrap all cores with values less than 50.
8. The Laboratory shall run core LOI on the core batches. Qualified cores shall be QUALITY CHECK tagged before being sent to the production floor.

Note: Until we are able to establish the capability of the new sand delivery a sample of the raw Wexford W450 sand shall be taken each 5-7-mixer batches (once per half hour). A 1050-degree LOI, moisture, and screen analysis shall be preformed on each sample.

Steve Knight
Mgr. Process Engineering

PRODUCTION CORE MAKING - STACK "IN" Preliminary 15 minutes

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/13/01											SAMPLES TO CLAYTON LAB
Preliminary Test 1											Train: CERP # 1 "IN"
NIOSH 2002	EC00101		1						25	1	SKC 226-15
NIOSH 1500	EC00102					1			25	1	SKC 226-01
Excess									25	2	Excess
NIOSH 2002	EC00103		1						60	3	SKC 226-15
NIOSH 1500	EC00104					1			60	3	SKC 226-01
Excess									60	4	Excess
NIOSH 2002	EC00105		1						200	5	SKC 226-15
NIOSH 1500	EC00106					1			200	5	SKC 226-01
NIOSH 2002	EC00107		1						500	6	SKC 226-15
NIOSH 1500	EC00108					1			500	6	Orbo 32L
Excess									500	7	Excess
NIOSH 2002	EC00109		1						750	8	SKC 226-15
NIOSH 1500	EC00110					1			750	8	Orbo 32L
Excess									750	9	Excess
NIOSH 2002	EC00112		1						1000	10	SKC 226-15
NIOSH 1500	EC00112					1			1000	10	Orbo 32L
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "IN" Preliminary 30 minutes

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/13/01											SAMPLES TO CLAYTON LAB
Preliminary Test 2											Train: CERP # 1 "IN"
NIOSH 2002	EC00201		1						25	1	SKC 226-15
NIOSH 1500	EC00202					1			25	1	SKC 226-01
Excess									25	2	Excess
NIOSH 2002	EC00203		1						60	3	SKC 226-15
NIOSH 1500	EC00204					1			60	3	SKC 226-01
Excess									60	4	Excess
NIOSH 2002	EC00205		1						200	5	SKC 226-15
NIOSH 1500	EC00206					1			200	5	SKC 226-01
NIOSH 2002	EC00207		1						500	6	SKC 226-15
NIOSH 1500	EC00208					1			500	6	Orbo 32L
Excess									500	7	Excess
NIOSH 2002	EC00209		1						750	8	SKC 226-15
NIOSH 1500	EC00210					1			750	8	Orbo 32L
Excess									750	9	Excess
NIOSH 2002	EC00212		1						1000	10	SKC 226-15
NIOSH 1500	EC00213					1			1000	10	Orbo 32L
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "IN" 3-1 hr

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 1 "IN"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC00301		1						60	3	SKC 226-15
NIOSH 1500	EC00302					1			60	3	Orbo 32L
NIOSH 2002	EC00303		1						60	4	SKC 226-15
NIOSH 1500	EC00304					1			60	4	Orbo 32L
NIOSH 2002	EC00305		1						60	5	SKC 226-15, Sample time 15 min. "A"
NIOSH 2002	EC00306		1						60	5	SKC 226-15, Sample time 15 min. "B"
NIOSH 2002	EC00307		1						60	5	SKC 226-15, Sample time 15 min. "C"
NIOSH 2002	EC00308		1						60	5	SKC 226-15, Sample time 15 min. "D"
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "IN" 3-1 hr

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 1 "IN"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC00401		1						60	3	SKC 226-15
NIOSH 1500	EC00402					1			60	3	Orbo 32L
NIOSH 2002	EC00403		1						60	4	SKC 226-15
NIOSH 1500	EC00404					1			60	4	Orbo 32L
NIOSH 2002	EC00405		1						60	5	SKC 226-15, Sample time 15 min. "A"
NIOSH 2002	EC00406		1						60	5	SKC 226-15, Sample time 15 min. "B"
NIOSH 2002	EC00407		1						60	5	SKC 226-15, Sample time 15 min. "C"
NIOSH 2002	EC00408		1						60	5	SKC 226-15, Sample time 15 min. "D"
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "IN" 3-1 hr

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)		Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 1 "IN"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC00501		1						60	3	SKC 226-15
NIOSH 1500	EC00502					1			60	3	Orbo 32L
NIOSH 2002	EC00503		1						60	4	SKC 226-15
NIOSH 1500	EC00504					1			60	4	Orbo 32L
NIOSH 2002	EC00505		1						60	5	SKC 226-15, Sample time 15 min. "A"
NIOSH 2002	EC00506		1						60	5	SKC 226-15, Sample time 15 min. "B"
NIOSH 2002	EC00507		1						60	5	SKC 226-15, Sample time 15 min. "C"
NIOSH 2002	EC00508		1						60	5	SKC 226-15, Sample time 15 min. "D"
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "OUT" Preliminary 15 minutes

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/13/01											SAMPLES TO CLAYTON LAB
Preliminary Test 1											Train: CERP # 2 "IN"
NIOSH 2002	EC02101		1						25	1	SKC 226-15
NIOSH 1500	EC02102					1			25	1	SKC 226-01
Excess									25	2	Excess
NIOSH 2002	EC02103		1						60	3	SKC 226-15
NIOSH 1500	EC02104					1			60	3	SKC 226-01
Excess									60	4	Excess
NIOSH 2002	EC02105		1						200	5	SKC 226-15
NIOSH 1500	EC02106					1			200	5	SKC 226-01
NIOSH 2002	EC02107		1						500	6	SKC 226-15
NIOSH 1500	EC02108					1			500	6	Orbo 32L
Excess									500	7	Excess
NIOSH 2002	EC02109		1						750	8	SKC 226-15
NIOSH 1500	EC02110					1			750	8	Orbo 32L
Excess									750	9	Excess
NIOSH 2002	EC02112		1						1000	10	SKC 226-15
NIOSH 1500	EC02113					1			1000	10	Orbo 32L
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "OUT" Preliminary 30 minutes

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/13/01											SAMPLES TO CLAYTON LAB
Preliminary Test 2											Train: CERP # 2 "IN"
NIOSH 2002	EC02201		1						25	1	SKC 226-15
NIOSH 1500	EC02202					1			25	1	SKC 226-01
Excess									25	2	Excess
NIOSH 2002	EC02203		1						60	3	SKC 226-15
NIOSH 1500	EC02204					1			60	3	SKC 226-01
Excess									60	4	Excess
NIOSH 2002	EC02205		1						200	5	SKC 226-15
NIOSH 1500	EC02206					1			200	5	SKC 226-01
NIOSH 2002	EC02207		1						500	6	SKC 226-15
NIOSH 1500	EC02208					1			500	6	Orbo 32L
Excess									500	7	Excess
NIOSH 2002	EC02209		1						750	8	SKC 226-15
NIOSH 1500	EC02210					1			750	8	Orbo 32L
Excess									750	9	Excess
NIOSH 2002	EC02212		1						1000	10	SKC 226-15
NIOSH 1500	EC02213					1			1000	10	Orbo 32L
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "OUT" CERP – 2

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 3											Train: CERP # 2 "OUT"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC02301		1						60	3	SKC 226-15
NIOSH 1500	EC02302					1			60	3	Orbo 32L
NIOSH 2002	EC02303		1						60	4	SKC 226-15
NIOSH 1500	EC02304					1			60	4	Orbo 32L
NIOSH 2002	EC02305		1						200	5	SKC 226-15, Sample time 1 hr.
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "OUT" CERP – 2

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)	Train Channel	Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 4											Train: CERP # 2 "OUT"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC02401		1						60	3	SKC 226-15
NIOSH 1500	EC02402					1			60	3	Orbo 32L
NIOSH 2002	EC02403		1						60	4	SKC 226-15
NIOSH 1500	EC02404					1			60	4	Orbo 32L
NIOSH 2002	EC02405		1						200	5	SKC 226-15, Sample time 1 hr.
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

PRODUCTION CORE MAKING - STACK "OUT" CERP – 2

Method	Sample #	Data	Sample	Duplicate	Blank	Breakthrough	Spike	Spike Amount	Flow (ml/min)		Comments
3/14/01											SAMPLES TO CLAYTON LAB
TEST 5											Train: CERP # 2 "OUT"
Excess									25	1	Excess
Excess									25	1	Excess
Excess									25	2	Excess
NIOSH 2002	EC02501		1						60	3	SKC 226-15
NIOSH 1500	EC02502					1			60	3	Orbo 32L
NIOSH 2002	EC02503		1						60	4	SKC 226-15
NIOSH 1500	EC02504					1			60	4	Orbo 32L
NIOSH 2002	EC02505		1						200	5	SKC 226-15, Sample time 1 hr.
Excess									500	6	Excess
Excess									500	7	Excess
Excess									750	8	Excess
Excess									750	8	Excess
Excess									750	9	Excess
Excess									1000	10	Excess
Excess									1000	10	Excess
Excess									1000	11	Excess
Moisture			1						500	12	EPA Method 4
Excess									2500	13	Excess

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APPENDIX B TEST SERIES EC DETAILED RESULTS

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Test Series EC Detailed Results

Test EC Individual Results Pre Scrubber - Lb/Lb Resin					
Compound/Sample Number	**EC003**	**EC004**	**EC005**	**Average**	**STDEV**
HC as Hexane	2.95E-02	6.04E-02	4.65E-02	4.55E-02	1.55E-02

Test EC Individual Results Post Scrubber - Lb/Lb Resin					
Compound/Sample Number	**EC023**	**EC024**	**EC025**	**Average**	**STDEV**
HC as Hexane	3.21E-02	4.20E-02	3.72E-02	3.71E-02	4.92E-03

Test EC Individual Results Pre-Scrubber - ppm					
Compound/Sample Number	**EC003**	**EC004**	**EC005**	**Average**	**STDEV**
Triethylamine	I	I	I	NA	NA

Test EC Individual Results Post Scrubber - ppm					
Compound/Sample Number	**EC023**	**EC024**	**EC025**	**Average**	**STDEV**
Triethylamine	<0.041	<0.041	<0.041	NA	NA

I: Data rejected based on data validation considerations.

NA: Not Applicable; ND: Not Detected

APPENDIX C VALIDATION LOG (AVAILABLE IN HARD COPY ONLY)

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APPENDIX D LISTING OF SUPPORT DOCUMENTS

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Listing of Support Documents

The following documents contain specific test results, procedures, and documentation used in support of this Test Plan

1. Casting Emission Reduction Program – Foundry Product Testing Guide: Reducing Emissions by Comparative Testing, May 4, 1998.

2. CERP Testing, Quality Assurance/Quality Control Procedures Manual.

3. Emission Baseline Test Results for the CERP Pre-Production Foundry Processes.

4. Evaluation of the Required Number of Replicate Tests to Provide Statistically Significant Air Emission Reduction Comparisons for the CERP Pre-Production Foundry Test Program.

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APPENDIX E GLOSSARY

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GLOSSARY

ND	Non Detect
No Test	Lab testing was not done on this analyte.
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.