UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

CERP
Casting Emission Reduction Program

Qualification Test – Preproduction Foundry

Prepared for

DELTA-HA

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AMERICAN FOUNDRY SOCIETY

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California Environmental Protection Agency AIR RESOURCES BOARD

Pre-production Air Emission Test

Test Plan #RV 100024AW

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

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Executive Summary

This report contains the results of emission testing for Test Plan AW conducted at the Casting Emission Reduction Program (CERP) Pre-production Foundry. The specific objective of the Test Plan was to determine the emission reductions, if any, of organic Hazardous Air Pollutants (HAPs) and Volatile Organic Compounds (VOCs) for a proposed core binder replacement compared to the "Core Baseline" tests. The test hypothesis is that the core binder replacement will significantly reduce organic HAP emissions compared to the "Core Baseline" tests during gray iron casting activities.

The test plan and baseline tests were conducted by 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.

The Pre-production Foundry is a simple general purpose manual foundry that was adapted and instrumented to make detailed organic emission measurements, using methods based on EPA protocols for pouring, casting cooling, and shakeout processes on discrete mold and core packages under tightly controlled conditions not feasible in a commercial foundry. The results of testing in the Pre-production Foundry are evaluated to determine whether further testing is warranted.

The testing performed involved the collection of continuous air samples over a seventy five minute period, including the mold pouring, cooling, shakeout, and post shakeout periods. Process and stack parameters were measured and included: the weights of the casting, mold, core binder additions, and core; Loss on Ignition (LOI) values for the mold prior to the test and at shakeout; percent clays; metallurgical data; and stack parameters including 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. Nine individual sampling events were conducted using procedures based on standard EPA stack test methods. Test and duplicate air samples were collected in adsorption tubes for analysis. The tubes were analyzed using EPA Method 18 (modified) for separate analytes including individual organic Hazardous Air Pollutants (HAPS). The mass emission rate, in pounds per ton of metal, was calculated for each analyte using the laboratory analytical results, the measured stack parameters, and the weight of the casting. Total organic HAP emissions were determined from the sum of the individual HAPS measured. Total VOCs were determined based on the sum of the individual VOCs measured.

The results of the tests performed for this test plan show a 41% reduction in total HAPS and a 55% reduction in VOCs as compared with the "Core Baseline" tests. Based on the results of the air emissions testing, this product is recommended for testing in the CERP Production Foundry.

It must be noted that the baseline and product testing performed as part of the CERP mission 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 manufacturing 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.

Assessment of the economic and commercial viability of this product is a function of Production Foundry testing. Inclusion of this product in the Production Foundry program is subject to review and approval by the CERP Steering Committee.

1.0 INTRODUCTION

1.1. Background

The Casting Emission Reduction Program (CERP) is a cooperative initiative between the Department of Defense (McClellan Air Force Base) and the United States Council for Automotive Research (USCAR). Its purpose is to evaluate alternative casting materials and processes that are designed to reduce air emissions and/or produce more efficient casting processes. Other technical partners directly supporting the project include: the American Foundrymen's Society (AFS); the Casting Industry Suppliers Association (CISA); the US Environmental Protection Agency (USEPA); and the California Air Resources Board (CARB). Each of these partners is represented on a Steering Committee (as voting or non-voting members) that has oversight for the testing conducted at the CERP facility.

1.2. CERP Objectives

The primary objective of CERP is to evaluate materials, equipment, and processes used in the production of metal castings. Specifically, the CERP facility has been designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions, especially for Hazardous Air Pollutants (HAP). The emission reduction goal for the alternative materials, equipment and production processes is fifty (50) percent. 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 commercial greensand casting facilities smoothly and with minimum capital expenditure.

Pre-production testing is conducted first in order to evaluate the air emissions impact of a proposed alternative material, equipment, or process. 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 discrete mold and core packages under tightly controlled conditions not feasible in a commercial foundry. The Pre-production Foundry uses an eight-cavity, bottom feed AFS step block as its test mold pattern.

Alternative materials, equipment, and processes that demonstrate significant air emission reduction potential, preserve casting quality parameters, and that are economically viable, are further evaluated in the Production 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 continuous 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 1-4 engine block. Castings are randomly selected to evaluate the impact of the material, equipment, or process on casting quality.

It must be noted that the results from the baseline and product testing performed as part of the CERP mission 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 in the Pre-production Foundry. 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 in support of this particular test plan are summarized in Section 3 of this report, with detailed data included in Appendices B and C of this report. Appendix A contains the approved test plan for Test AW. Appendix D contains the core baseline process data. Section 4 of this report contains a discussion of the results of Test Plan AW along with conclusions and recommendations.

The raw data for Test Series AW are included in the Test Series AW data binder which is maintained at the CERP facility.

There are several support documents that provide details regarding the testing and analytical procedures used, as well as documenting the results of various baseline tests. Appendix E contains a listing of these support documents.

1.4. Preliminary and Baseline Testing

The foundation for the specific test protocols and airborne emission baselines has been determined from testing performed to:

- Establish the required number of samples needed to statistically support the evaluation of emission reduction potentials of the alternative materials, equipment, and processes that may be evaluated;

- Provide a series of baseline emissions from standard mold and core packages.

It has been determined that nine replicate tests will provide a statistically significant sample for the purposes of evaluating the emission reductions from alternative materials, equipment, and processes. The results of the testing conducted in support of this conclusion is included in a report entitled Evaluation of the Required Number of Replicate Tests to Provide Statistically Significant Air Emission Reduction Comparisons for the CERP Pre-production Foundry Test Program.

The detailed results of the Pre-production Foundry emission baseline tests are provided in a test report entitled Baseline Testing Emission Results, Pre-production Foundry. Baseline testing was performed for four separate scenarios including:

- A "Background Baseline" using new Bridgeman ILSW lake sand, clay, and water mold with no known organic components. The cores were J.B. DeVeene Kleencast #1 organic-free sodium silicate cores made with Bridgeman ILSW lake sand.

- A "Greensand Baseline" using CERP System Sand with H&G seacoal. The cores were J.B. DeVeene Kleencast #1 organic-free sodium silicate cores made with Bridgeman ILSW lake sand.

- A "Core Baseline" using new Bridgeman ILSW lake sand, clay, and water mold. The cores were Ashland Chemical Company ISOCURE® LF305/904GR cores (1.75% resin BOS) made with Bridgeman ILSW lake sand.

- A "Core/Greensand Baseline" using CERP System Sand with H&G seacoal. The cores were Ashland Chemical Company ISOCURE® LF305/904GR cores (1.75 % resin BOS) made with Bridgeman ILW lake sand.

Appendices C and D of this report contain result summaries of the "Core Baseline" test (Test Plan Identification AP). The results of the AW Test Plan are compared against the "Core Baseline" to evaluate the emission reduction potential of the test material.

Baseline testing was also performed to determine the extent to which emissions are also into virgin mold materials. These tests were performed to determine the number of casting/sand reconditioning cycles required before a stable emission output was achieved. These tests demonstrated that emissions from the Pre-production Foundry test arena are not overly affected by the number of reconditioning cycles. All test series data, including baseline tests, had similar slight reductions in measured emissions escaping from the first three molds. Since all test groups showed similar reductions, the same bias is applied to each nine-mold series. The detailed results of this testing are contained in a report entitled Baseline Test of Absorption by Bentonite Clays, Sand and Seacoal Using Coldbox Cores: Test Plan Identification: AH.

1.5. Specific Test Plan and Objectives

This report contains the results of testing performed to assess the emission reduction potential of a core binder replacement. The test hypothesis is that the core binder replacement will show a significant reduction in organic HAP emissions as compared with the "Core Baseline". The Test Plan AW results were compared with the "Core Baseline" to determine the percentage reductions from the core binder replacement. 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 AW
Type of Material Tested	Core Binder
Test Plan Number	CERP# RV100024AW
Mold Type	Hand Rammed Greensand
Core Type	Organic Free Sodium Silicate
Casting Type	Eight-Cavity Bottom Feed AFS Step Block
Baseline Comparison	Core Binder
Number of Molds Poured	9
Test Dates	2-4 February 1999
Emissions Measured	70 Organic HAPs and VOCs
Process Parameters Measured	Total Casting, Mold and Core Weights, Metallurgical Data, Mold and Core Component Weights, % LOI (mold and core), % Clay, Stack Temperature, Stack Moisture Content, Stack Pressure, and Stack Volumetric Flow Rate

2.0 TEST METHODOLOGY

2.1. Description of Process and Testing Equipment

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

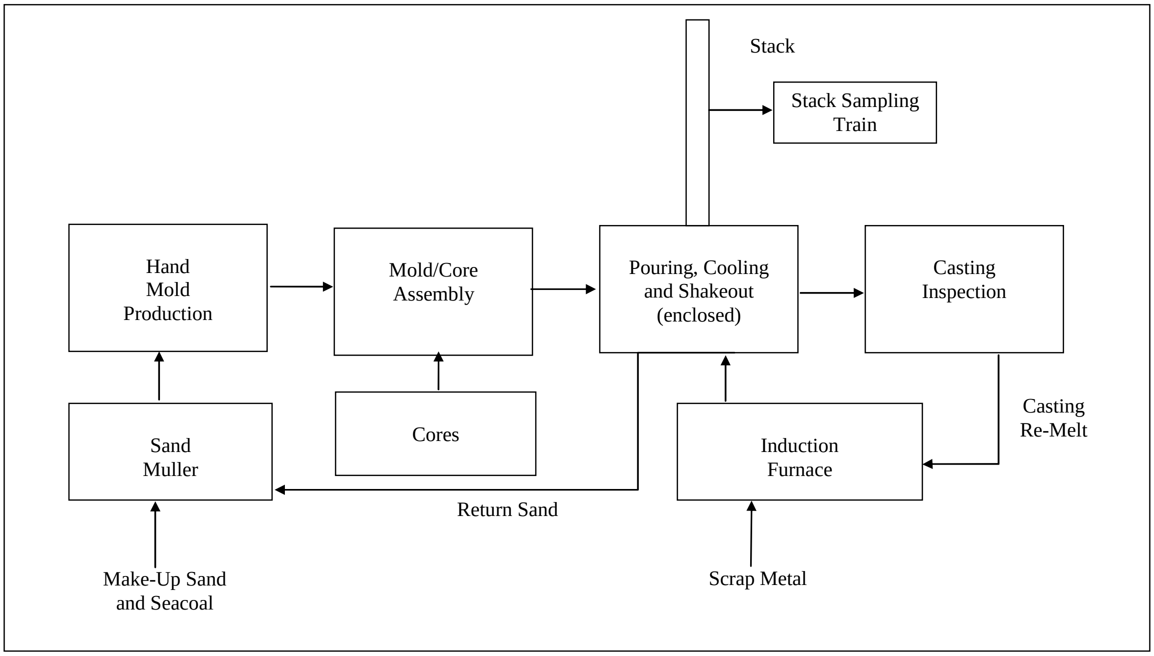


Figure 2-1 Pre-production Foundry Layout Diagram.

2.2. Description of Testing Program

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

1. **<u>Test Plan Review and Approval:</u>** The supplier/manufacturer seeking an evaluation in the Pre-production Foundry must provide information regarding the specific nature of the alternative material, equipment, or process change along with evidence to support the potential for emissions reductions, maintenance of casting quality, and economic and commercial viability. The "Foundry Product Testing Guide" provides specific details supplied by the manufacturer or supplier for Test Plan AW**.** The proposed test plan is reviewed by the Facilities and Process Team and the Emissions Measurements Team and approved by the respective Team Chairmen.

2. **Mold, Core and Metal Preparation:** The molds and cores are prepared to a standard composition by the CERP production team. The cores are made either by hand (if sodium silicate) or blown by a Redford core blower, and relevant process data are collected. If new core processes are being tested, the cores are placed in new lake sand/clay/water molds. If new mold binder systems or processes are being evaluated, organic free sodium silicate step cores are placed into the molds.

   Iron is melted in a 1000 lb. Ajax induction furnace (Model MFB-1000). The amount of metal melted is determined from the poured weight of the casting and the number of molds to be poured. The metal composition is prescribed by a metal composition worksheet. The weight of metal poured into each mold is recorded on the process data summary sheet.

Setting of Step Cores in Mold

3. **Individual Sampling Events:** Replicate tests are performed on nine mold/core packages. The mold/core packages are placed into an enclosed test stand. Iron is poured through an opening in the top of the enclosure. The opening is closed as soon as pouring is completed. Continuous air samples are collected during the forty-five minute pouring and cooling process, during the fifteen minute shakeout of the mold, and for an additional fifteen minute period following shakeout. The total sampling time is seventy-five minutes.

Pouring of Step Core Molds Through Opening in Collection Hood

   The finished castings are cleaned and quality checks of the castings are performed. Additional tests may be required for new mold materials with the molding sand being recycled into new molds to evaluate the long-term effects on molding sand properties.

Castings on the Shake out Deck

The weights of the molds, cores, seacoal additions, and binder are recorded for each mold on the Process Data Summary Sheet. In addition, the pouring temperature, number of cavities poured, the %LOI and the % clays of the mold before pouring and at shakeout, and the % LOI of the core are recorded on the Process Data Summary Sheet.

The unheated emission hood is ventilated at approximately 800 SCFM through a 12-inch diameter heated duct. Emissions samples are drawn from a sampling port located to ensure conformance with EPA Method 1. The tip of the probe is located in the centroid of the duct. The samples are collected at a constant rate in adsorption tubes (test sample and duplicate sample).

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
Core Weight	Mettler PJ8000 Digital Scale (Gravimetric)
Mold Weight	Acme 4260 Crane Scale (Gravimetric)
Casting Weight	Westweigh PP2847 Platform Scale (Gravimetric)
Seacoal Weight	Toledo PAC-DPC-606050 balance (Gravimetric)
Binder Weight	Mettler PJ8000 Digital Scale (Gravimetric)
LOI, % at mold and shakeout	Mettler Pb302 Scale (AFS procedure 212-87-S)
Core LOI, %	Denver Instruments XE-100 Analytical Scale (AFS procedure 321-87-S)
Clay, % at mold and shakeout	Dietert 535A MB Clay Tester (AFS Procedure 210-89-S)
Metallurgical Parameters	
Pouring Temperature	Electro-Nite DT 260 (T/C immersion pyrometer)
Carbon/Silicon	Electro-Nite DataCast 2000 (Thermal Arrest)
Alloy Weights	Mettler PJ8000 (Gravimetric)
Mold Compactability	Dietert 319A Sand Squeezer (AFS procedure 221-87-S)

5. **Air Emissions Analysis:** The specific sampling and analytical methods used in the Pre-production Foundry 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
HAPs concentration	EPA Method 18, TO11*
VOCs analysis	EPA Method 18, TO11*

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

6. **<u>Data Reduction. Tabulation and Preliminary Report Preparation:</u>** The analytical results of the emissions tests provide the mass of each analyte in the sample. The total mass of the analyte emitted is calculated by multiplying the mass of analyte in the sample times the ratio of total stack gas volume to sample volume. The total stack gas volume is calculated from the measured stack gas velocity and duct diameter, and corrected to dry standard conditions using the measured stack pressures, temperatures, gas molecular weight, and moisture content. The total mass of analyte is then divided by the weight of the casting poured to provide emissions data in pounds of analyte per ton of metal. The specific calculation formulas are included in the CERP Standard Operating Procedures.

   The results of duplicate samples for individual sampling events are averaged to provide the results for each analyte for each sampling event. The results of each of the sampling events are included in Section 3 of this report. The results of the nine sampling events are also averaged and are compared against the average results from the appropriate baseline test. The results of this test series and the baseline test series are compared using a standard statistical T-test to verify the statistical validity of the overall conclusions of this report. The calculated T statistic, Ts, is compared against a table value. The table value is a function of the sample size and the level of confidence desired. For tests with nine sample values each, the T value associated with a confidence level of 95% is 2.12. Calculated values of Ts greater than or equal to this value indicate that there is 95% or better probability that the differences between the two test series are not the result of test variability.

7. **<u>Report Preparation and Review:</u>** The Preliminary Draft Report is reviewed by the Process Supervisor and the Research Manager to ensure its completeness, consistency with the test 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 Research Manager, the Operations Manager and the Program Manager. Comments are incorporated into a Final Report that is circulated for signatures and then distributed.

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 <u>CERP Standard Operating Procedures</u>. 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 baseline test, specific process parameters are reviewed by the Process Supervisor to ensure that the parameters are maintained within the prescribed control ranges. Where data are not within the prescribed ranges, the Process Supervisor and the Operations Manager determine whether the individual test samples should be invalidated or flagged for further analysis following review of the laboratory data.

- The 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 Research Manger and Operations Manager determine whether individual sample data should be invalidated, and any invalidated data are rejected from the database.

3.0 TEST RESULTS

The air emission results in pounds per ton of metal poured are presented in Table 3-1. Table 3-1 includes the organic HAP compounds that comprise at least 95% of the total HAPS measured along with specific organic compounds of concern. Appendix B contains the detailed data including the results for all analytes measured. Table 3-2 presents the measured process and stack data for each of the sample tests.

Table 3-3 presents the average emission test results along with the average test results for the comparable baseline test. The percentage change from the baseline and the calculated T statistic (Ts) are also presented. Table 3-4 includes averages of the key process and stack parameters, the percent change from the baseline, and the data target ranges. Figure 3-1 presents the individual HAP emission data from Table 3-1 in graphic form.

Table 3-1 Test Plan AW Selected Test Results (Top 95%by Mass)

TEST NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
DATE POURED	2/2/99	2/2/99	2/2/99	2/3/99	2/3/99	2/3/99	2/4/99	2/4/99	2/4/99		
Emissions Data Lbs./Ton of Metal											
SUM of VOCs	0.2036	0.2150	0.2291	0.1902	0.2339	0.2419	0.1839	0.2163	0.2049	0.2132	0.0065
SUM of HAPs	0.1907	0.1933	0.1929	0.1672	0.2051	0.2000	0.1697	0.1884	0.1762	0.1871	0.0044
THC ref. To Undecane	0.2313	0.3156	0.3897	0.3367	0.3491	0.3905	0.2567	0.2944	0.3575	0.3246	0.0185
Individual Organic HAPs											
Aniline	0.1105	0.0853	0.0806	0.0658	0.0958	0.0769	0.0724	0.0900	0.0650	0.0825	0.0049
Benzene	0.0495	0.0672	0.0675	0.0679	0.0661	0.0688	0.0574	0.0546	0.0612	0.0622	0.0023
Toluene	0.0125	0.0177	0.0166	0.0186	0.0170	0.0208	0.0143	0.0162	0.0185	0.0169	0.0008
Acetaldehyde	0.0053	0.0069	0.0076	I	0.0065	0.0066	0.0054	0.0068	0.0064	0.0064	0.0003
m,p-Xylene	0.0033	0.0046	0.0061	0.0049	0.0054	0.0065	0.0043	0.0053	0.0061	0.0052	0.0003
Naphthalene	0.0022	0.0033	0.0043	0.0031	0.0040	0.0052	0.0022	0.0033	0.0042	0.0035	0.0003
MEK/Butyraldehyde	0.0025	0.0023	0.0019	I	0.0026	0.0023	0.0034	0.0029	0.0039	0.0027	0.0002
Propionaldehyde	0.0006	0.0006	0.0016	I	0.0012	0.0019	0.0015	0.0013	0.0016	0.0013	0.0002
o-Xylene	0.0008	0.0010	0.0015	0.0012	0.0013	0.0016	0.0009	0.0012	0.0014	0.0012	0.0001
2-Methylnaphthalene	0.0010	0.0012	0.0011	0.0011	0.0013	0.0016	0.0010	0.0010	0.0012	0.0012	0.0001
Styrene	0.0008	0.0012	0.0014	0.0010	0.0013	0.0014	0.0008	0.0011	0.0013	0.0011	0.0001
Ethylbenzene	0.0007	0.0009	0.0012	0.0011	0.0011	0.0013	0.0010	0.0012	0.0014	0.0011	0.0001
o-Cresol/Indan	ND	ND	ND	ND	ND	0.0032	ND	0.0022	0.0017	0.0008	0.0004
Phenol/3-Ethyltoluene	ND	ND	ND	0.0019	ND	ND	0.0036	ND	0.0007	0.0007	0.0004
1-Methylnaphthalene	0.0005	0.0006	0.0006	0.0006	0.0007	0.0009	0.0006	0.0006	0.0007	0.0006	0.0000
Formaldehyde	0.0005	0.0006	0.0006	I	0.0006	0.0007	0.0006	0.0006	0.0007	0.0006	0.0000
Hexaldehyde	ND	ND	0.0003	I	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0000
1,2-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,5-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Table 3-1 Test Plan AW Selected Test Results (Top 95% by Mass)

TEST NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
DATE POURED	2/2/99	2/2/99	2/2/99	2/3/99	2/3/99	2/3/99	2/4/99	2/4/99	2/4/99		
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cumene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
p-cymene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
M,p-Cresol/Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Other Organic Compounds of Concern											
4-Ethyltoluene	0.0033	0.0066	0.0098	0.0060	0.0102	0.0175	0.0067	0.0115	0.0072	0.0088	0.0014
Decane	0.0045	0.0077	0.0110	0.0088	0.0071	0.0100	ND	0.0056	0.0099	0.0072	0.0011
Undecane	0.0013	0.0020	0.0034	0.0020	0.0030	0.0037	0.0013	0.0021	0.0019	0.0023	0.0003
Octane	ND	ND	0.0030	0.0027	0.0025	0.0032	0.0024	0.0028	0.0031	0.0022	0.0004
1,2,4-Trimethylbenzene	0.0007	0.0011	0.0016	0.0010	0.0015	0.0019	0.0005	0.0013	0.0016	0.0012	0.0002
Hexane	0.0005	0.0007	0.0029	0.0009	0.0007	0.0015	0.0006	0.0009	0.0010	0.0011	0.0002
1,3,5-Trimethylbenzene	0.0005	0.0009	0.0014	0.0008	0.0012	0.0014	0.0007	0.0011	0.0013	0.0010	0.0001
Benzaldehyde	0.0009	0.0010	0.0009	I	0.0010	0.0010	0.0005	0.0009	0.0009	0.0009	0.0001
1,2,3-Trimethylbenzene	0.0002	0.0005	0.0007	0.0005	0.0006	0.0008	0.0003	0.0005	0.0006	0.0005	0.0001
2-Ethyltoluene	0.0003	0.0004	0.0007	0.0003	0.0005	0.0004	0.0003	0.0005	0.0005	0.0004	0.0000
Pentanal	ND	ND	0.0005	I	0.0004	0.0005	0.0004	0.0006	0.0005	0.0004	0.0001
4-Methyl-2-pentanone	0.0005	0.0009	0.0003	ND	ND	0.0002	0.0004	ND	0.0003	0.0003	0.0001
1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Table 3-1 Test Plan AW Selected Test Results (Top 95% by Mass)

TEST NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
DATE POURED	2/2/99	2/2/99	2/2/99	2/3/99	2/3/99	2/3/99	2/4/99	2/4/99	2/4/99		
Isobutylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Tridecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methacrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
sec-Butylbenzene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NA	NA
tert-Butylbenzene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NA	NA
Acetone	0.0052	0.0056	0.0061	I	0.0113	0.0078	0.0085	0.0147	0.0118	0.0089	0.0011

I: Data was rejected based on data validation considerations.
Acetone is not included in the sum of VOCs.
ND: Not detected.
NT: No Test
NA: Not Applicable

Table 3-2 Process and Stack Data for Test Series AW

Test Number / Pour Date	AW001 2/2/99	AW002 2/2/99	AW003 2/2/99	AW004 2/3/99	AW005 2/3/99	AW006 2/3/99	AW007 2/4/99	AW008 2/4/99	AW009 2/4/99	SERIES AVERAGE
Process Data										
Casting Metal Weight, lbs.	245	247	258	269	267	248	241	242	251	252
Total Mold Weight, lbs.	1466	1476	1456	1466	1436	1456	1436	1476	1456	1458
Total Core Weight, lbs.	64.19	63.18	63.95	63.98	64.08	63.98	64.32	64.24	64.25	64.02
Compactability, %	50	49	48	45	48	45	44	47	45	47
Total Binder Weight, lbs	1.104	1.078	1.081	1.088	1.102	1.100	1.106	1.105	1.105	1.10
No. Cavities Poured	8	8	8	8	8	8	8	8	8	8
LOI, % (at mold)	0.63	0.63	0.67	0.67	0.70	0.60	0.83	0.77	0.83	0.70
LOI, % (at shakeout)	0.60	0.60	0.67	0.67	0.67	0.67	0.76	0.67	0.80	0.68
Clays, % (at mold)	6.12	6.12	6.91	6.65	6.78	7.18	7.58	7.18	7.58	6.90
Clays, % (at shakeout)	5.19	5.05	5.72	5.98	5.72	5.72	6.12	5.72	7.45	5.85
LOI, % (Cores)	1.68	1.72	2.12	1.67	1.64	1.91	1.94	1.98	2.38	1.89
Volatiles, % (at mold) avg.	0.21	0.22	0.27	0.29	0.25	0.34	0.37	0.33	0.39	0.30
Volatiles, % (at shakeout) avg.	0.23	0.25	0.28	0.31	0.25	0.32	0.35	0.29	0.31	0.29
Pouring Temperature, °F	2640	2640	2640	2640	2637	2631	2640	2636	2636	2638
Stack Data										
Average Stack Temperature, °F	118	127	133	115	129	126	130	126	129	126
Total Moisture Content, %	1.4	1.4	1.8	1.6	1.4	1.6	0.5	1.6	1.4	1.4
Average Stack Velocity, ft./sec.	17.54	20.98	21.35	20.30	20.54	20.49	17.77	17.79	17.85	19.40
Avg. Stack Pressure, in. Hg	30.40	30.43	30.43	30.13	30.12	30.12	30.12	29.96	29.92	30.18
Stack Flow Rate, scfm	756	892	895	870	861	862	751	745	743	819

Table 3-3 Test Plan AW and "Core Baseline" Test Average Results

	Average of "Core Baseline"	Average of Test Series AW	% Change From Baseline	T Statistic, Ts*
Sum of VOCs	0.4708	0.2132	-55%	13.41
Sum of HAPs	0.3161	0.1871	-41%	11.95
THC ref. to Undecane	0.9374	0.3246	-65%	29.08
Individual HAPs				
Benzene	0.1390	0.0622	-55%	34.16
Aniline	0.0916	0.0825	-10%	5.07
Toluene	0.0324	0.0169	-48%	23.55
Naphthalene	0.0226	0.0035	-84%	15.44
Phenol/3-Ethyltoluene	0.0137 (a)	0.0007 (a)	-95%	18.15
m,p-Xylene	0.0130	0.0052	-60%	27.09
2-Methylnaphthalene	0.0115	0.0012	-90%	15.71
Acetaldehyde	0.0060	0.0064	7%	-4.40
1-Methylnaphthalene	0.0052	0.0006	-88%	15.96
o-Cresol/Indan	0.0052 (b)	0.0008 (b)	-85%	10.11
Propylbenzene	0.0041	ND	-100%	15.95
o-Xylene	0.0033	0.0012	-63%	22.88
Styrene	0.0016	0.0011	-30%	12.92
Ethyl Benzene	0.0015	0.0011	-30%	11.85
MEK/Butyraldehyde	0.0009 (c)	0.0027 (c)	203%	-24.61
Propionaldehyde	0.0008	0.0013	52%	-8.29
Formaldehyde	0.0008	0.0006	-24%	9.08
Hexaldehyde	ND	0.0002	NA	NA
1,3-Dimethylnaphthalene	0.0008	ND	-100%	11.89
Organic Compounds of Concern				
1,2,4-Trimethylbenzene	0.0387	0.0012	-97%	32.33
Undecane	0.0151	0.0023	-85%	31.09
1,2,3-Trimethylbenzene	0.0129	0.0005	-96%	31.61
1,3,5-Trimethylbenzene	0.0108	0.0010	-91%	30.89
2-Ethyltoluene	0.0087	0.0004	-95%	28.18
4-Ethyltoluene	0.0074	0.0088	18%	-2.37
1,4-Diethylbenzene	0.0062	ND	-100%	14.53
Dodecane	0.0049	ND	-100%	26.64
2,6-Dimethylphenol	0.0033	ND	-100%	14.63
Decane	0.0020	0.0072	253%	-12.30
1,3-Diethylbenzene	0.0017	ND	-100%	14.96
Heptane	0.0017	ND	-100%	15.62
Hexane	0.0011	0.0011	0%	-0.04
Tridecane	0.0011	ND	-100%	4.86
Indene	0.0010	ND	-100%	9.38
Benzaldehyde	0.0001	0.0009	667%	-14.67
Methacrolein	0.0001	ND	-100%	5.36
Octane	ND	0.0022	NA	NA
Pentanal	ND	0.0004	NA	NA
4-Methyl-2-pentanone	ND	0.0003	NA	NA

ND: Not detected.
NA: Not Applicable
(a) Phenol and 3-Ethyltoluene coeluted in both the Core Baseline (AP) Test and Test AW.
(b) o-Cresol and Indan coeluted in both the Core Baseline (AP) and Test AW.
(c) MEK and Butyraldehyde coeluted in both the Core Baseline (AP) and Test AW
*** Where Ts is greater than 2.12, the probability is greater than 95% that the differences between the two test series are not a result of**

Table 3-4 Test Plan AW and "Core Baseline" (AP) Test Average Results

Average Process and Stack Parameters				
Average Process and Stack Parameters	**Core Baseline Average - AP**	**Average of Test AW**	**% Difference**	**Target Range**
Casting Metal Weight, lbs.	259	252	-2.7	230-250
Total Mold Weight, lbs.	1403	1458	3.9	1300-1400
Total Core Weight, lbs.	63.40	64.02	1.0	62-64
Compactability, % avg.	48	47	-2.1	48-51
Total Binder Weight, lbs	1.09	1.10	0.9	1.07-1.11
LOI, % (at mold)	0.66	0.70	6.1	0.50-0.80
LOI, % (at shakeout)	0.72	0.68	-5.6	None
Clays, % (at mold)	5.54	6.90	24.5	6.5-7.5
Clays, % (at shakeout)	5.49	5.85	6.6	None
LOI, % (Cores)	1.60	1.89	18.1	1.50-1.60
Volatiles, % (at mold) avg.	ND	0.30	ND	0.10-0.20
Volatiles, % (at shakeout) avg.	ND	0.29	ND	None
Pouring Temperature, °F	2632	2638	0.2	2630+/- 10
Stack Data				
Average Stack Temperature, °F	135	126	-6.7	120 ± 20
Total Moisture Content, %	2.6	1.4	-46.2	0-4
Average Stack Velocity, ft./sec.	17.77	19.40	9.20	17± 20
Avg. Stack Pressure, in. Hg	30	30.18	0.6	29.92 ± 1
Stack Flow Rate, scfm	726	819	12.3	700-800

Figure 3-1 Comparison of HAP Emissions from Test Series AW and "Core" Baseline AP

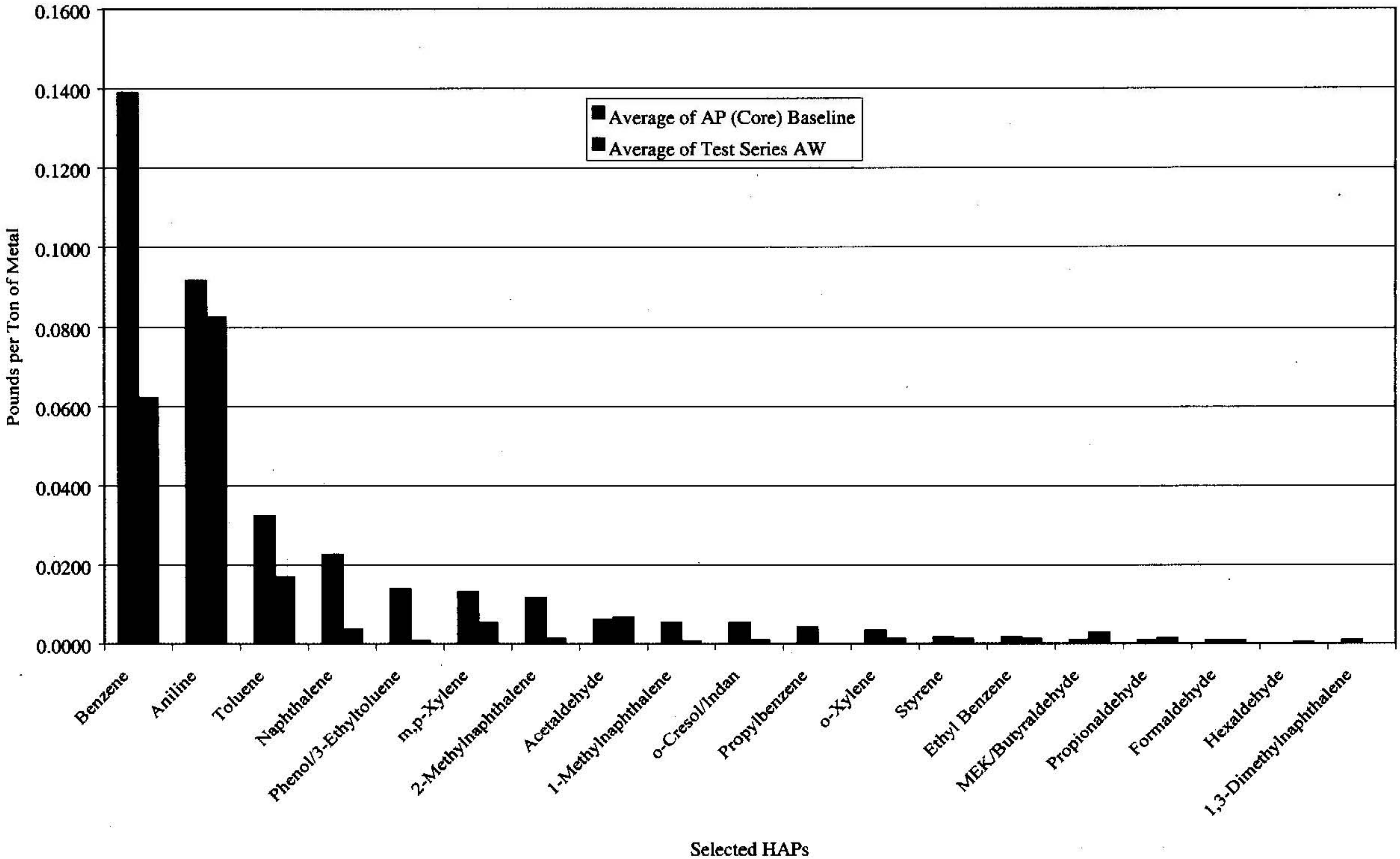
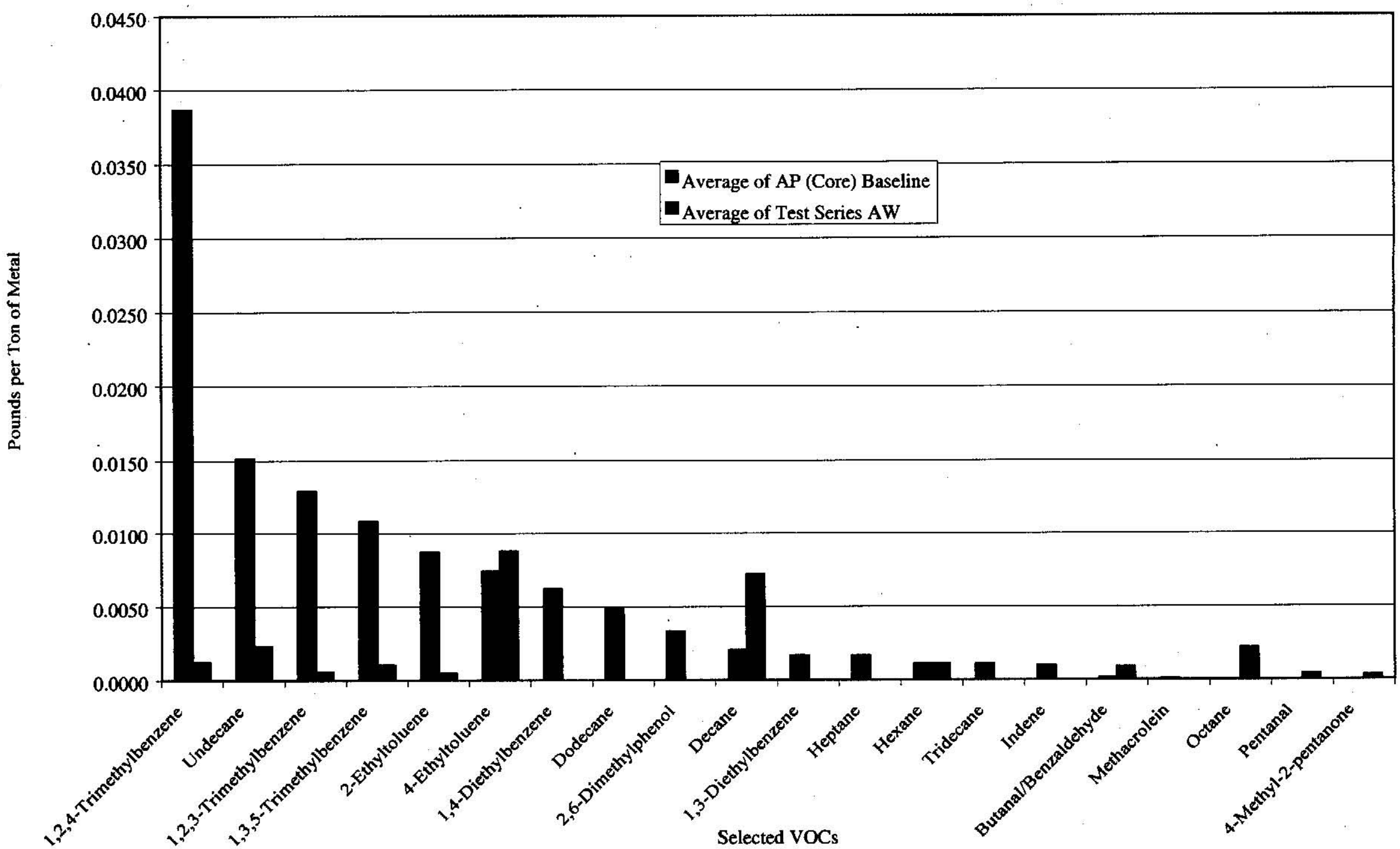


Figure 3-2 Comparison of VOC Emissions from Test Series AW and "Core" Baseline AP



4.0 DISCUSSION OF RESULTS AND CONCLUSIONS

The sampling and analytical methodologies were the same for the Test Plan AW and the "Core Baseline". Observation of measured process parameters indicates that the tests were run within an acceptable range. The T statistic, calculated for the AW and baseline test series, showed that there is a greater than 95% probability that the differences in the average values for Total Organic HAPs and Total VOC were not the result of test variability.

The results of the tests associated with this test plan showed a 41% reduction in total HAPS. Similar levels of reductions were achieved for most of the other HAPS measured including a 55% reduction in benzene as compared with the "Core Baseline" tests. The sum of VOCs measured showed a 54% reduction, and total hydrocarbon (in reference to undecane) was reduced 65%.

Assessment of the economic and commercial viability of this product is a function of Production Foundry testing. Inclusion of this product in the Production Foundry program is subject to review by the CERP Steering Committee.

APPENDIX A:

APPROVED TEST

PLAN FOR TEST

SERIES AW

CERP TEST PLAN

- **CONTROL NUMBER: RV 1 00021**
- **SAMPLE FAMILY: AW**
- **SAMPLE EVENTS: 001 thru 009**
- **SITE: X PRE-PRODUCTION(243) ____ CERP FOUNDRY(238)**
- **TEST TYPE: Vendor Core Resin Replacement Product Test**
- **MOLD TYPE: Virgin Sands and Clays with no Seacoal**
- **NUMBER OF MOLDS: 9**
- **CORE TYPE: Lodi Produced Delta-HA Step, Block Cores**

TEST DATE: START: 02 FEB 99
FINISH: 04 FEB 99

TEST OBJECTIVES:
Primary: To determine the emissions from a low emission Delta-HA resin bonded step block cores in a mold with no identified organic material in the molding sand. The statistical validity will be based on nine sampling events (molds).

VARIABLES:
All mold materials will be made using virgin materials, i.e. sand, Southern Bentonite, Western Bentonite. The cores are step block cores made by Lodi Iron Works using Wedron 420 sand and 1.75% Delta-HA Technicure 24-702123-302 resin in a 57 I43 % ratio and DMEA catalyzed.

BRIEF OVERVIEW:
This experiment is to compare emissions from the Delta-HA Technicure 24-702123-302 resin to the baseline service AJ (organic core baseline). The mold materials used are made with "virgin" materials that are deemed to be organic free. There is no seacoal used in these molds.

SPECIAL CONDITIONS:
None.

Senior Process Engineer	Date
Operations Manager	Date
Emissions Team (USCAR)	Date
Process and Facilities Team (USCAR)	Date
Project Manager	Date

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/2/99									
POUR 1									
AIRSENSE	AW00101	X							
ENERAC	AW00102	X							
M-18	AW00103		1						15
M-18	AW00104			1					15
M-18	AW00105				1				0
TO11	AW00106		1						500
TO11	AW00107				1				0
OSHA 42	AW00108		1						750
OSHA 42	AW00109				1				0
NIOSH 2002	AW00110		1						350
NIOSH 2002	AW00111				1				0
2010 NIOSH	AW00112		1						350
2010 NIOSH	AW00113				1				0

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/2/99									
POUR 2									
AIRSENSE	AW00201	X							
ENERAC	AW00202	X							
M-18	AW00203		1						15
M-18	AW00204			1					15
M-18	AW00205					1			15
M-18	AW00206						1		
M-18	AW00207							X	
TO11	AW00208		1						500
TO11	AW00209						1		
TO11	AW00210							X	
OSHA 42	AW00211		1						750
NIOSH 2002	AW00212		1						350
2010 NIOSH	AW00213		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/2/99									
POUR 3									
AIRSENSE	AW00301	X							
ENERAC	AW00302	X							
M-18	AW00303		1						15
M-18	AW00304			1					15
TO11	AW00305		1						500
OSHA 42	AW00306		1						750
NIOSH 2002	AW00307		1						350
2010 NIOSH	AW00308		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/3/99									
POUR 4									
AIRSENSE	AW00401	X							
ENERAC	AW00402	X							
M-18	AW00403		1						15
M-18	AW00404			1					15
TO11	AW00405		1						500
OSHA 42	AW00406		1						750
NIOSH 2002	AW00407		1						350
2010 NIOSH	AW00408		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/3/99									
POUR 5									
AIRSENSE	AW00501	X							
ENERAC	AW00502	X							
M-18	AW00503		1						15
M-18	AW00504			1					15
TO11	AW00505		1						500
OSHA 42	AW00506		1						750
NIOSH 2002	AW00507		1						350
2010 NIOSH	AW00508		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/3/99									
POUR 6									
AIRSENSE	AW00601	X							
ENERAC	AW00602	X							
M-18	AW00603		1						15
M-18	AW00604			1					15
TO11	AW00605		1						500
OSHA 42	AW00606		1						750
NIOSH 2002	AW00607		1						350
2010 NIOSH	AW00608		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/4/99	[redacted]								
POUR 7									
AIRSENSE									
ENERAC									
M-18									15
M-18	AW00704			1					15
TO11	AW00705		1						500
OSHA 42	AW00706		1						750
NIOSH 2002	AW00707		1						350
2010 NIOSH	AW00708		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/4/99									
POUR 8									
AIRSENSE	AW00801	X							
ENERAC	AW00802	X							
M-18	AW00803		1						15
M-18	AW00804			1					15
M-18	AW00805						1		
M-18	AW00806							X	
TO11	AW00807		1						500
TO11	AW00808						1		
TO11	AW00809							X	
OSHA 42	AW00810		1						750
NIOSH 2002	AW00811		1						350
2010 NIOSH	AW00812		1						350

Pre Production - AW Series Sample Test Plan

Method	Sample #	Data	Sample	Duplicate	Blank	Spike	Spike Amount	Flow (sccm)	Comments
2/4/99									
POUR 9									
AIRSENSE	AW00901	X							
ENERAC	AW00902	X							
M-18	AW00903		1						15
M-18	AW00904			1					15
M-18 by MS	AW00905		1						15
TO11	AW00906		1						500
OSHA 42	AW00907		1						750
NIOSH 2002	AW00908		1						350

Pre-Production Process Instructions

A. Experiment: Delta-HA Technicure 24-702123-302 Organic Core Resin.
  1. Mold sand: Virgin Lake sand, Western and Southern Bentonite clay, and water. No Seacoal is to be used.
  2. Core: Eight step cores made from virgin Wedron 420 sand and 1.75% Delta-HA Technicure binder part I(24-702) 57 %, part I1 (23-302) 43 %, gassed with DMEA.
  3. Metal: Class-35 Gray cast iron.

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

B. Cores:
  1. Cores to be supplied by Lodi Iron Works.
  2. The sand lab will sample one (1) core from each 10-core box of cores just prior to the emission test to represent the eight cores placed in each mold. Those cores will be tested for LO1 using the standard core MI test method and reported out associated with the test mold it is to represent.

C. Sand preparation
  1. Start up batches: make 2; AW001, AW002.
    a. Thoroughly clean the pre-production muller.
    b. Add a pre-weighed quantity of lake sand (50 GFN) and Okie #1 sand (90 GFN) per the new mixture recipe, approximately 1500 pounds total to the running pre-production muller.
    c. Add 5 pounds of potable water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
    d. Add the clays per the new mixture recipe slowly to the muller to allow them to be distributed throughout the sand mass.
    e. Dry mull for about 3 minutes to allow distribution and some grinding of the clays to occur.
    f. Split the batch into approximately equal sized portions.
    g. To each half-batch temper the sand-clay mixture slowly with water to allow for distribution.
    h. After about 2 gallons of water have been added allow 30 seconds of mixing then start taking compactability test samples.
    i. Based on each test add water incrementally to adjust the temper. Allow 1 minute of mixing. Retest. Repeat until the compactability is in the range 45- 51%.
    j. Discharge the sand into the mold half.
    k. Record the total sand mixed in the combined batch, the total of each type of clay added to the combined batch, the amount of water added to each half batch, the total

mix time on each half batch, the final compactability and sand temperature at discharge on each half batch.

2. Re-mulling: make 7; AW003-AW009.
  a. Add all the sand from the previous mold to the muller.
  b. Add 5 pounds of potable water to the muller to suppress dust distributing it across the sand. Allow to mix for 1 minute.
  c. Add the clays per the re-bond recipe slowly to the muller to allow them to be distributed throughout the sand mass.
  d. Follow the above procedure beginning at C.1.e.

3. The sand lab will sample the mold sand from each mold as it is being made and from the shaken out sand after it has been re-blended but before the additions are made. The three (3) "MOLD samples will be taken from the initial muller discharge into the drag, from the last sand into the drag, and the last sand into the cope. The three (3) "SHAKEOUT samples will be taken from within the muller at three locations approximately 120 degrees apart. The sand will be tested for LOI,900 OF Volatiles, MB clay, compactability, and moisture content and reported associated with the mold (test number, ATOOx) from which it was taken.

D. Molding: Step block pattern.
1. Pattern preparation:
  a. Inspect and tighten all loose pattern and gating pieces.
  b. Repair any damaged pattern or gating parts.

2. Making the green sand mold.
  a. Lightly rub parting oil from a damp oil rag on the pattern particularly in the corners and recesses.

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

  b. Place 4 inches of loose sand on the pattern and ram all pockets and the perimeter tightly using only vertical strokes. Caution: non- vertical ramming strokes will move blocks of compacted sand leaving voids which may cause the mold to fail. Do not ram all the sand to form a parting plane surface or the mold can fail. Add sand in increments of 4-6 inches of loose sand ramming tightly around the pattern.
  c. When the rammed sand covers the pattern by 3 or more inches the sand can be rammed less tightly but still avoid lamination planes.
  d. Level off the cope and drag mold surfaces opposite the pattern to minimize metal splatter and allow the mold to be fully supported.
  e. Cut the pour basin smoothly to reduce the amount of sand prone to get washed down the sprue.
  f. Remove the pattern, inspect and blow out the mold, and set the cores in the drag. Verify that the cores are fully set in their prints. The step cores will be flush with the

parting line. If a piece of the mold is missing contact your supervision for a decision on the acceptability of the mold.

- **g.** Vent the cope with % vents according to the template.
- **h.** Close the mold straight being careful not to crush anything.
- **i.** Bolt the flask halves together and deliver the mold to the pouring area.

E. Emission hood:

1. Loading.

- **a.** Hoist the mold onto the shakeout deck within the emission hood.
- **b.** Close, seal, and lock the emission hood

2. Shakeout.

- **a.** After the cooling time prescribed in the emission test plan turn on the shakeout unit and run for the time prescribed in the emission test plan.
- **b.** Turn off the shakeout, open the hood, remove the flask with casting, and recover the sand from the pit.
- **c.** Weigh and record the closed unpoured mold weight, the core weight, cast metal weight, and the sand weight by difference.

F. Melting:

1. Initial charge:

- **a.** Charge the furnace according to the heat recipe.
- **b.** Place part of the steel scrap on the bottom, followed by carbon alloys, and the balance of the steel.
- **c.** Place a pig on top on top.
- **d.** Bring the furnace contents to the point of beginning to melt over a period of 1 hour at reduced power.
- **e.** Add the balance of the metallic under full power until all is melted and the temperature has reached 2600 to 2700°F.
- **f.** Slag the furnace and add the balance of the alloys.
- **g.** Raise the temperature of the melt to 2700 "F and take a DataCast 2000 sample. The temperature of the primary liquidus (TPL) must be in the range of 2200-2350°F.
- **h.** Hold the furnace at 2500-2550°F until near ready to tap.
- **i.** When ready to tap raise the temperature to 2700°F and slag the furnace.
- **j.** Record all metallic and alloy additions to the furnace, tap temperature, and pour temperature. Record all furnace activities with an associated time.

2. Back charging.

- **a.** Back charge the furnace according to the heat recipe,
- **b.** Charge a few pieces of steel first to make a splash barrier, followed by the carbon alloys.
- **c.** Follow the above steps beginning with F.1.e

3. Emptying the furnace.

- **a.** Pig the extra metal only after the last emission measurement is complete to avoid contaminating the air sample.

- **b.** Cover the empty furnace with ceramic blanket to cool.

G. Pouring:

1. Preheat the ladle.

- **a.** Tap 400 pounds more or less of 2700°F metal into the cold ladle.
- **b.** Casually pour the metal back to the furnace.
- **c.** Cover the ladle.
- **d.** Reheat the metal to 2780 +I- 20°F.
- **e.** Tap 450 pounds of iron into the ladle while pouring Inoculating alloys onto the metal stream near its base.
- **f.** Cover the ladle to conserve heat.
- **g.** Move the ladle to the pour position, open the emission hood pour door and wait until the metal temperature reaches 2630 +I- 10°F.
- **h.** Commence pouring keeping the sprue full.
- **i.** Upon completion close the hood door, return the extra metal to the furnace and cover the ladle.

Steven Knight
Sr. Process Engineer

APPENDIX B: TEST PLAN AW EMISSION TEST RESULTS

Appendix B: Test Plan AW Emission Test Results

HAP	COMPOUND / SAMPLE NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
	Pour Date	2/2/99	2/2/99	2/2/99	2/3/99	2/3/99	2/3/99	2/4/99	2/4/99	2/4/99		
	Sum of VOCs	0.2036	0.2150	0.2291	0.1902	0.2339	0.2419	0.1839	0.2163	0.2049	0.2132	0.0065
	Sum of HAPs	0.1907	0.1933	0.1929	0.1672	0.2051	0.2000	0.1697	0.1884	0.1762	0.1871	0.0044
	THC ref. to Undecane	0.2313	0.3156	0.3897	0.3367	0.3491	0.3905	0.2567	0.2944	0.3575	0.3246	0.0185
	Individual VOC's and HAP's											
*	Aniline	0.1105	0.0853	0.0806	0.0658	0.0958	0.0769	0.0724	0.0900	0.0650	0.0825	0.0049
*	Benzene	0.0495	0.0672	0.0675	0.0679	0.0661	0.0688	0.0574	0.0546	0.0612	0.0622	0.0023
*	Toluene	0.0125	0.0177	0.0166	0.0186	0.0170	0.0208	0.0143	0.0162	0.0185	0.0169	0.0008
*	Acetaldehyde	0.0053	0.0069	0.0076	I	0.0065	0.0066	0.0054	0.0068	0.0064	0.0064	0.0003
*	m,p-Xylene	0.0033	0.0046	0.0061	0.0049	0.0054	0.0065	0.0043	0.0053	0.0061	0.0052	0.0003
*	Naphthalene	0.0022	0.0033	0.0043	0.0031	0.0040	0.0052	0.0022	0.0033	0.0042	0.0035	0.0003
*	MEK/Butyraldehyde	0.0025	0.0023	0.0019	I	0.0026	0.0023	0.0034	0.0029	0.0039	0.0027	0.0002
*	Propionaldehyde	0.0006	0.0006	0.0016	I	0.0012	0.0019	0.0015	0.0013	0.0016	0.0013	0.0002
*	o-Xylene	0.0008	0.0010	0.0015	0.0012	0.0013	0.0016	0.0009	0.0012	0.0014	0.0012	0.0001
*	2-Methylnaphthalene	0.0010	0.0012	0.0011	0.0011	0.0013	0.0016	0.0010	0.0010	0.0012	0.0012	0.0001
*	Styrene	0.0008	0.0012	0.0014	0.0010	0.0013	0.0014	0.0008	0.0011	0.0013	0.0011	0.0001
*	Ethylbenzene	0.0007	0.0009	0.0012	0.0011	0.0011	0.0013	0.0010	0.0012	0.0014	0.0011	0.0001
*	o-Cresol/Indan	ND	ND	ND	ND	ND	0.0032	ND	0.0022	0.0017	0.0008	0.0004
*	Phenol/3-Ethyltoluene	ND	ND	ND	0.0019	ND	ND	0.0036	ND	0.0007	0.0007	0.0004
*	1-Methylnaphthalene	0.0005	0.0006	0.0006	0.0006	0.0007	0.0009	0.0006	0.0006	0.0007	0.0006	0.0000
*	Formaldehyde	0.0005	0.0006	0.0006	I	0.0006	0.0007	0.0006	0.0006	0.0007	0.0006	0.0000
*	Hexaldehyde	ND	ND	0.0003	I	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0000
*	1,2-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	1,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	1,5-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	2,3-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	2,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	2,7-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	Acenaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Appendix B: Test Plan AW Emission Test Results

HAP	COMPOUND / SAMPLE NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
*	Cumene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	p-Cymene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	M,p-Cresol/Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
*	Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	4-Ethyltoluene	0.0033	0.0066	0.0098	0.0060	0.0102	0.0175	0.0067	0.0115	0.0072	0.0088	0.0014
	Decane	0.0045	0.0077	0.0110	0.0088	0.0071	0.0100	ND	0.0056	0.0099	0.0072	0.0011
	Undecane	0.0013	0.0020	0.0034	0.0020	0.0030	0.0037	0.0013	0.0021	0.0019	0.0023	0.0003
	Octane	ND	ND	0.0030	0.0027	0.0025	0.0032	0.0024	0.0028	0.0031	0.0022	0.0004
	1,2,4-Trimethylbenzene	0.0007	0.0011	0.0016	0.0010	0.0015	0.0019	0.0005	0.0013	0.0016	0.0012	0.0002
	Hexane	0.0005	0.0007	0.0029	0.0009	0.0007	0.0015	0.0006	0.0009	0.0010	0.0011	0.0002
	1,3,5-Trimethylbenzene	0.0005	0.0009	0.0014	0.0008	0.0012	0.0014	0.0007	0.0011	0.0013	0.0010	0.0001
	Benzaldehyde	0.0009	0.0010	0.0009	I	0.0010	0.0010	0.0005	0.0009	0.0009	0.0009	0.0001
	1,2,3-Trimethylbenzene	0.0002	0.0005	0.0007	0.0005	0.0006	0.0008	0.0003	0.0005	0.0006	0.0005	0.0001
	2-Ethyltoluene	0.0003	0.0004	0.0007	0.0003	0.0005	0.0004	0.0003	0.0005	0.0005	0.0004	0.0000
	Pentanal	ND	ND	0.0005	I	0.0004	0.0005	0.0004	0.0006	0.0005	0.0004	0.0001
	4-Methyl-2-pentanone	0.0005	0.0009	0.0003	ND	ND	0.0002	0.0004	ND	0.0003	0.0003	0.0001
	1,2-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	1,3-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	1,3-Diisopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	1,4-Diethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	2,3,5-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	2,3-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	2,6-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	3,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Heptane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Indene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Isobutylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Nonane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA

Appendix B: Test Plan AW Emission Test Results

HAP	COMPOUND / SAMPLE NUMBER	AW001	AW002	AW003	AW004	AW005	AW006	AW007	AW008	AW009	AVERAGE	STDEV
	Tetradecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Tridecane	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Methacrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	m,p-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	sec-Butylbenzene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NA	NA
	tert-Butylbenzene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NA	NA
	Acetone	0.0052	0.0056	0.0061	I	0.0113	0.0078	0.0085	0.0147	0.0118	0.0089	0.0011

I: Data was rejected based on data validation considerations.
Acetone is not included in the sum of VOCs.
ND: Not detected.
NT: No Test
NA: Not Applicable

APPENDIX C:

AVERAGE "CORE BASELINE" PROCESS DATA

Appendix C: Average "Core Baseline" Process Data

	COMPOUND / SAMPLE NUMBER	Series Average
		Emissions Data, lbs./ton metal
	POUR DATE	20-22 Oct 98
	SUM of VOC's	0.4708
	SUM of HAP's	0.3161
HAPs	Individual VOC's and HAP's	
	1,2,3-Trimethylbenzene	1.29E-02
	1,2,4-Trimethylbenzene	3.86E-02
	1,3,5-Trimethylbenzene	1.08E-02
	1,3-Diethylbenzene	1.68E-03
X	1,3-Dimethylnaphthalene	8.08E-04
	1,4-Diethylbenzene	6.18E-03
X	1-Methylnaphthalene	5.21E-03
	2,6-Dimethylphenol	3.30E-03
	2-Ethyltoluene	8.68E-03
X	2-Methylnaphthalene	1.15E-02
	4-Ethyltoluene	7.39E-03
X	Acetaldehyde	6.00E-03
	Acetone	5.15E-03
	Aniline	9.17E-02
	Butanal/Benzaldehyde	1.15E-04
X	Benzene	1.39E-01
	Decane	2.03E-03
	Dodecane	4.89E-03
X	Ethyl Benzene	1.55E-03
X	Formaldehyde	8.16E-04
	Heptane	1.65E-03
	Hexane	1.08E-03
	Indene	9.70E-04
X	m,p-Xylene	1.30E-02
	MEK/Butryaldehyde	9.00E-04
	Methacrolein	5.18E-05
X	Naphthalene	2.26E-02
X	o-Cresol/Indan	5.20E-03
X	o-Xylene	3.26E-03
X	Phenol/3-Ethyltoluene	1.37E-02
X	Propionaldehyde	8.48E-04
	Propylbenzene	4.11E-03
X	Styrene	1.64E-03
X	Toluene	3.24E-02
	Tridecane	1.06E-03
	Undecane	1.51E-02

APPENDIX D: "CORE BASELINE" PROCESS DATA

Appendix D: Average "Core Baseline" Process

Process Data		
Casting Metal Weight	Lbs.	259
Total Mold Weight	Lbs.	1403
Total Core Weight	Lbs.	63.40
Compactability	%	48
Total Binder Weight	Lbs.	1.09
LOI, (at mold)	%	0.66
LOI, (at shakeout)	%	0.72
Clays, (at mold)	%	5.54
Clays, (at shakeout)	%	5.49
LOI, (Cores)	%	1.60
Volatiles, (at mold)	%	ND
Volatiles, (at shakeout)	%	ND
Pouring Temperature	°F	2632
Stack Data		
Average Stack Temperature	°F	135
Total Moisture Content	%	2.6
Average Stack Velocity	ft./sec.	17.77
Avg. Stack Pressure	in. Hg	30.00
Stack Flow Rate	scfm	726

APPENDIX E:

LISTING OF SUPPORT DOCUMENTS

Appendix E -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.

APPENDIX E:

VENDOR

CONFIDENTIALITY

AGREEMENT

Appendix E: Vendor Confidentiality Agreement

MODEL CONFIDENTIALITY AGREEMENT

The Casting Emission Reduction Program (hereinafter "Recipient"), which for the purposes of this agreement is comprised of Chrysler Corporation, Ford Motor Corporation, General Motors Corporation and the Sacramento Air Logistics Center, and (hereinafter "Discloser") agree to the following conditions under which certain valuable Proprietary Information and/or Products (as hereinafter defined) owned by Discloser will be provided to Recipient for the purpose of performing emission and process testing. The Recipient and Discloser mutually agree that:

1. "Proprietary information" shall mean information which Discloser shall furnish to Recipient in written or tangible form marked as "proprietary" or "confidential" and which relates to the subject matter of this Agreement. "Products" shall mean those products developed or provided by discloser. Information disclosed in non-written or non-tangible form and considered to be propriety must be reduced to written form, marked as indicated above and delivered to Recipient within thirty (30) days of the non-written or non-tangible disclosure in order to be considered Proprietary Information hereunder. Proprietary information and Products furnished and marked as described in this paragraph shall be considered proprietary and confidential and be subject to this Agreement, except if the Recipient can show the disclosed information and/or product:

a) is at the time of disclosure available to the general public as evidenced by generally available documents or publications;
a) becomes available to the general public after the date of disclosure through no fault or negligence of Recipient and then only after such time as the Proprietary Information becomes available.
b) was in Recipient's possession before receipt from Discloser as evidenced by authenticated documentation.
is disclosed to Recipient without restriction by a third party who the Recipient reasonably believes has the lawful to disclose such information; or
c) is independently developed by Recipient's employee(s) not having access to Discloser's Propriety Information or Products.

2. The Discloser, intends to maintain the trade secret status of its Proprietary information and Products.

3. The subject matter of Proprietary information and/or Products for Discloser is related to ***Delta-HA***.

4. The parties agree that Proprietary Information and Products shall not be considered to be within the scope of the exceptions stated in Paragraphs 1a, 1b, 1c, 1d and 1e merely because more general information concerning the subject matter of Proprietary Information and Products is shown to be within the scope of the exceptions stated in Paragraphs 1a, 1b, 1c, 1d and 1e.

5. Information and Products shown to fall within the scope of Paragraphs 1a, 1b, 1c, 1d and 1e shall not be disclosed by Recipient to third parties unless disclosure is mandated by operation of law.

6. Recipient shall entrust Proprietary Information with the same degree of care it applies to its own proprietary information of like importance which it does not wish to disclose, publish or disseminate to third parties. In no event shall Recipient exercise less than reasonable care.

7. It is further agreed that Recipient shall not, without prior written approval by Discloser:

   a) use Proprietary Information and/or Products received from Discloser, in whole or in part, except for the purpose set forth under this agreement;
   b) disclose Proprietary Information and/or Products, in whole or in part, to its employees except to those whose knowledge thereof is necessary for the purpose set forth above;
   C) disclose to any third party Proprietary Information and/or Products in whole or in part unless disclosure is mandated by operation of law; or
   d) analyze or cause to be analyzed samples of said Products submitted under this Agreement. (In the event Discloser authorizes any analysis of said Products, the results of such analysis shall be considered part of Proprietary Information under this Agreement.)

8. All quantities of said Products received by Recipient from Discloser are not to be resold to any third party without Discloser's written permission. Recipient shall report to Discloser all results of evaluation of said Products, and said reports shall be Proprietary Information subject to the obligations of this Agreement. All Products (or raw materials used to make same) and Proprietary Information shall be returned to Discloser on written request.

9. Nothing contained herein shall be construed as granting or implying any right or license under any intellectual property right of the other party.

10. This Agreement shall terminate five (5) years following the effective date of this Agreement.

11. Recipient may, if required by a local, state, or federal governmental agency, court or body, disclose Proprietary Information protected hereunder to said agency, court or body, provided, however, that prior to release of Proprietary Information, Recipient must use best effort to inform Discloser of the need to disclose the Proprietary Information prior to disclosure, and that upon disclosure to the agency, court or body, Recipient must advise the agency, court or body of the confidential status of Proprietary Information.

12. This Agreement shall be governed by applicable Federal law.

13 This Agreement shall be executed in duplicate and be effective as of the date signed by both parties.

Accepted and Agreed to this
___ day of ________, 1997

____

By: ____________________ Casting Emission Reduction Program

Name: Jonathan Stone Name: George M. Crandell

Title: Director - Environ. Services Title: [illegible]

APPENDIX G:

GLOSSARY

Appendix G: Glossary

DNR	Data not recorded.
NA	Not Applicable
ND	Non Detect, No Data
NT	No Test. Lab testing was not done on this analyte
Organic Compound of Concern	Organic compounds routinely found in foundry processes that are not considered HAPS but because of their presence are monitored.
THC	Calculated by the summation of all area before elution of Hexane to after the elution of Anthracene. The quantity of THC is performed against a five-point calibration curve of Undecane by dividing the total area count from C6 to C14 to the area of Undecane curve from the initial calibration curve.
t-Test	The calculated T statistic, Ts, is compared against a table value. The table value is a function of the sample size and on the level of confidence desired. For tests with nine sample values each, the T value associated with a confidence level of 95% is 2.12. Calculated values of Ts greater than or equal to this value would indicate that there is 95% or better probability that the differences between the two test series were not the result of test variability.