Foundry Process Emission Factors: Baseline Emissions from Automotive Foundries in Mexico

Produced by

Emissions Measurement Team
Casting Emission Reduction Program

McClellan Air Force Base, California

January 19, 1999

Table of Contents

Acknowledgments

During the months of April and May, 1997, a CERP stack test team from McClellan AFB, California, performed emission testing at the General Motors foundry in Toluca, Mexico, and the Ford foundry in Cuautitlan, Mexico. The scope of our testing was large and included the collection of emissions' data as well as process data. The results of this testing have been compiled and will prove to be valuable data for the foundry industry and nation.

The logistics of this type of effort are very complex. We obtained clearances for a 10 person team, transported three vehicles, and numerous supplies and equipment, including hazardous materials, into Mexico. Only with the efforts of many people did all equipment and supplies clear customs and arrive on time.

During testing we were supported by many people from General Motors (GM) and Ford in Detroit and in Mexico. We would like to take this opportunity to recognize the efforts of the many people that contributed to the success of this effort.

A special thank you and appreciation goes to Mr. Gonzolo Garcia, the Plant Manager in Toluca, Mexico, and to Mr. Pedro Jelley, the Plant Manager in Cuautitlan, Mexico, for inviting us into their foundries and offering support over and above our expectations. Without their help, none of the testing would have been possible.

Without the expertise of Larry Bahan (GM, Mexico), and his staff, our vehicles and equipment would have never gotten into or out of Mexico. During our stay in Mexico, Larry always made himself available, going out of his way to help us get the job done. We also appreciate the efforts of Guillermo Trevino and Carmen Rodriquez who graciously took on additional duties when called upon.

Special thanks go to Mr. Eduardo Gomez, Mr. Guillermo Arias and Ms. Yvonne Acevedo at GM and to Mr. Carlos Cuevas, Mr. Dionisio Menchero, Mr. Gustavo Roa, and Ms. Maria Lara at Ford, all of whom spent many hours working with us from the beginning to the end of this project. They were instrumental in coordinating the many tasks of a project this size. Once in Mexico they were very supportive, going out of their way to support our many requirements. Because of their efforts we had continual office support, a vehicle to drive, and drivers to accompany us when needed. This group made us feel very much at home while in Mexico.

The collection of numerous amounts of process data would not have been possible without help from Mr. Elias Corona and Mr. Juan Martinez at GM and Mr. Rafael Ortega, Mr. Alejandro Calderon, Mr. Raula Alvrado, and Mr. Carlos Escobedo at Ford and the many dedicated folks that work with them. We thank you for taking your time to educate us in the foundry processes and provide us with an enormous amount of data.

We would also like to thank Oscar Olguin who unselfishly provided us with workers. We would also like to thank the many workers who worked with us daily and provided us a safe working environment.

Thank you to the following folks from GM and Ford in Detroit, who guided us throughout the testing, taking time to travel to Mexico to set the foundation for a successful endeavor, and who have spent numerous hours working with us to analyze and compile data:

Steve Tomaszewski, GM Worldwide Facilities	*Jim Schifo, GM Worldwide Facilities*	*Jerry Ortmann, GM Research*
Sonny Rodriquez, GM Malleable Iron	*Martin Ruthkosky, GM Research*	*Don Russell, Ford*

We also would like to thank the members of the CERP Emissions Measurement Team, who were instrumental in defining sampling and analysis methods to ensure successful sampling events in Mexico.

Working with the people from GM and Ford in Detroit and in Mexico was a very rewarding experience and further proves that professionals from many walks of life can work together to achieve a common purpose.

William C. Walden
Program Manager

Jerry Rogers
Chair, Emissions Measurement Team

Executive Summary

The Casting Emission Reduction Program (CERP) is an on-going, five year Dual-Use initiative between the Department of Defense (McClellan Air Force Base) and the United States Council for Automotive Research (USCAR). The CERP mission is to develop new materials, processes or equipment for metalcasting manufacturing which will achieve a near zero effect on the environment. This will result in cleaner and more efficient metal casting processes for military and commercial applications. 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).

As part of CERP, McClellan AFB has assembled a team to conduct source testing pollutant emission factors for various foundry processes. These emission factors will be used to: (1) establish and evaluate options for air quality regulations or standards, (2) develop source-specific emission factors for use in emission inventories, dispersion modeling, and other air quality activities, and (3) provide a baseline for emissions against which new processes and materials will be benchmarked. This information will be critical to the development of Maximum Achievable Control Technology (MACT) standards for emissions of Hazardous Air Pollutants (HAPS) from iron foundries.

CERP is led by a steering committee and several subcommittees made up of members from each of the Big Three U.S. Automobile Manufacturers, USCAR, the American Foundrymen's Society, and McClellan AFB. Members of the Emissions Measurement Committee have worked with the McClellan AFB source test team to develop the foundry emission measurement program and to select sampling methods for use in stack measurements.

This report documents results from data collection efforts at the General Motors foundry in Toluca, Mexico and the Ford foundry in Cuautitlan, Mexico:

General Motors De Mexico, SA. DE C.V.
Complejo De Manufactura Toluca,
AV. Industria Automotriz S/N
C.P. 50000 Toluca, Mexico

Ford Motor Company
Cuautitlan Casting Plant
Km 36.5 Carretera
Mexico – Queretaro
Cuautitlan
Edo de Mexico, Mexico

The foundries produce iron cylinder blocks, bearing caps, cylinder heads, manifolds, water pumps, crankshafts, clutch housings, and fly wheels. The production rate is approximately 75 - 100 molds/hr. Testing at the foundries focused mainly on emissions from casting blocks. Processes tested included metal melting, core making, mold pouring, cooling, and shakeout.

Components of the testing program included:

- Simultaneous measurement of the emissions of:
  - volatile and semi-volatile organic compounds as well as aldehydes, ketones, and isocyanates
  - particulate matter (total particles, particles ≤ 10 micrometers, and particles ≤ 2.5 micrometers) and condensable particulate matter
  - metals
- Collection of process data concurrently with the sampling times for the processes tested
- Collection of stack flow, moisture, pressure and temperature information from all test emission points

A summary of the methods is presented in Table i.

Table i. CERP Sampling Methods

Reference Method	Pollutant or Parameter
EPA Method 1	Traverse Point/determination
EPA Method 2	Flow Rate
EPA Method 3	Molecular weight of gas stream
EPA Method 4	Moisture content
EPA Method 5	Particulate matter
EPA Method 18	Volatile and semi-volatile organics
EPA Method 29 Draft	Metals
EPA Method 201A	Particulate matter less than 10 microns
EPA Method 202	Condensable particulate matter
EPA Method TO-11	Aldehydes and Ketones
OSHA Method 42	Isocyanates
NIOSH Method 2002	Aromatic Amines
NIOSH Method 2010	Aliphatic Amines

Our best estimate for emissions of HAPs from pouring, cooling, and shakeout are sorted alphabetically in Table ii and sorted by magnitude of emissions in Table iii. These emission factors are expressed in units of lb HAP/ton iron poured. Other HAPs were tested for, but were not detected. Note that these best estimates for emission factors do not account for stack capture efficiency, the inclusion of which would raise the values shown in Table iii. The table includes the pouring and cooling results for engine block production on Line 1 and the shakeout results for clutch housings on Line 3. The results for organic HAP emissions from shakeout for the clutch housings on Line 3 were used instead of the blocks on Line 1 because the emissions from Line 1 shakeout were not completely captured by the stack ventilation system. Use of the data for the engine blocks for the shakeout emissions would have led to erroneously low emission factors due to incomplete capture of the emissions. However, metal HAP contributions to shakeout are taken from the block results, since metal emissions from shakeout were not measured on Line 3. Figure i.1 shows the emission factors for the major HAP species emitted from pouring, cooling, and shakeout. The contribution from shakeout dominates most of the organic HAP emissions. HAPs with large emission factors were benzene, phenol, toluene, and xylenes.

Table ii also includes the speciated emissions of polycyclic organic matter (POM). Figure i.2 shows this speciated distribution across pouring, cooling, and shakeout. As shown in Figure i.2, the POMs emitted at the highest rate are naphthalene and the monomethylated naphthalenes (1-methylnaphthalene and 2-methylnaphthalene). These three POMs account for 80% of the total POM emissions from pouring, cooling, and shakeout. Many of the recognized carcinogenic POMs were not detected; for example, benzo[a]pyrene (BaP), benz[a]anthracene, and chrysene. Thus, the use of BaP as a surrogate for POM would be incorrect for pouring, cooling, and shakeout emissions.

Major emissions of metal HAPs from melting include manganese, lead, nickel, copper, and chromium. Manganese is the metal whose emissions were highest. Figure i.3 shows these results.

We also report here for the first time emissions information on particulate matter sized less than or equal to 10 μm (PM_{10}) and less than or equal to 2.5 μm ($PM_{2.5}$). By this definition, PM_{10} includes $PM_{2.5}$. Figure i.4 shows the contributions to the total PM emissions from pouring, cooling, and shakeout. Figure i.5 shows the relative contributions of PM_{10} and $PM_{2.5}$ to the total PM emissions. PM_{10} is about 50% of the total PM emissions from cooling, but less than 30% of the total PM from pouring, cooling, and shakeout combined. As noted above, however, not all the emissions from shakeout were captured, yet shakeout is one of the process steps in which particulate matter emissions are high. Size-segregated information on PM emissions from foundries has not been available to the scientific community and will be invaluable in determining the impact of future $PM_{2.5}$ regulations on the foundry industry.

In summary, the HAP measurements reported here for these foundry processes provide the best, most complete set of emission factors with associated process data available publicly.

Table ii. Nonzero HAP Emissions from Pouring, Cooling, and Shakeout
Lb Analyte / Ton Metal Poured

Analyte	Pouring[1]	Cooling[1]	Shakeout[2]	Totals
Acetaldehyde	2.94E-04	3.20E-03	5.78E-02	6.13E-02
Acetophenone	ND	1.98E-04	7.92E-04	9.90E-04
Benzene	2.19E-03	3.49E-02	2.68E-02	6.39E-02
Cadmium	4.55E-06	2.03E-05	1.67E-05	4.16E-05
Chromium	4.85E-05	2.31E-04	1.71E-04	4.51E-04
Copper	5.71E-05	1.87E-04	1.36E-04	3.80E-04
Cumene	6.00E-06	1.21E-04	3.82E-04	5.09E-04
Dibenzofuran	ND	1.63E-05	3.34E-04	3.50E-04
Ethylbenzene	1.01E-04	1.87E-03	2.91E-03	4.88E-03
Formaldehyde	1.38E-04	1.73E-03	2.57E-02	2.76E-02
Lead	1.79E-04	2.22E-04	7.29E-05	4.74E-04
m,p-Xylene	4.22E-04	7.61E-03	1.25E-02	2.05E-02
Manganese	8.37E-04	5.21E-04	3.39E-04	1.70E-03
Naphthalene	1.81E-04	2.41E-03	8.37E-03	1.10E-02
Nitrobenzene	ND	5.03E-06	ND	5.03E-06
o-Cresol	1.65E-06	9.27E-04	1.40E-02	1.49E-02
o-Xylene	1.90E-04	3.82E-03	5.32E-03	9.33E-03
Phenol	2.86E-04	5.48E-03	2.80E-02	3.38E-02
POMs	3.56E-04	4.64E-03	2.21E-02	2.71E-02
1,3-Dimethylnaphthalene	4.33E-06	1.14E-04	1.03E-03	1.15E-03
1,4-Dimethylnaphthalene	ND	2.51E-05	4.64E-04	4.89E-04
1,6-Dimethylnaphthalene	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	5.32E-06	1.06E-03	1.07E-03
1-Methylnaphthalene	7.69E-05	9.04E-04	3.41E-03	4.39E-03
2,3,5-Trimethylnaphthalene	ND	ND	7.14E-04	7.14E-04
2,3-Dimethylnaphthalene	ND	9.53E-05	6.50E-04	7.45E-04
2,6-Dimethylnaphthalene	ND	1.13E-05	5.68E-04	5.79E-04
2,7-Dimethylnaphthalene	1.27E-06	2.49E-05	4.10E-04	4.36E-04
2-Methylnaphthalene	9.10E-05	1.03E-03	5.22E-03	6.34E-03
Acenaphthalene/1,2-Dimethylnaphthalene	1.51E-06	2.30E-05	2.20E-04	2.45E-04
Naphthalene	1.81E-04	2.41E-03	8.37E-03	1.10E-02
Propanal	ND	3.71E-05	5.70E-03	5.74E-03
Selenium	ND	4.10E-06	ND	4.10E-06
Styrene	5.31E-05	4.35E-04	4.81E-03	5.30E-03
Toluene	1.05E-03	1.89E-02	2.21E-02	4.21E-02
Xylenes	6.12E-04	1.14E-02	1.78E-02	2.99E-02

[1]Pouring and cooling are from the results for engine block production on Line 1.
[2]Shakeout VOC HAPs are from the results for clutch housing production on Line 3. Metal HAP contributions are from the block results.

Table iii. Rank-Ordered HAP Emissions from Pouring, Cooling, and Shakeout Lb Analyte / Ton Metal Poured

Analyte	Pouring[1]	Cooling[1]	Shakeout[2]	Totals
Benzene	2.19E-03	3.49E-02	2.68E-02	6.39E-02
Acetaldehyde	2.94E-04	3.20E-03	5.78E-02	6.13E-02
Toluene	1.05E-03	1.89E-02	2.21E-02	4.21E-02
Phenol	2.86E-04	5.48E-03	2.80E-02	3.38E-02
Xylenes	6.12E-04	1.14E-02	1.78E-02	2.99E-02
Formaldehyde	1.38E-04	1.73E-03	2.57E-02	2.76E-02
POMs	3.56E-04	4.64E-03	2.21E-02	2.71E-02
m,p-Xylene	4.22E-04	7.61E-03	1.25E-02	2.05E-02
o-Cresol	1.65E-06	9.27E-04	1.40E-02	1.49E-02
Naphthalene	1.81E-04	2.41E-03	8.37E-03	1.10E-02
o-Xylene	1.90E-04	3.82E-03	5.32E-03	9.33E-03
Propanal	ND	3.71E-05	5.70E-03	5.74E-03
Styrene	5.31E-05	4.35E-04	4.81E-03	5.30E-03
Ethylbenzene	1.01E-04	1.87E-03	2.91E-03	4.88E-03
Manganese	8.37E-04	5.21E-04	3.39E-04	1.70E-03
Acetophenone	ND	1.98E-04	7.92E-04	9.90E-04
Cumene	6.00E-06	1.21E-04	3.82E-04	5.09E-04
Lead	1.79E-04	2.22E-04	7.29E-05	4.74E-04
Chromium	4.85E-05	2.31E-04	1.71E-04	4.51E-04
Copper	5.71E-05	1.87E-04	1.36E-04	3.80E-04
Dibenzofuran	ND	1.63E-05	3.34E-04	3.50E-04
Cadmium	4.55E-06	2.03E-05	1.67E-05	4.16E-05
Nitrobenzene	ND	5.03E-06	ND	5.03E-06
Selenium	ND	4.10E-06	ND	4.10E-06

[1]Pouring and cooling are from the results for engine block production on Line 1.
[2]Shakeout VOC HAPs are from the results for clutch housing production on Line 3. Metal HAP contributions are from the block results.

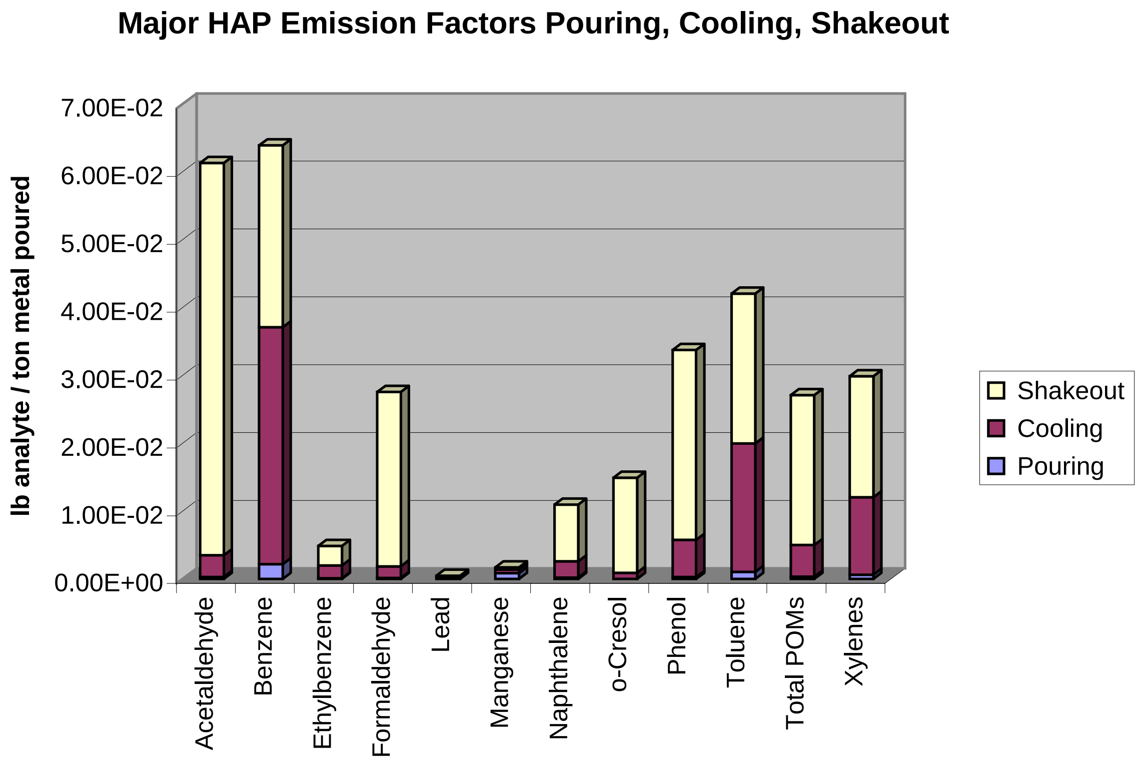


Figure i.1. Major Nonzero HAP Emissions from Pouring, Cooling, and Shakeout

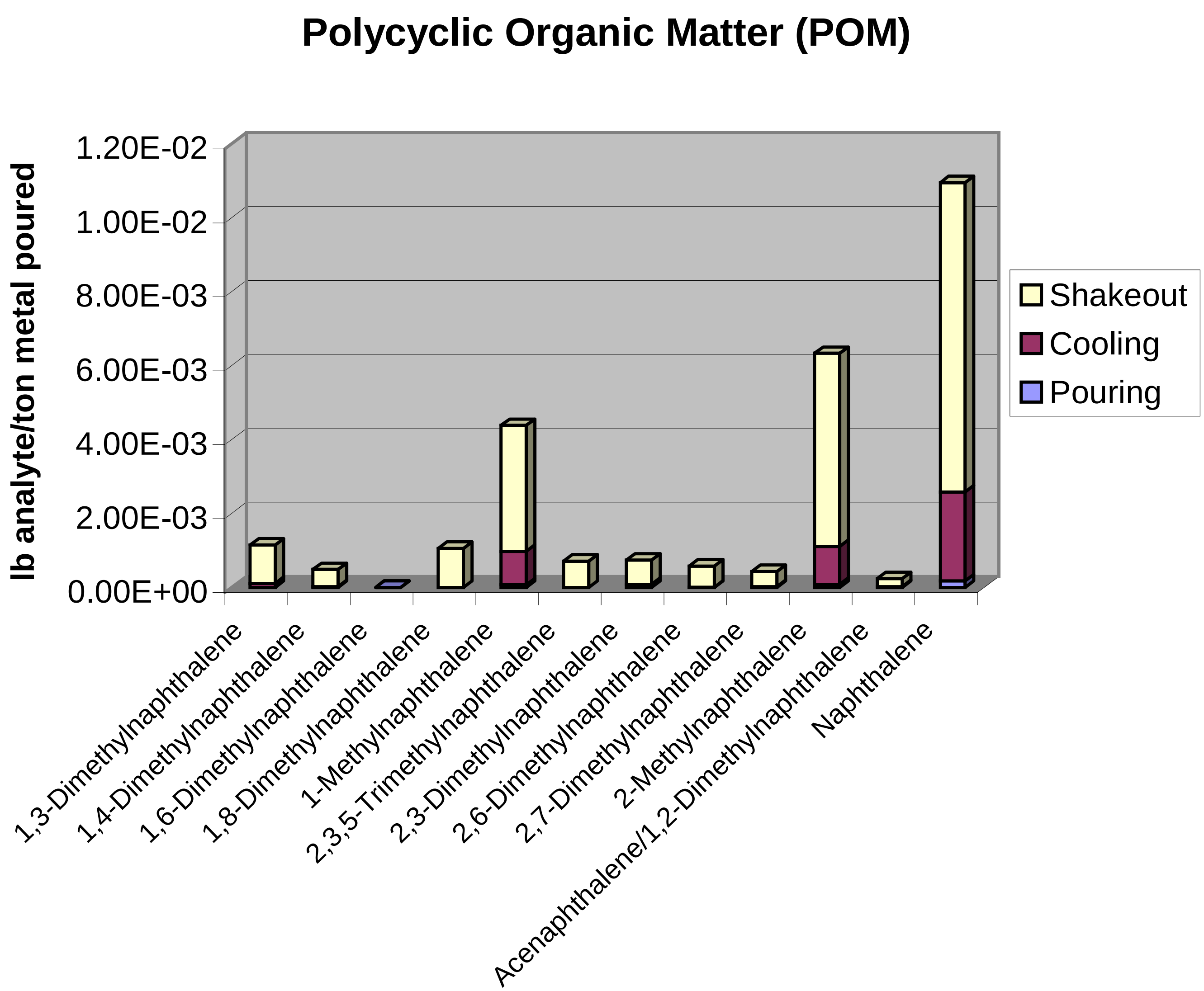


Figure i.2. Speciated Polycyclic Organic Matter (POM) Emission Factors from Pouring, Cooling, and Shakeout

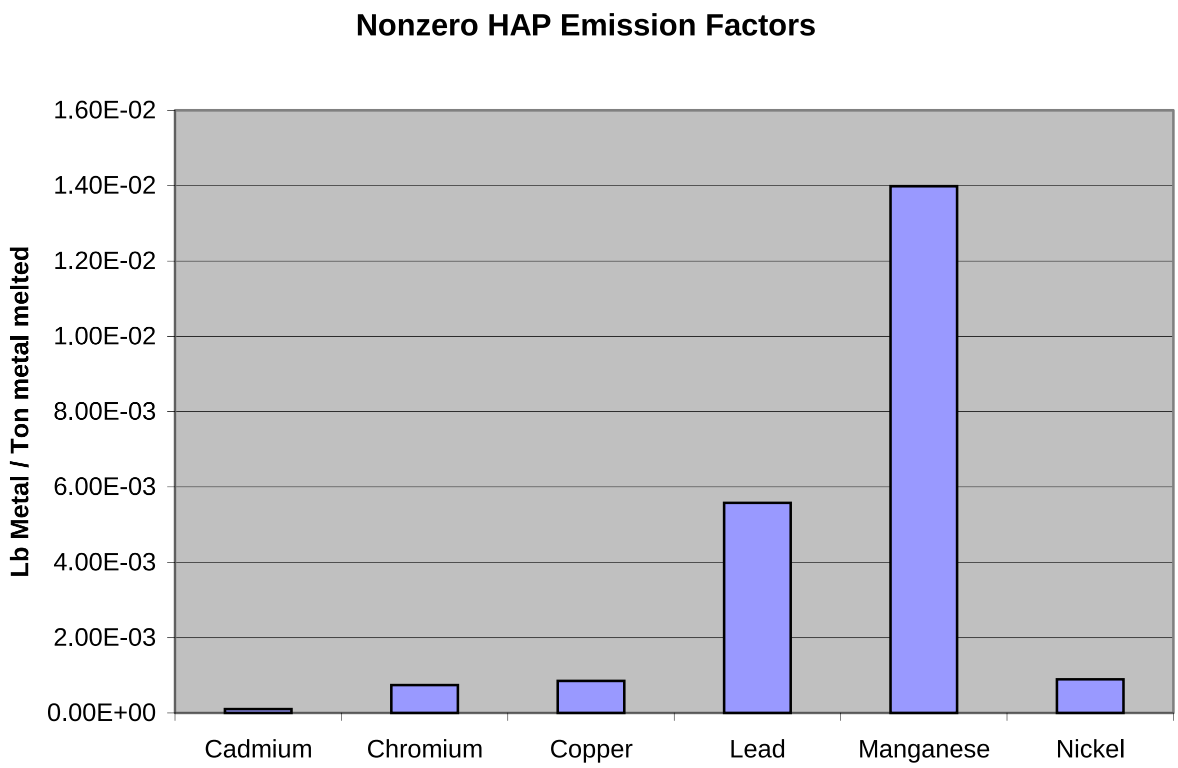


Figure i.3. Nonzero HAP Emission Factors for Metal Melting

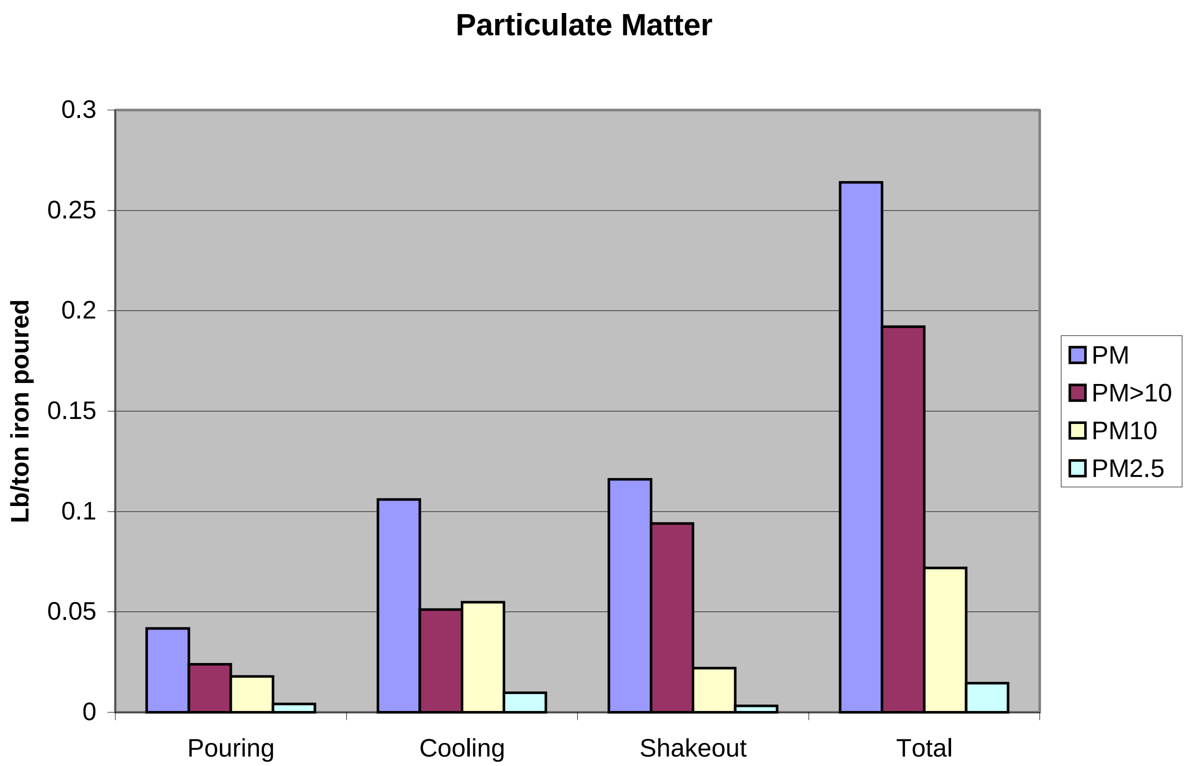


Figure i.4. Particulate Matter Emission Factors for Pouring, Cooling, and Shakeout

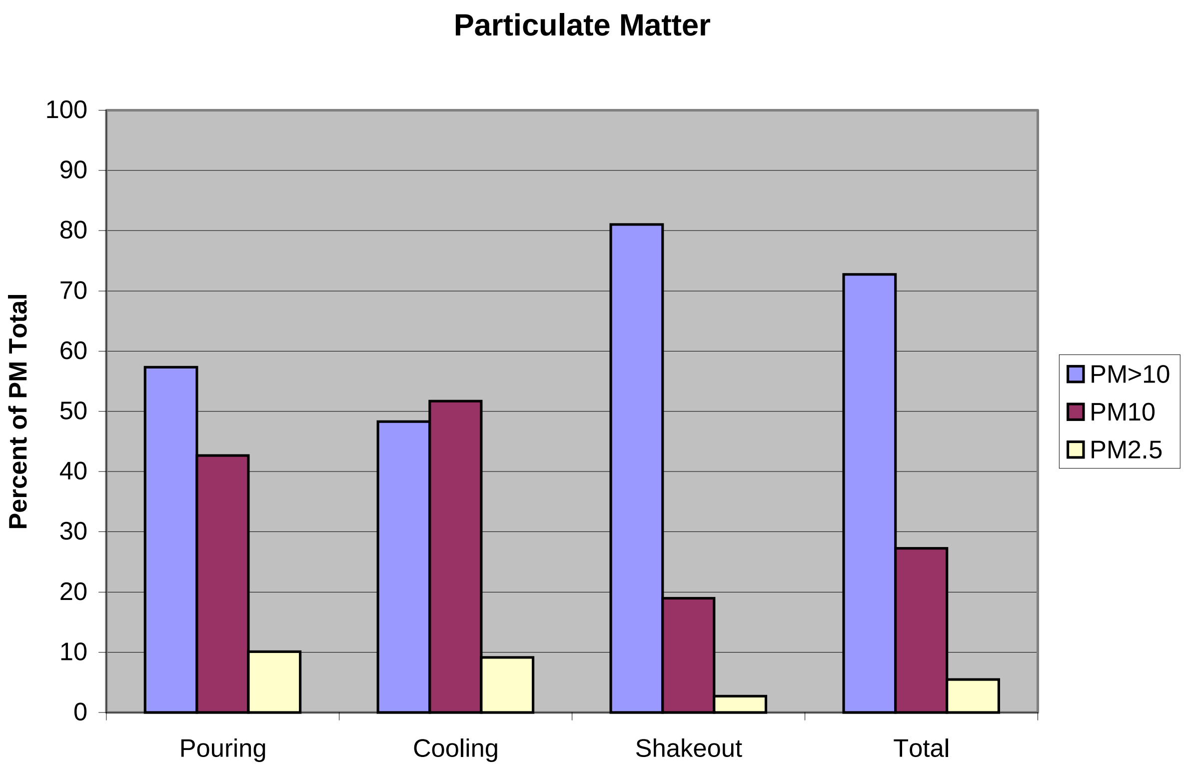


Figure i.5. PM_{10} and $PM_{2.5}$ Contributions to Total PM Emissions from Pouring, Cooling, and Shakeout

1.0 Introduction

The CERP project is an on-going, five year Dual-Use initiative between the Department of Defense (McClellan Air Force Base) and the United States Council for Automotive Research (USCAR). Its purpose is to develop cleaner and more efficient metal casting processes to provide long term support for military metal castings. 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).

The initial objective is to develop new materials, processes or equipment for metalcasting manufacturing which will achieve a near zero effect on the environment. A second, but equally important objective is to bridge the critical gap between laboratory and full scale casting production. As part of CERP, McClellan AFB has assembled a team to conduct source testing of various foundry processes. This information will be critical to the development of Maximum Achievable Control Technology (MACT) standards for emissions of Hazardous Air Pollutants (HAPS) from iron foundries.

This report is organized into five sections. Section 2.0 of this document provides information regarding the testing protocol. Section 3.0 describes the process data collected. This includes stack parameters as well as characteristics of the parts being produced during emission testing. Section 4.0 provides a sampling matrix that identifies, by process, the parts that were being produced during testing and the number of samples collected. Results, which include the estimation of cooling stacks not sampled are explained through charts and figures in Section 5.0. Section 5.0 also contains additional charts relating process data and providing emission factors. Additional testing data and quality control procedures are described in Appendix B of this report.

1.1 Summary of Test Program

A steering committee, and several sub-committees, made up of members from each of the Big Three U.S. automobile manufacturers, USCAR, the American Foundrymen's Society and McClellan AFB lead CERP. Members of the Emissions Measurement Committee have provided guidance to the McClellan AFB source test team in the development of the foundry emission measurement program, and selected the sampling methods described in this report. Data were collected at the General Motors plant and Foundry in Toluca, Mexico, and at the Ford foundry in Cuautitlan, Mexico, during the months of April and May, 1997.

1.1.1 Test Program Objectives

The purpose of this source testing program is to determine the pollutant concentration in a gas stream or the rate the pollutant is being emitted from a stack, duct, or process exhaust. Emission data will be used to: (1) establish and evaluate options for air quality regulations or standards, (2) develop source-specific emission factors for use in emission inventories, dispersion modeling, and other air quality activities, and (3) provide an emissions baseline against which new materials and processes are benchmarked. Specific objectives include:

- Simultaneous measurement of the emissions of:
  - volatile and semi-volatile organic compounds as well as aldehydes, ketones, and isocyanates
  - particulate matter (total particles, particles ≤ 10 micrometers, and particles ≤ 2.5 micrometers) and condensable particulate matter
  - metals

- Collection of process data concurrently with the sampling times for the processes tested

- Collection of stack flow, moisture, pressure and temperature information from all test emission points

1.1.2 Foundry Locations and Mailing Addresses

General Motors De Mexico, SA. DE C.V.
Complejo De Manufactura Toluca,
AV. Industria Automotriz S/N
C.P. 50000 Toluca, Mexico

Ford Motor Company
Cuautitlan Casting Plant
Km 36.5 Carretera
Mexico – Queretaro
Cuautitlan
Edo de Mexico, Mexico

1.1.3 Methods and Processes

Table 1.1 presents the methods used for the processes that were tested.

Table 1.1. Methods and Processes

SAMPLING METHOD	POURING	IN MOLD CASTING COOLING	SHAKEOUT & DEGATE	COREMAKING	SAND PREPARATION
Methods 1, 2, 3, 4, and 5 (Non-Condensable Particulate Matter)				x	
Methods 1, 2, 3, 4, and 5 / 29 (Non-Condensable Particulate Matter / Determination of Metals)	x	x	x		x
Method 1,2,3,4 and 201A/202 (Particulate Matter (PM_{10} & $PM_{2.5}$)/Condensable Particulate Matter)	x	x	x		
Method 1,2,3,4 and 18 (Organic Train with Volatiles/Semivolatiles Cartridges)	x	x	x	x	x
Method 1,2,3,4 and TO-11 (Organic Train with Aldehydes/Ketones Cartridges)	x	x	x	x	
Method 1,2,3,4 and OSHA 42 (Organic Train with Isocyanate Cartridges)	x	x	x	x	
Method 1,2,3,4 and NIOSH 2010/2002 (Organic Train with Amine Cartridges)	x	x	x	x	

1.2 Test Program Organization

Figure 1.1 presents the CERP partnership, made up of representatives from McClellan AFB, the big three US automobile manufacturers, the United States Council for Automotive Research (USCAR), 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). Leaders for the technical teams are indicated in Figure 1.1, but note that the Foundry Process Modeling Team is awaiting startup.

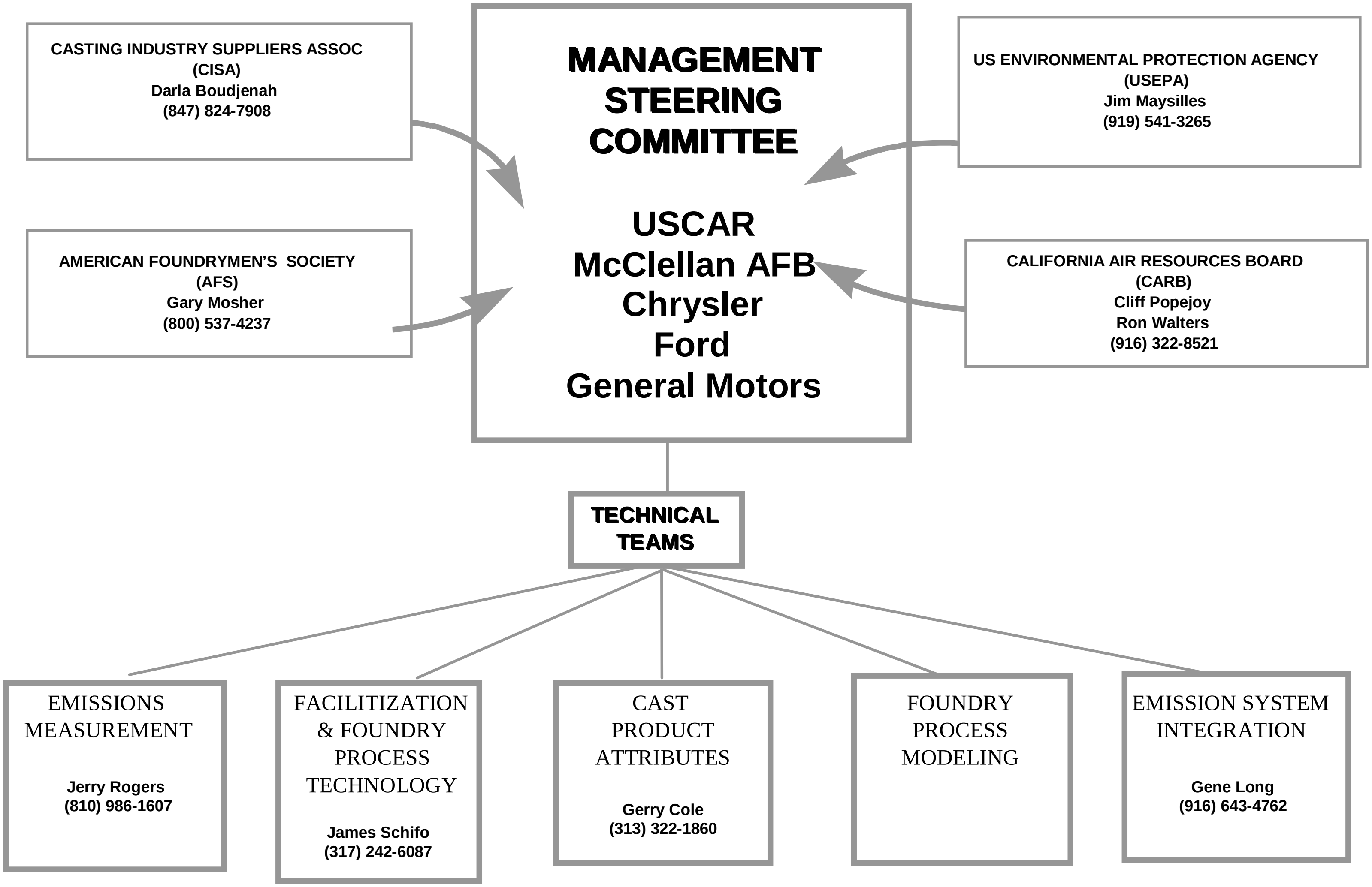


Figure 1.1. The CERP Partnership

Figure 1.2 presents the CERP source test team organization, major lines of communications, and names and phone numbers of responsible individuals.

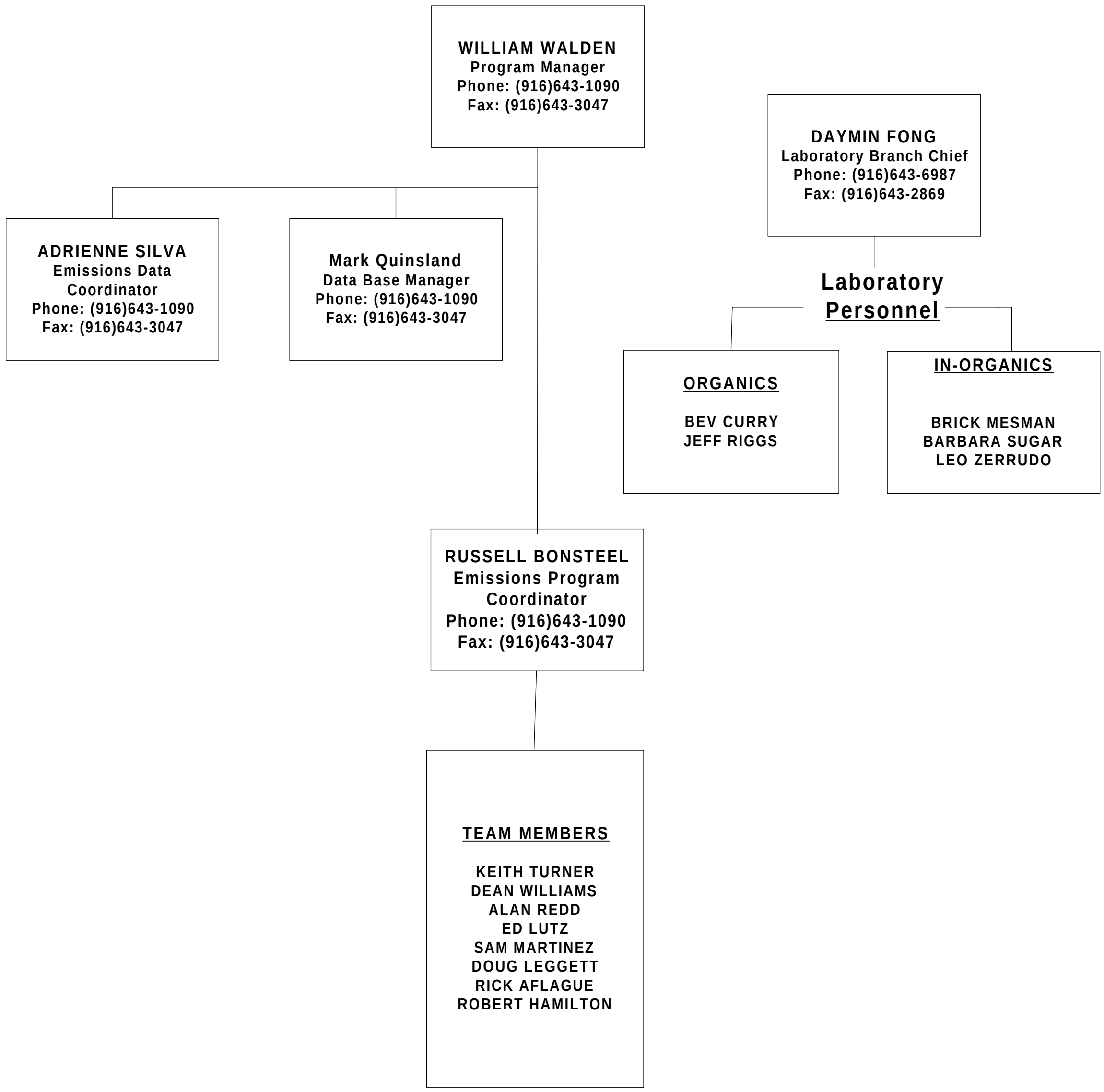


Figure 1.2. CERP Source Test Team Organization

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 Testing Protocol

This section describes the methods used to obtain and compile information on the measurements taken during emission testing in Mexico.

2.1 Table of Analytes

Table 2.1 lists the targeted analytes, provides the reporting limit, and identifies the category of analyte (HAP, POM, or VOC).

Table 2.1. Table of Analytes

Analyte	CAS	Reporting Limit (ng)	HAP	POM	VOC
1,1,2-Trichloroethane	120-82-1	50	X		X
1,2,3-Trimethylbenzene	526-73-8	20			X
1,2,4-Trimethylbenzene	95-63-6	20			X
1,2-Diethylbenzene	135-01-3	20			X
1,2-Dimethylnaphthalene	573-98-8	20		X	X
1,3,5-Trimethylbenzene	108-67-8	20			X
1,3-Diethylbenzene		20			X
1,3-Diisopropylbenzene	99-62-7	20			X
1,3-Dimethylnaphthalene	575-41-7	20		X	X
1,4-Diethylbenzene	105-05-5	20			X
1,4-Dimethylnaphthalene	571-58-4			X	X
1,5-Dimethylnaphthalene	571-61-9	20		X	X
1,6-Hexamethylene Diisocyanate	822-06-0	800	X		
1,6-Dimethylnaphthalene	575-43-9	20		X	X
1,8-Dimethylnaphthalene	569-41-5	20		X	X
1-Methylnaphthalene	90-12-0	20		X	X
2,3,5-Trimethylnaphthalene	2245-38-7	20		X	X
2,3,5-Trimethylphenol	697-82-5	100			X
2,3-Dimethylnaphthalene	581-40-8	20		X	X
2,3-Dimethylphenol	526-75-0	50			X
2,4-Toluene Diisocyanate	584-84-9	800	X		
2,4,6-Trimethylphenol	527-60-6	100			X
2,4-Diaminobiphenyl		20,000			X
2,4-Diaminotoluene	95-80-7				
2,4-Dinitrotoluene	121-14-2		X		X
2,5-Dimethylphenol	95-87-4	50			X

** Method 0010, not performed

Table 2.1. (continued)

Analyte	CAS	Reporting Limit (ng)	HAP	POM	VOC
2,6- Toluene Diisocyanate	584-84-9	800			
2,6-Dimethylnaphthalene	581-42-0	20		X	X
2,6-Dimethylphenol	576-26-1	50			X
2,7-Dimethylnaphthalene	582-16-1	20		X	X
2-Ethyltoluene	611-14-3	20			X
2-Methylnaphthalene	91-57-6	20		X	X
3,3'-Dimethoxybenzidine	119-90-4	20,000	X		
3,4-Dimethylphenol	95-65-8	50			X
3,5-Dimethylphenol	108-68-9	50			X
3-Ethyltoluene	620-14-4	20			X
4,-Methylene Bis(2-Chloroaniline)	101-14-4	20,000			
4,4-Methylene Bis(Phenylisocyanate)	101-68-8		X		
4,4'-Methylene Bis (2-Chloroaniline)	101-14-4	20,000	X		
4,4'-Methylenedianiline	101-77-9	20,000	X		
4-Aminobiphenyl	92-67-1	20,000			
4-Ethyltoluene	622-96-8	20			X
a-Methylstyrene	98-83-9	20			X
Acenaphthalene	209-96-8	20		X	X
Acenaphthalene/1,2-Dimethylnaphthalene	209-96-8/573-98-8	20		X	X
Acetaldehyde	75-07-0	300	X		
Acetone	67-64-1	300			
Acetophenone	98-86-2	20	X		
Acrolein	107-02-8	300	X		
Aluminum		50,000			
Aniline	62-53-3	20,000	X		
Anthracene	120-12-7	**		X	X
Antimony		2,500	X		
Arsenic		2,500	X		
Barium		50,000			
Benz[a]anthracene	56-55-3	**		X	X
Benzene	71-43-2	20	X		
Benzidine	92-87-5	20,000	X		
Benzo[a]pyrene	50-32-8	**		X	X
Benzo[b]&[j]fluoranthene	205-99-2	**		X	X
Benzo[e]pyrene	192-97-2	**		X	X
Benzo[ghi]perylene	191-24-2	**		X	X
Benzofuran	271-89-6	20	X		X
Beryllium	Various	250	X		

** Method 0010, not performed

Table 2.1. (continued)

Analyte	CAS	Reporting Limit (ng)	HAP	POM	VOC
Bibenzyl	103-29-7	20			X
Biphenyl	92-52-4	20	X		X
Butanal/Benzaldehyde		300			
Butylbenzene	105-05-5	20			X
Cadmium	Various	125	X		
Carbon Dioxide	124-38-9				
Carbon Monoxide	630-08-0				
Chromium	Various	2,500	X		
Chrysene	218-01-9	**		X	X
Cobalt	Various	2,500	X		
Copper	Various	2,500			
Crotonaldehyde	123-73-9	300			
Cumene	98-82-8	20	X		X
Cyclohexane	110-82-7	20			X
Decane	124-18-5	20			X
Dibenz[a,c]&[a,h]anthracene		**		X	X
Dibenz[a,j]anthracene		**		X	X
Dibenzofuran	132-64-9	20	X		X
Dodecane	112-40-3	20			X
Ethylbenzene	100-41-4	20	X		X
Fluoranthene	206-44-0	**		X	X
Fluorene	86-73-7	**		X	X
Formaldehyde	500-00-0	300	X		
Heptane	142-82-5	20			X
Hexanal	66-25-1	300			
Indan	496-11-7	20			X
Indene	95-13-6	20			X
Indeno[1,2,3-cd]pyrene	193-39-5	**			X
Iron	Various	50,000			
Isobutylbenzene	538-93-2	20			X
Lead	Various	1,250	X		
m,p-Cresol	108-39-4	100	X		X
m,p-Xylene	108-38-3	20	X		X
m-Tolualdehyde	620-23-5	300			
Manganese	Various	1,250	X		
Methyl Ethyl Ketone	78-93-3	300	X		
Methacrolein	78-85-3	300			
Methyl Methacrylate	80-62-6	50	X		X
N,N-Dimethylaniline	121-69-7	20,000	X		

** Method 0010, not performed

Table 2.1. (continued)

Analyte	CAS	Reporting Limit (ng)	HAP	POM	VOC
N-Nitrosodimethylamine	62-75-9	20,000	X		
n-Propylbenzene	103-65-1	20			X
Naphthalene	91-20-3	20	X	X	X
Nickel	Various	2,500	X		
Nitrobenzene	98-5-3	20	X		X
Nitrogen Dioxide	10102-44-0				
Nitrogen Monoxide	10102-43-9				
Non-Condensable Particulate Matter	No CAS #	0.1mg			
Nonane	111-84-2	20			X
o-Anisidine	90-04-0	20,000	X		
o-Cresol	95-48-7	50	X		X
o-Toluidine	95-53-4	20,000	X		
o-Xylene	95-47-6	20	X		X
Octane	111-65-9	20			X
Oxygen	7782-44-7				
p-cymene	99-87-6	20			X
p-Phenylenediamine	106-50-3	20,000	X		
Particulate Matter (PM_{10})	No CAS #	0.1mg			
Perylene	198-55-0	**		X	X
Phenanthrene	85-01-8	**		X	X
Phenol	108-95-2	20	X		X
Propanal	123-38-6	300	X		
Pyrene	129-00-0	**		X	X
Selenium	Various	2,500	X		
Silver	Various	250			
Styrene	100-42-5	20	X		X
Styrene Oxide	96-09-3		X		X
Sulfur Dioxide	7446-09-5				
Tetradecane	629-54-4	20			X
Toluene	108-88-3	20	X		X
Total HydroCarbons	Various				
Tridecane	629-50-5	20			X
Triethylamine	121-44-8	20,000	X		
Undecane	1120-21-4	20			X
Valeraldehyde	110-62-3	300			
Zinc	Various	7,500			

** Method 0010, not performed

2.2 Sampling Methods and Analytical Procedures

This section describes the sampling methods and analytical procedures used during foundry source testing while in Mexico. Samples were collected and analyzed in accordance with reference methods of the U.S. Environmental Protection Agency (U.S. EPA), the Occupational Safety and Health Administration (OSHA), and the National Institute of Occupational Safety and Health (NIOSH).

Appendix B contains method summaries describing the reagents and media required, and the preparation and recovery of the sampling train. Schematics of the sampling equipment used are also contained in Appendix B.

A summary of the methods is presented in Table 2.2.

Table 2.2. CERP Sampling Methods

Reference Method	Pollutant or Parameter
EPA Method 1	Traverse Point/determination
EPA Method 2	Flow Rate
EPA Method 3	Molecular weight of gas stream
EPA Method 4	Moisture content
EPA Method 5	Particulate matter
EPA Method 18	Volatile and semi-volatile organics
EPA Method 29 Draft	Metals
EPA Method 201A	Particulate matter less then 10 microns
EPA Method 202	Condensable particulate matter
EPA Method TO-11	Aldehydes and Ketones
OSHA Method 42	Isocyanates
NIOSH Method 2002	Aromatic Amines
NIOSH Method 2010	Aliphatic Amines

2.2.1 U.S. EPA Methods 1-4

The number and location of sampling traverse points necessary for isokinetic sampling and velocity measurements at each stack gas sampling location were determined by U.S. EPA Method 1 protocol. The number of traverse points at each stack was based upon how much duct distance separates the sampling ports from the closest downstream and upstream flow disturbances. An assessment of potential interferences from cyclonic flow was made prior to sample collection by a two-man team that went to the sites for a pre-survey in February 1997.

The volumetric flow rate of each stack or duct was measured according to U.S. EPA Method 2. A type K thermocouple and S-type Pitot tube were used to measure stack gas temperature and velocity, respectively. The parameters that were measured to calculate stack gas velocity included the total and static pressures and the gas temperature. These parameters were measured at each traverse point, as applicable, and average values were used to determine the velocity.

Oxygen (O_2) and carbon dioxide (CO_2) stack gas concentrations can be determined using U.S. EPA Method 3 or continuous emission monitors. Continuous emission monitors were used during the Mexico testing period (see Section 2.2.7).

The average stack gas moisture content was determined according to U.S. EPA Method 4. Before sampling, the initial weights of the impingers are recorded. When sampling is completed, the final weights of the impingers are recorded, and the weight gain is calculated. The weight gain and the volume of gas sampled were used to calculate the average moisture content (percent) of the stack gas.

2.2.2 Particulate Matter (U.S. EPA Method 5)

Particulate matter emissions from the targeted foundry process stacks were measured using U.S. EPA Method 5. Method 5 also refers to U.S. EPA Methods 1 through 4 as part of its protocol. A sample of stack gas was withdrawn isokinetically from the stack through a temperature-controlled, glass-lined probe and collected on a glass fiber or quartz filter. The gas was then drawn through a series of four impingers. The first two impingers contained deionized water, the third impinger was empty, and the fourth impinger contained silica gel. The first, third, and fourth impinger are modified Greenburg-Smith impingers; the second impinger is a standard Greenburg-Smith.

Samples were collected from multiple traverse points across the stack diameter (refer to U.S. EPA Methods 1 and 2) in each of two ports located at 90 degrees from each other. The minimum sampling time per run was approximately 60 minutes and the minimum sample volume was approximately 30 dry standard cubic feet (dscf). Included in Appendix B is a list of media and reagents used in Method 5 and information on preparation of the sampling train, along with the procedures to follow to recover the various samples from the sampling train. On some sources, determination of total particulate matter (filterable plus condensable) was required. To determine total particulate mater, Method 5 (filterable) is combined with Method 202 (condensable) results. Appendix B contains information on the preparation and recovery of samples from this sampling train.

2.2.3 Particulate Matter Less than 10 Microns (PM_{10}) and Less than 2.5 Microns ($PM_{2.5}$)

U.S. EPA Method 201A, “Determination of PM_{10} and $PM_{2.5}$ Emissions (Constant Sampling Rate Procedure)” and U.S. EPA Method 202, “Determination of Condensable Emissions from Stationary Sources” were used to determine the emissions of total particulate matter from some of the foundry processes. There is no current EPA Method for $PM_{2.5}$. Method 201A protocol was used for $PM_{2.5}$. We cascaded the PM_{10} and the $PM_{2.5}$ cyclones together. Method 201A was used to measure particulate matter with an aerodynamic diameter equal to or less than 10 micrometers and Method 202 will be used to determine condensable particulate matter (CPM) and any non-condensable less then 2.5 microns.

Method 201A involves collection of solid particulate matter with an in-stack nozzle. The cyclones and filter were at the end of the probe. Sampling was conducted isokinetically ($\pm$ 20 percent) at a constant flow rate at traverse points selected according to the procedures described in U.S. EPA Method 1. Particulate matter greater than 10 micrometers in aerodynamic diameter was separated by and retained in the cyclone. The PM_{10} fraction that passes through the first cyclone was collected in the catch of the second cyclone. The $PM_{2.5}$ fraction passes through both cyclones and was collected on a filter immediately behind the second cyclone. The condensable particulate matter is collected in an impinger train that is attached to the cyclone/filter assembly via a sampling probe. An S-type Pitot tube and thermocouple mounted on the probe were used to measure gas temperature and velocity.

The back half of the sampling train contained four impingers immersed in an ice bath. The first two impingers were Greenburg-Smith impingers and contained deionized water. The last two are modified Greenburg-Smith impingers. The third impinger contained deionized water and the fourth impinger contained silica gel. An EPA Method 5 pump and meter box were used to withdraw the gas sample, control the sampling rate, and display the stack gas and sampling system operating parameters.

Prior to commencement of the test, a leak check of the Pitot tube lines and the sampling system was performed. Sampling was initiated after the probe reached operating temperature (248 $\pm$ 25° F) and the cyclone/filter reached equilibration with the exhaust gas temperature. Sampling was performed at a constant rate at the traverse points selected according to EPA Method 1. Sampling duration at a given traverse sampling point was varied in proportion to the gas velocity at the sampling point. The cyclone/filter/probe assembly was then disconnected from the impinger train. The inlets and outlets of the nozzle/cyclone/probe and impinger train were sealed. The cyclone/filter/probe assembly and impinger train were then transferred to the recovery trailer. The minimum sampling time per run was 60 minutes and the minimum sample volume was 30 dry standard cubic feet (dscf).

Prior to sampling, preliminary measurements of gas velocity, temperature, moisture content, and molecular weight were performed using EPA Methods 1 through 4. These preliminary data were used to calculate the appropriate nozzle size for the range of Pitot tube readings such that the isokinetic-sampling ratio can be maintained within ± 20 percent throughout the test.

2.2.4 Metals (U.S. EPA Method 29 Draft)

U.S. EPA Method 29 was used to determine stack gas emissions of metals. A sample of stack gas was withdrawn isokinetically from the stack, passed through a quartz filter, and then passed through a series of four impingers. The first and second impingers contain 5% nitric acid/10% hydrogen peroxide solution, the third impinger is empty, and the fourth impinger contains silica gel.

The minimum sampling time was 60 minutes per run and measurements were collected at multiple traverse points across each of two stack diameters. Sample recovery included rinsing the probe, filter holder, and the lines connecting the probe to the filter with acetone then 0.1N nitric acid.

The Graseby/Anderson Auto5™ sampler was used to collect all particulate and metals samples. Included in Appendix B is information regarding preparation of the impinger reagents, set up of the sampling train, and recovery of all the sample fractions from the Method 29 sampling system. It should be noted that on most occasions it was necessary to use the Method 29 sampling train for the determination of particulate matter (filterable fraction only). In order to do this, the filter was desiccated and weighed to a constant number prior to preparing this sample fraction for the multiple metals analysis.

2.2.5 Volatile and Semi-Volatile Organics

The organic compounds of concern were collected on sample collection tubes using a custom made sampling train. The sample gas stream was drawn from the stack using a 3/8" nickelized stainless steel probe that was located at the average stack gas velocity point. The sample gas stream traveled through this probe, a 10 micron quartz glass filter, and a nickel plated manifold before reaching the sample collection tube. The sample gas was drawn through the sample collection tube by a vacuum pump. Each sample tube gas stream was regulated by fine metering valves.

The sample gas stream passed through each of the sample collection tubes for a minimum of 60 minutes at a set flowrate of 10 to 1,000 ml/minute depending on the requirements of the specific sample tube. The actual flowrate through each of the sample tubes was manually measured and recorded every 10 minutes to ensure that the flow had not been reduced by sample tube loading. The total stack gas flow rate was obtained via the Auto5™ sampling system.

2.2.6 Aldehydes and Ketones, Isocyanates, and Amines

Aldehydes and Ketones, Isocyanates and Amines were collected according to EPA methods. See Appendix B.

2.2.7 Continuous Emission Monitors

Due to equipment problems oxygen and carbon dioxide were the only compounds monitored. Oxygen (O_2) was measured using the Enerac 3000. Carbon dioxide (CO_2) was measured using the Enviromax 3000. These on-line portable gas analyzers measured the percentage (%) of each of the gases in the sample gas stream. The sample gas stream was drawn from the stack using a 3/8" nickelized stainless steel probe that was located at a point of average stack gas velocity. The sample gas stream was drawn through this probe, a 10 micron quartz glass filter, a nickel plated manifold, another 10 micron quartz glass filter, a chiller (to remove moisture) to the continuous monitor.

The concentration of pollutants in the sample gas stream was determined at a controlled flowrate of about 850 ml/minute for the Enerac 3000, and 2000 ml/minute for the Enviromax 3000. The Enerac 3000 and the Enviromax 3000 readings were recorded on a data sheet. The total stack gas flowrate corrected to standard conditions was obtained using the Auto5™ sampling system that was run in the stack.

2.2.8 Total Hydrocarbons

Total hydrocarbons were not measured due to equipment malfunction.

THIS PAGE INTENTIONALLY LEFT BLANK

3.0 Process Description

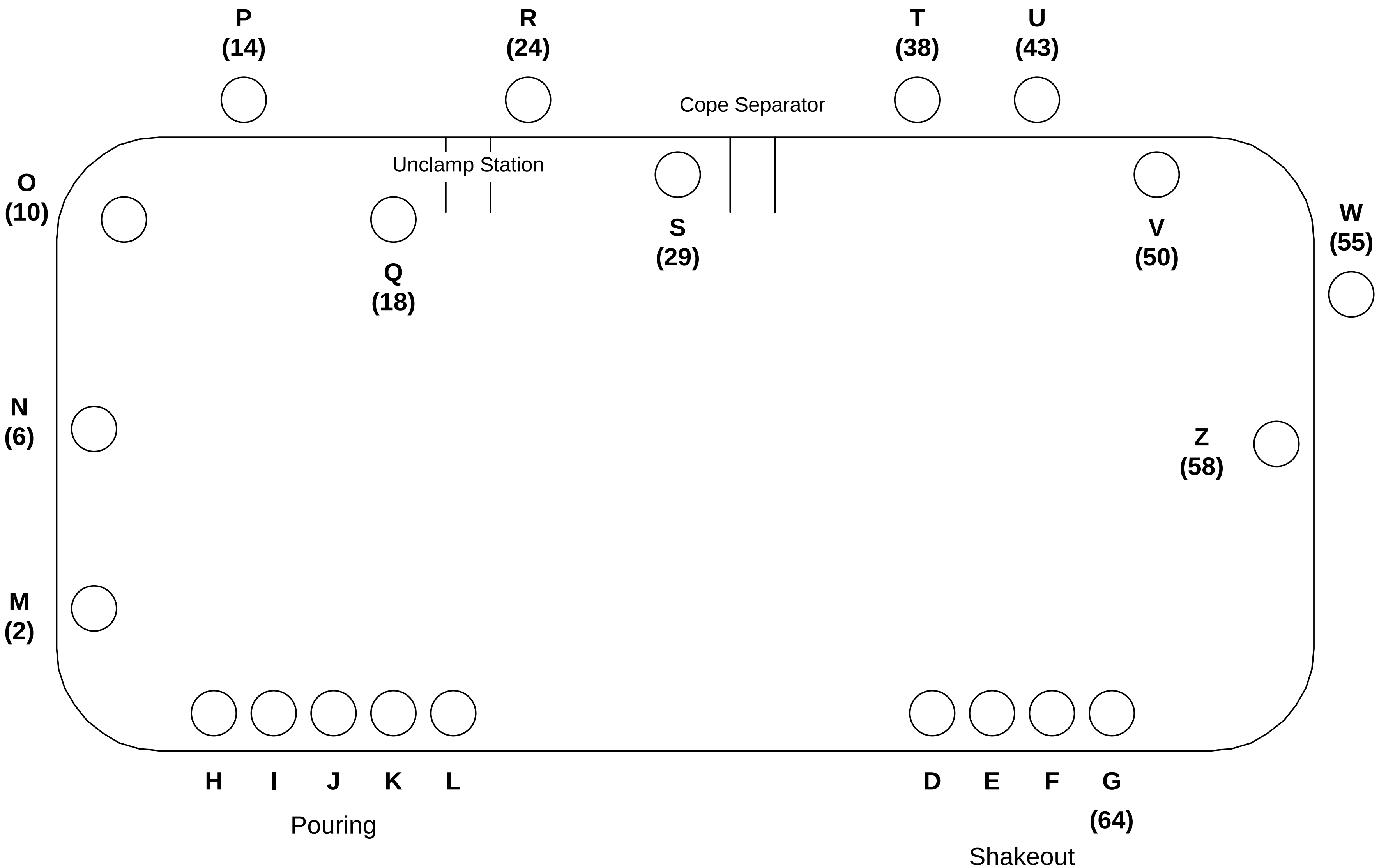
The following section describes foundry operations, lists stack parameters and characterizes the parts being produced during testing for three mold lines at the foundries.

3.1 Foundry Operations

The products of Mold Lines 1 and 2 are blocks, bearing caps, cylinder heads, manifolds, water pumps, and crankshafts. The production rate is approximately 75 - 105 molds/hr. Mold Line 3 produces blocks, cylinder heads, clutch housings, and flywheels. The production rate on Line 3 is also approximately 75 - 100 molds/hr. Figs. 3.1 – 3.3 show the molding line layouts. The basic processing steps are:

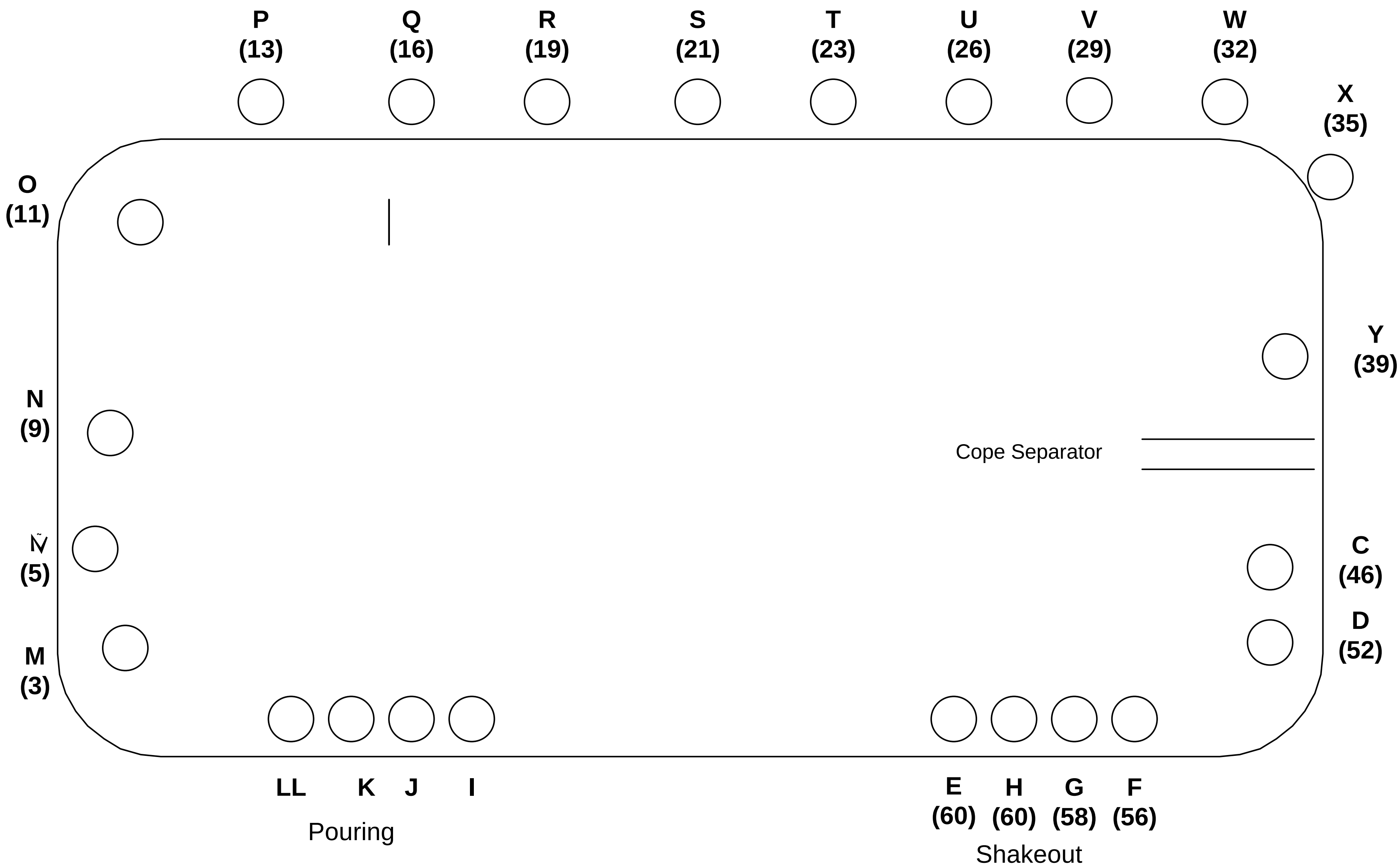
- The sand is first mixed and resin is added.
- Molds are then made and coated.
- Once the molds are coated, they proceed on the line through mold assembly points to the pouring carousel.
- Metal is poured into the mold and allowed to solidify and cool within the mold.
- The castings are removed and sent to shakeout, where the sand is removed from the casting.
- The metal castings go on for further cooling and finishing.

All three mold lines use manual pouring. The cooling time is about 50 - 60 minutes. Although four stacks for shakeout are shown for Mold Lines 1 and 2, only one stack on each line was being operated during our testing. Also, the shakeout emissions from stacks 55 – 57 on Mold Line 3 were subsequently routed through two collection stacks (58 and 59). Stacks 58 and 59 were sampled for shakeout emissions.



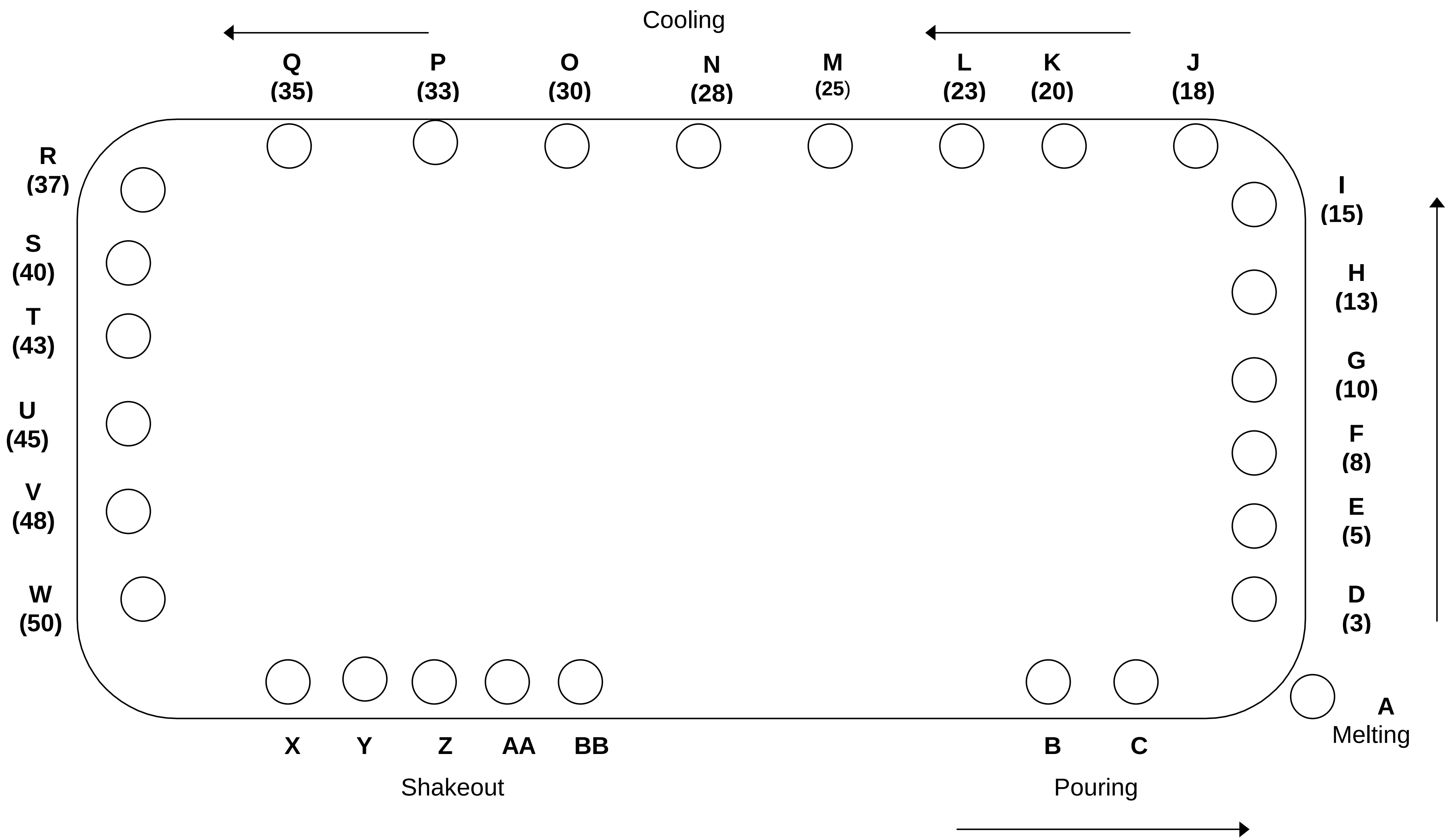
Note: Numbers in parentheses = Minutes from pour
Letters = Stack IDs

Figure 3.1. Mold Line 1 Layout



Note: Numbers in ( ) = Minutes from Pour
Letters = Stack ID's

Figure 3.2. Mold Line 2 Layout



Note: **Numbers in ( ) = Minutes from Pour**
Letters = Stack Ids

Figure 3.3. Mold Line 3 Layout

3.2 Nominal Stack Parameters

Tables 3.1 – 3.3 describe the nominal stack parameters for the stacks on Lines 1, 2, and 3. Most of the measurements were concentrated on Line 1, during the times when that line was producing engine blocks. Thus, the stack parameter data for Lines 2 and 3 are less complete than that for Line 1 due to the fact that fewer emission samples were taken on those two lines. Note that the altitude of the plants is around 7500 - 8500 feet; thus, ambient pressure and available oxygen are significantly reduced compared to sea level. Most of the stacks were near ambient temperature. The lines each had several cooling stacks. Line 1, for example had 12 separate cooling stacks and Line 2 had 16 cooling stacks. This large number of cooling stacks on a mold line is atypical of the situation for U. S. foundries, where several cooling line sections are typically routed to central collection stacks.

Table 3.1. Stack Parameters for Line 1

Stack ID **Line 1**	**Temp ° F**	**Diameter (in.)**	**Moisture Content (%)**	**Gas Molecular Wgt (lb/lb-mole)**		**Abs Gas Pressure (Hg)**	**Gas Velocity (ft/sec)**	**Flow (DSCFM)**
				Dry	**Wet**			
Sand Prep								
A	81.20	50	2.3	28.08	27.85	22.20	60.77	35,200
B	82.40	50	1.5	28.06	27.91	22.15	46.54	32,850
C	74.32	53	2.2	28.04	27.83	22.18	55.30	34,700
Shakeout								
D								2,570
E								3,220
F								1,960
G	94.12	36	1.6	28.05	27.89	22.13	48.71	14,400
Pouring								
H	81.89	36	1.5	28.07	27.92	22.16	54.07	16,300
I	90.02	36	1.5	28.05	27.90	22.17	45.67	13,800
J	84.10	36	1.5	28.06	27.91	22.16	38.86	13,700
K	80.82	36	.6	28.05	27.99	22.10	49.87	14,500
L	91.62	36	1.5	28.06	27.91	22.15	35.45	10,650
Cooling								
M	95.75	28	1.5	28.11	27.96	22.19	17.08	3,280
N	83.50	28	1.9	28.25	28.05	22.15	45.80	8,540
O	90.73	28	1.5	28.27	28.12	22.19	32.89	5,910
P	88.32	28	1.5	28.32	28.17	22.18	35.04	6,420
Q	87.41	28	2.3	28.35	28.11	22.21	41.47	6,810
R	90.55	28	1.5	28.38	28.22	22.17	16.22	6,175
S	92.88	28	1.5	28.77	28.61	22.17	19.35	6,610
T	83.85	28	2.4	28.79	28.53	22.15	30.56	5,890
U	93.50	28	3.2	28.92	28.56	22.18	30.17	5,840
V	59.04	28	.8	28.82	28.73	22.12	47.33	9,070
W	78.63	28	1.5	28.85	28.69	22.18	16.31	2,490
Z	105.92	28	1.5	28.87	28.71	22.20	25.25	4,480

Table 3.2. Stack Parameters for Line 2

Stack ID Line 2	Temp ° F	Diameter (in.)	Moisture Content (%)	Gas Molecular Wgt (lb/lb-mole)		Abs Gas Pressure (Hg)	Gas Velocity (ft/sec)	Flow (DSCFM)
				Dry	Wet			
Sand Prep								
A								
B								
Shakeout								
F	75.66	30	.018	28.87	28.68	22.14	56.14	10,300
G	68.96	33	.011	28.92	28.80	22.16	46.06	12,000
H								
Pouring								
I								
J								
K								
L								
LL								
Cooling								
M								10,000
N								10,200
ñ	61.33	30	.014	28.25	28.11	22.16	52.56	12,000
O								10,500
P	65.43	30	.019	28.27	28.08	22.16	43.78	9,900
Q								10,200
R	61.00	30	.018	28.32	28.14	22.17	52.73	12,000
S								12,100
T								11,900
U								16,000
V								8,200
W								9,800
X								5,800
Y								13,800
C								11,900
D								10,500
F								
H								
E								

Table 3.3. Stack Parameters for Line 3

Stack ID Line 3	Temp ° F	Diameter (in.)	Moisture Content (%)	Gas Molecular Wgt (lb/lb-mole)		Abs Gas Pressure (Hg)	Gas Velocity (ft/sec)	Flow (DSCFM)
				Dry	Wet			
Melting								
A	134	47	.9	28.92	28.83	22.74	48.00	23,300
Shakeout								
AA	79	30	1.7	28.91	28.73	22.64	66.95	20,700
BB	78	36	1.0	28.98	28.87	22.38	58.82	18,200
Pouring								
B	90	24	1.6	28.89	28.71	22.70	25.82	3,600
C	94	24	1.5	31.60	31.40	22.89	26.97	3,700
Cooling								
D	92	27	1.5	28.84	28.68	22.90	9.74	1,700
E	79	30	.8	28.89	28.80	22.49	39.31	8,500
F	64	18	1.5	28.88	28.72	22.89	13.10	1,100
G	60	12.5	1.5	28.89	28.73	22.90	7.91	310
H	72	36	1.5	28.89	28.73	22.85	20.52	6,500
I	70	15	1.5	28.88	28.72	22.87	15.79	840
J	77	30	1.5	28.88	28.71	22.86	15.03	3,300
K	81	13	1.5	*28.86*	28.70	22.91	13.72	560
L	75	30	1.5	28.87	28.70	22.91	19.84	4,400
M	73	15.5	1.5	28.87	28.70	22.91	10.14	560
N	70	30.5	1.5	28.84	28.68	22.88	30.14	6,900
O	84	15	1.5	28.83	28.67	22.91	6.76	380
P	79	29.5	1.5	28.83	28.67	22.88	12.66	2,700
Q	74	30	3.1	28.96	28.62	22.87	52.96	11,500
R	82	15.5	1.5	28.98	28.82	22.91	17.05	990
S	80	28	1.5	28.94	28.78	22.87	22.31	4,200
T	84	24	1.5	28.94	28.77	22.90	16.36	2,300
U	82	18	1.5	28.92	28.76	22.91	965	710
V	81	15.5	1.5	28.91	28.75	22.91	29.31	1,700
W	86	15.5	1.5	28.90	28.74	22.89	7.33	1,700

3.3 Characteristics of Parts Produced

Table 3.4 describes the characteristics of the parts produced on Mold Lines 1 and 2. Table 3.5 shows similar data for Mold Line 3. These parameters were monitored and recorded during each emission test. Values in Tables 3.4 and 3.5 are the averages over all the measurements. The major differences between Lines 1 and 2 compared to Line 3 are that on Line 3, the mold sand has a slightly higher permeability, less active clay, and greater compactibility. The loss-on-ignition (LOI) of about 5% is similar to U. S. foundries producing engine blocks. Other casting parameters are also similar to U. S. values.

Table 3.4. Characteristics of Parts Produced on Mold Lines 1 and 2

Mold Parameters

Mold Name	Nominal Molds/Hr	# of Parts On	Wgt of Iron Poured (lbs)	Wgt of Mold Sand (lbs)	Wgt of Core Sand (lbs)	Wgt of Seacoal (lbs)	Wgt of Resin (lbs)	Iron °F
Bearing Caps								
Bearing Cap 1	113.9	18	276.01	1582.00	0	79.10	0	2408 - 2480
Bearing Cap 2	93.3	12	216.74	1560.00	0	78.00	0	2408 - 2480
Bearing Cap 3	74.4	11	219.74	1560.00	0	78.00	0	2408 - 2480
Bearing Cap 4	105.0	9	289.67	1580.00	0	79.00	0	2408 - 2480
Bearing Cap 5	43.9	10	208.34	1604.94	0	80.25	0	2426 - 2498
Blocks								
Block 1	73.2	1	273.89	1472.66	110.28	73.60	2.05	2588 - 2642
Block 2	73.5	2	297.25	1403.25	172.80	70.20	3.17	2570 - 2624
Block 3	73.7	1	257.40	1437.45	155.52	71.90	2.87	2642 - 2687
Block 4	75	2	220.50	1405.10	133.0	70.0	1.11	2580 - 2620
Manifolds								
Manifold 1	95.5	2	76.82	1612.10	9.75	80.60	0.18	2552 - 2624
Manifold 2	84.0	2	78.76	1620.96	10.13	81.00	0.18	2552 - 2624
Manifold 3	104.0	2	114.93	1612.86	7.96	80.60	0.07	2516 - 2588
Manifold 4	85.4	4	163.9	1569.33	77.19	78.45	1.70	2624 - 2696

Sand Parameters

LOI	4.2 - 5.6 %
Permeability	190 AFS Units
Total Clay	18 % Max
Active Clay	5.3 - 6.7 %
Moisture Content	2.5 - 3.5 %
Temperature	77 - 95 Degrees F
Compactibility	27 - 33 %

Table 3.5. Characteristics of Parts Produced on Mold Line 3

Mold Parameters

Mold Name	Nominal Molds/Hr	# of Parts On	Wgt of Iron Poured (lbs)	Wgt of Mold Sand (lbs)	Wgt of Core Sand (lbs)	Wgt of Seacoal (lbs)	Wgt of Resin (lbs)	Temp of Iron Degrees F
Block 5	80	1	264	1,100	120	8.8	5.3	2534-2588
Cylinder Head 1	94	2	165	880	32	7.04	.768	2570-2624
Clutch Housing	88	1	70	800	0	6.4	0	2516-2588
Fly Wheels	80	2	114	700	0	5.6	0	2540-2600

Sand Parameters

LOI	4.2 - 5.6 %
Permeability	180-250 AFS Units
Total Clay	18% Max
Active Clay	4-5 %
Moisture Content	2.8- 3.4 %
Temperature	75 - 88 Degrees F
Compactibility	45 - 55 %

4.0 Sampling Matrix

It was not practical to sample every stack on each line during testing due to limited personnel and equipment. Line 1 had 24 stacks, for example (See Fig. 3.1), while there were only two sampling teams with two sets of equipment. Furthermore, the two teams were responsible for simultaneously measuring emissions of organic species, metals, and particulate matter (which was segregated into total PM, PM_{10}, and $PM_{2.5}$). Consequently, the decision was made to sample only selected stacks on the cooling line and then to extrapolate emissions from those measurements to nearby cooling stacks based on the relative stack flows. Testing of the pouring stacks was coordinated with plant personnel so that pours were made only under the pouring stacks that were sampled at the time. Tables 4.1 – 4.3 summarize the stacks for which organic, metal, and particulate matter samples, respectively, were collected for each part produced.

Table 4.1. Organic Samples Collected from Pouring, Cooling, and Shakeout

Line 1	Shakeout		Pouring		Cooling										
	F	G[1]	H[2]	K	M	N	O	P	Q	R	S	T	U	V	W
Bearing Cap															
2			12										1		
3						4			7						
5						3			3						
Block															
1		1	5			13			8			5	8	11	
2									7			8	4		
3		11	8	8											
Manifold															
1		6													
2												6			
3		3													
4						6									

Line 2	Shakeout		Pouring		Cooling											
	F	G	H	K	M	N	Ñ	O	P	Q	R	S	T	U	V	W
Bearing Cap																
1	3	3														
4		3														
Crankshaft																
1							2		2		2					
Combo[3]																
3		3														

Line 3	Shakeout		Pouring		Cooling			
	58	59	29	30	31	32	---	51
Block 5	1					3		
Clutch Housing	5	6	1					
Cylinder Head	3							
Fly Wheel						3		

[1]Total shakeout emissions were routed to stack G. Stack F was not running.

[2]Total pouring emissions were routed to stack H or K.

[3]This part is a combination of bearing caps and cylinder heads.

Table 4.2. Metal Samples (Method 29) Collected by Part

Line 1	Shakeout		Pouring		Cooling										
	F	G[1]	H[2]	K	M	N	O	P	Q	R	S	T	U	V	W
Bearing Cap															
2			2	1											
3			1	1					2						
5				1					1						
Block															
1		3	1			1			2			3	2		
2			2			2			1				1		
3				3											
Combo[3]															
1		1													
2		1													
Manifold															
1															
2															
3															
4				1											

Line 2	Shakeout		Pouring		Cooling										
	F	G	H	K	M	N	O	P	Q	R	S	T	U	V	W
Bearing Cap															
1		2													
4															
Combo[4]															
3		1													

Line 3	Melting	Shakeout		Pouring		Cooling					
	27	58	59	29	30	31	32	---	46	---	52
Melting	1										
Block 5		3		2							
Clutch Housing				2			2		2		
Cylinder Head		1									
Fly Wheel							3				

[1]Total shakeout emissions were routed to stack G. Stack F was not running.

[2]Total pouring emissions were routed to stack H or K.

[3]Combo 1 is a combination of Manifold 2 and Water Pumps. Combo 2 combines Manifolds 2 and 4.

[4]Combo 3 is a combination of Bearing Caps and Cylinder Heads.

Table 4.3. Particulate Matter (Total, PM_{10} & $PM_{2.5}$)

Line 1	Shakeout		Pouring		Cooling										
	F	G[1]	H[2]	K	M	N	O	P	Q	R	S	T	U	V	W
Bearing Cap															
2		3													
3						2									
5						1									
Block															
1		1	3			1			2			1	1	3	
2						2			1			2			
3		2											2		
Manifold															
4															
Combo[3]															
1															
2															

Line 2	Shakeout		Pouring		Cooling										
	F	G	H	K	M	N	O	P	Q	R	S	T	U	V	W
Bearing Cap															
1	1	2													
Combo[4]															
3		1													

[1] Total shakeout emissions were routed to stack G. Stack F was not running.

[2] Total pouring emissions were routed to stack H or K.

[3] Combo 1 is a combination of Manifold 2 and Water Pumps. Combo 2 combines Manifolds 2 and 4.

[4] This part is a combination of bearing caps and cylinder heads.

THIS PAGE INTENTIONALLY LEFT BLANK

5.0 Results and Discussion

This section includes all the emissions measurement data on organic emissions, metals, and particulate matter and relates those emissions to production data. Results are reported in terms of lb HAP/hr emission rates as well as lb emissions per unit of production quantity; for example, as lb HAP/ton iron poured and lb HAP/ton seacoal. Processes covered include pouring, cooling, shakeout, core making, and metal melting.

5.1 Emission Factors - Pouring, Cooling, Shakeout

5.1.1 VOC Emissions

<u>5.1.1.1 Pouring</u>

Table 5.1 lists the emissions from pouring in units of lb species/ton metal poured for all casting parts for which results were obtained. Results are shown for two of the mold lines (1 and 3) that were tested. For Line 1, results from two stacks are shown because of the logistics of coordinating manual pours under stacks being sampled; for the purposes of this analysis, the two stacks are thus equivalent. The average pouring emissions from block production are shown in the last column of Table 5.1. Figure 5.1 shows some of the major species emitted from pouring. They include benzene and other aromatic species, formaldehyde, and phenol; emissions of benzene are highest. Generally, the pouring emissions from engine block production are lower than those from either clutch housing or bearing cap production, although the clutch housing and block emissions are close to each other for several species, including benzene, ethyl benzene, xylenes, and toluene.

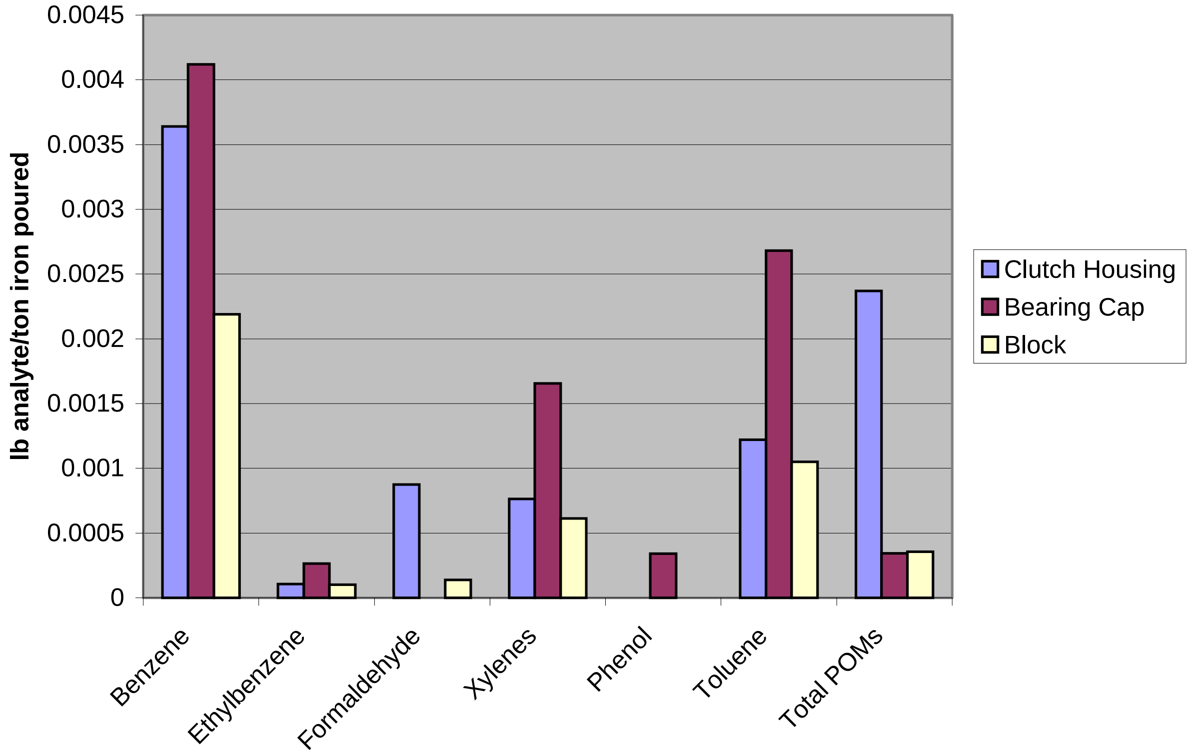


Figure 5.1. Emission Factors For Major Species Emitted from Pouring

Table 5.1. Emissions From Pouring (Average Lb / Ton Metal Poured)

	Line 3 Stack 29	Line 1 Stack H			Line 1 Stack K	Line 1 Pouring Average
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	ND	2.69E-04	ND	ND	1.98E-04	9.91E-05
1,2,4-Trimethylbenzene	2.85E-04	4.04E-04	1.91E-04	3.54E-04	2.33E-04	2.53E-04
1,2-Diethylbenzene	ND	ND	3.06E-05	ND	ND	7.65E-06
1,3,5-Trimethylbenzene	5.71E-05	2.13E-04	8.81E-05	1.87E-04	1.03E-04	1.20E-04
1,3-Diethylbenzene	8.75E-05	ND	ND	ND	ND	ND
1,3-Diisopropylbenzene	1.22E-04	5.29E-05	2.91E-05	ND	ND	7.27E-06
1,3-Dimethylnaphthalene	1.10E-04	ND	ND	9.06E-06	4.13E-06	4.33E-06
1,4-Diethylbenzene	3.23E-04	2.19E-04	1.07E-04	7.97E-05	ND	4.67E-05
1,4-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND
1-Methylnaphthalene	4.22E-04	6.19E-05	1.56E-05	8.37E-05	1.04E-04	7.69E-05
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	1.14E-04	ND	2.55E-05	ND	ND	6.37E-06
2,3-Dimethylnaphthalene	7.99E-05	ND	ND	ND	ND	ND
2,3-Dimethylphenol	ND	ND	1.44E-04	ND	ND	3.59E-05
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	2.47E-04	ND	ND	ND	ND	ND
2,6-Dimethylnaphthalene	8.37E-05	ND	ND	ND	ND	ND
2,6-Dimethylphenol	ND	ND	3.36E-05	ND	ND	8.40E-06
2,7-Dimethylnaphthalene	ND	7.08E-06	ND	5.08E-06	ND	1.27E-06
2-Ethyltoluene	6.85E-05	7.29E-05	1.65E-05	7.77E-05	4.54E-05	4.62E-05
2-Methylnaphthalene	6.88E-04	9.42E-05	2.13E-05	1.31E-04	1.06E-04	9.10E-05
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	ND	ND	1.83E-05	ND	ND	4.57E-06
3,5-Dimethylphenol	9.89E-05	ND	5.58E-05	ND	8.99E-05	5.89E-05
3-Ethyltoluene	ND	2.21E-04	5.29E-05	ND	ND	1.32E-05
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	ND	6.17E-05	9.09E-05	6.85E-05	ND	3.99E-05
a-Methylstyrene	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	ND	ND	ND	ND	3.01E-06	1.51E-06
Acetaldehyde	1.61E-03	4.30E-04	1.54E-04	5.03E-04	2.00E-04	2.94E-04
Acetone	9.88E-03	5.65E-04	2.99E-04	6.40E-04	3.15E-04	4.21E-04
Acetophenone	ND	ND	ND	ND	ND	ND
Acrolein	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND
Benzene	3.64E-03	4.12E-03	8.73E-04	3.63E-03	2.12E-03	2.19E-03
Benzidine	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	3.93E-04	ND	ND	ND	ND	ND
Butylbenzene	ND	ND	ND	ND	ND	ND
Crotonaldehyde	ND	ND	ND	ND	ND	ND
Cumene	ND	1.36E-05	ND	1.35E-05	5.24E-06	6.00E-06
Cyclohexane	ND	ND	ND	ND	ND	ND
Decane	3.04E-04	6.87E-04	3.13E-04	7.47E-04	3.93E-04	4.62E-04
Dibenzofuran	ND	ND	ND	ND	ND	ND
Dodecane	7.42E-04	6.81E-04	2.74E-04	9.52E-04	6.38E-04	6.26E-04
Ethylbenzene	1.07E-04	2.65E-04	8.53E-05	1.50E-04	8.44E-05	1.01E-04
Formaldehyde	8.74E-04	ND	ND	2.87E-04	8.36E-05	1.38E-04
Heptane	1.56E-04	1.12E-03	2.67E-04	4.35E-04	2.12E-04	2.81E-04
Hexanal	ND	ND	ND	ND	ND	ND
Indan	9.13E-05	1.04E-04	2.55E-05	3.23E-05	ND	1.44E-05
Indene	ND	1.17E-04	3.51E-05	9.43E-05	ND	3.23E-05
Isobutylbenzene	4.94E-05	3.02E-05	6.30E-06	ND	ND	1.57E-06
m,p-Cresol	2.40E-04	ND	ND	ND	ND	ND
m,p-Xylene	5.02E-04	1.16E-03	2.96E-04	6.39E-04	3.77E-04	4.22E-04
m-Tolualdehyde	4.06E-04	ND	ND	ND	ND	ND
Methacrolein	4.71E-04	ND	ND	ND	ND	ND
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	7.50E-05	ND	ND	ND	ND
Naphthalene	9.89E-04	1.80E-04	8.73E-05	2.88E-04	1.74E-04	1.81E-04
Nitrobenzene	ND	ND	ND	ND	ND	ND
Nonane	1.33E-04	5.41E-04	1.98E-04	3.08E-04	7.41E-05	1.63E-04
o-Anisidine	ND	ND	ND	ND	ND	ND
o-Cresol	1.42E-03	ND	6.60E-06	ND	ND	1.65E-06
o-Toluidine	ND	ND	ND	ND	ND	ND
o-Xylene	2.62E-04	4.95E-04	1.66E-04	2.95E-04	1.50E-04	1.90E-04
Octane	1.33E-04	6.54E-04	9.42E-05	3.09E-04	1.27E-04	1.64E-04
p-cymene	1.86E-04	4.04E-05	1.52E-04	3.54E-04	ND	1.27E-04
p-Phenylenediamine	ND	ND	ND	ND	ND	ND
Phenol	ND	3.40E-04	1.03E-04	4.92E-04	2.74E-04	2.86-04
Propanal	ND	ND	ND	ND	ND	ND
Styrene	1.26E-04	4.49E-05	1.17E-05	7.87E-05	6.10E-05	5.31E-05
Tetradecane	2.36E-04	7.71E-05	2.10E-05	1.11E-04	5.35E-05	5.98E-05
Toluene	1.22E-03	2.68E-03	6.88E-04	1.51E-03	1.01E-03	1.05E-03
Tridecane	6.12E-04	3.30E-04	1.35E-04	4.32E-04	2.67E-04	2.75E-04
Undecane	1.23E-03	1.18E-03	5.08E-04	1.60E-03	8.84E-04	9.68E-04
Valeraldehyde	ND	ND	ND	ND	ND	ND
Total POMs	2.37E-03	3.43E-04	1.24E-04	5.17E-04	3.91E-04	3.56E-04

Notes:
ND = not detected
Blank Spaces = not sampled
Manual pours done under stacks H or K during measurements

THIS PAGE INTENTIONALLY LEFT BLANK

5.1.1.2 Shakeout

Table 5.2 lists the emissions from shakeout for all parts measured; in this case, blocks and manifolds on Line 1; and clutch housings and cylinder heads on Line 3. Shakeout emissions from Line 3 were routed to both Stacks 58 and 59. The emissions from these stacks should thus be added together for each part. However, it was possible to obtain emissions measurements for both stacks only for the clutch housings; this sum for the clutch housing is shown in Table 5.2. The last column of Table 5.2 shows the shakeout emissions for block production.

Figure 5.2 compares the major shakeout emissions from clutch housing production on Line 3 and engine block production on Line 1. The shakeout emissions from Line 3 are much higher. It is important to note that not all the emissions from shakeout were captured on Line 1. The mold was first broken apart in an open area. Then, the mold and casting continued on to an area in which emissions were captured. The shakeout emissions for block production are, therefore, an underestimate.

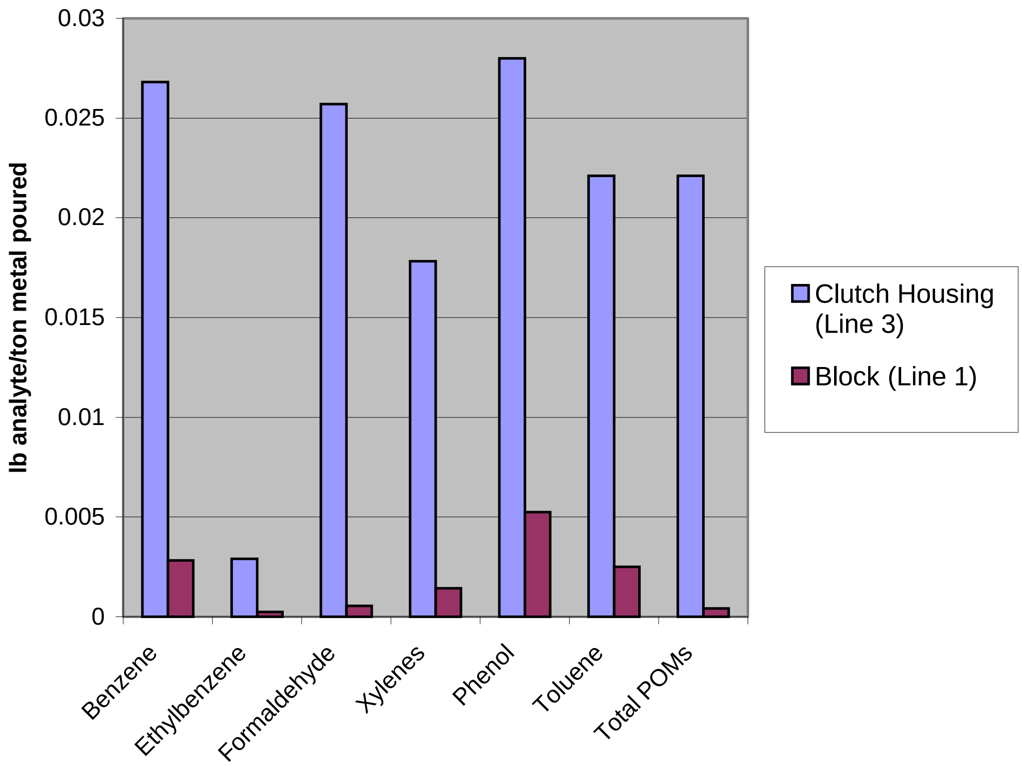


Figure 5.2. Emission Factors for Major Species Emitted from Shakeout

THIS PAGE INTENTIONALLY LEFT BLANK

Table 5.2. Emissions from Shakeout (Average Lb / Ton Metal Poured)

	Line 3 Stack 58	Line 3 Stack 58	Line 3 Stack 59	Line 3 Sum	Line 1 Stack G				Line 1 SHAKEOUT
Analyte Name	**Cylinder Head**	**Clutch Housing**	**Clutch Housing**	**Clutch Housing**	**Block 1**	**Block 3**	**Manifold 1**	**Manifold 3**	**Average Blocks (1, 3)**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND			ND
1,2,3-Trimethylbenzene	ND	6.88E-04	ND	6.88E-04	4.06E-04	ND			1.35E-04
1,2,4-Trimethylbenzene	5.57E-04	4.26E-03	2.22E-03	6.48E-03	6.44E-04	4.55E-04			5.18E-04
1,2-Diethylbenzene	1.25E-05	2.18E-03	2.63E-04	2.44E-03	ND	1.91E-05			1.27E-05
1,3,5-Trimethylbenzene	5.07E-04	2.65E-03	1.06E-03	3.71E-03	3.07E-04	2.08E-04			2.41E-04
1,3-Diethylbenzene	5.62E-05	ND	5.71E-04	5.71E-04	ND	ND			ND
1,3-Diisopropylbenzene	ND	1.69E-03	4.61E-04	2.15E-03	ND	6.39E-05			4.26E-05
1,3-Dimethylnaphthalene	ND	8.55E-04	1.73E-04	1.03E-03	ND	ND			ND
1,4-Diethylbenzene	3.96E-05	3.54E-03	7.42E-04	4.29E-03	ND	1.85E-04			1.23E-04
1,4-Dimethylnaphthalene	ND	3.98E-04	6.57E-05	4.64E-04	ND	ND			ND
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND			ND
1,8-Dimethylnaphthalene	ND	1.04E-03	2.54E-05	1.06E-03	ND	ND			ND
1-Methylnaphthalene	1.03E-04	2.92E-03	4.95E-04	3.41E-03	ND	5.48E-05			3.65E-05
2,3,5-Trimethylnaphthalene	ND	6.84E-04	3.01E-05	7.14E-04	ND	ND			ND
2,3,5-Trimethylphenol	3.23E-05	2.70E-03	6.72E-04	3.38E-03	ND	2.34E-05			1.56E-05
2,3-Dimethylnaphthalene	2.32E-05	5.34E-04	1.16E-04	6.50E-04	ND	1.60E-05			1.07E-05
2,3-Dimethylphenol	3.12E-05	7.14E-03	1.39E-03	8.54E-03	2.87E-04	3.25E-04			3.12E-04
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND			ND
2,4-Diaminobiphenyl	ND	ND	ND	ND		ND	ND	ND	ND
2,5-Dimethylphenol	ND	2.89E-03	5.03E-04	3.39E-03	ND	ND			ND
2,6-Dimethylnaphthalene	1.46E-05	4.58E-04	1.10E-04	5.68E-04	ND	ND			ND
2,6-Dimethylphenol	4.06E-05	1.94E-03	7.68E-05	2.02E-03	ND	5.04E-05			3.36E-05
2,7-Dimethylnaphthalene	ND	3.47E-04	6.32E-05	4.10E-04	ND	ND			ND
2-Ethyltoluene	4.44E-05	1.69E-03	8.47E-04	2.53E-03	1.58E-04	1.12E-04			1.28E-04
2-Methylnaphthalene	1.76E-04	4.39E-03	8.30E-04	5.22E-03	ND	6.98E-05			4.65E-05
3,3'-Dimethoxybenzidine	ND	ND	ND	ND		ND	ND	ND	ND
3,4-Dimethylphenol	3.44E-05	3.01E-03	7.31E-04	3.74E-03	ND	1.40E-04			9.31E-05
3,5-Dimethylphenol	ND	4.30E-03	7.66E-04	5.07E-03	ND	1.26E-04			8.37E-05
3-Ethyltoluene	7.52E-04	2.24E-03	8.62E-04	3.10E-03	2.77E-04	ND			9.24E-05
4,4'-Methylene Bis(2-Chloroaniline)	ND	ND	ND	ND		ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND		ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND		ND	ND	ND	ND
4-Ethyltoluene	5.94E-04	3.90E-03	1.25E-03	5.16E-03	2.87E-04	2.12E-04			2.37E-04
a-Methylstyrene	5.54E-05	ND	ND	ND	ND	ND			ND
Acenaphthalene/1,2-Dimethylnaphthalene	2.09E-05	1.75E-04	4.46E-05	2.20E-04	ND	ND			ND
Acetaldehyde	5.24E-04	4.12E-02	1.65E-02	5.78E-02		4.88E-04	2.56E-03	1.77E-04	4.88E-04
Acetone	1.05E-03	2.68E-02	1.07E-02	3.75E-02		9.11E-04	1.58E-03	1.94E-04	9.11E-04
Acetophenone	2.81E-05	2.25E-04	5.67E-04	7.92E-04	ND	ND			ND
Acrolein	ND	ND	2.20E-04	2.20E-04		ND	ND	ND	ND
Aniline	ND	ND	ND	ND		ND			ND
Benzene	3.03E-03	1.86E-02	8.18E-03	2.68E-02	4.12E-03	2.16E-03			2.82E-03
Benzidine	ND	ND	ND	ND		ND	ND	ND	ND
Benzofuran	ND	1.93E-03	ND	1.93E-03	ND	ND			ND
Bibenzyl	ND	7.81E-05	ND	7.81E-05	ND	ND			ND
Biphenyl	ND	5.16E-04	ND	5.16E-04	ND	ND			ND
Butanal/Benzaldehyde	2.31E-04	9.44E-03	3.37E-03	1.28E-02		4.43E-05	2.32E-04	ND	4.43E-05
Butylbenzene	ND	1.27E-03	4.53E-04	1.73E-03	2.48E-04	ND			8.25E-05
Crotonaldehyde	ND	ND	ND	ND		ND	ND	ND	ND
Cumene	ND	3.13E-04	6.84E-05	3.82E-04	ND	ND			ND
Cyclohexane	ND	ND	ND	ND	ND	ND			ND
Decane	2.92E-04	8.88E-03	3.06E-03	1.19E-02	6.44E-04	2.32E-04			3.69E-04
Dibenzofuran	ND	3.03E-04	3.14E-05	3.34E-04	ND	ND			ND
Dodecane	4.72E-04	1.32E-02	4.14E-03	1.74E-02	4.16E-04	2.66E-04			3.16E-04
Ethylbenzene	2.29E-04	1.55E-03	1.36E-03	2.91E-03	3.57E-04	1.92E-04			2.47E-04
Formaldehyde	6.88E-05	1.98E-02	5.88E-03	2.57E-02		5.43E-04	ND	4.54E-04	5.43E-04
Heptane	8.18E-05	5.73E-04	8.48E-04	1.42E-03	7.23E-04	1.94E-03			1.53E-03
Hexanal	ND	1.05E-03	5.66E-04	1.62E-03		ND	ND	ND	ND
Indan	8.70E-05	1.91E-03	3.62E-04	2.27E-03	2.08E-04	6.53E-05			1.13E-04
Indene	1.96E-04	2.54E-03	4.92E-04	3.03E-03	1.29E-04	1.78E-04			1.62E-04
Isobutylbenzene	1.35E-05	1.92E-04	1.24E-04	3.16E-04	ND	ND			ND
m,p-Cresol	ND	6.36E-04	ND	6.36E-04	ND	ND			ND
m,p-Xylene	1.19E-03	7.06E-03	5.45E-03	1.25E-02	1.27E-03	8.20E-04			9.69E-04
m-Tolualdehyde	ND	1.56E-02	4.73E-03	2.04E-02		ND	ND	ND	ND
Methacrolein	ND	1.46E-02	3.10E-03	1.77E-02		9.14E-05	ND	ND	9.14E-05
Methyl Ethyl Ketone	ND	ND	ND	ND		ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	5.65E-04	ND			1.88E-04
N,N-Dimethylaniline	ND	ND	ND	ND		ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND		ND	ND		ND
n-Propylbenzene	3.53E-05	ND	ND	ND	1.29E-04	ND			4.29E-05
Naphthalene	4.58E-04	6.62E-03	1.75E-03	8.37E-03	2.08E-04	3.78E-04			3.21E-04
Nitrobenzene	ND	ND	ND	ND	ND	ND			ND
Nonane	4.58E-05	3.20E-03	1.70E-03	4.90E-03	4.56E-04	1.98E-04			2.84E-04
o-Anisidine	ND	ND	ND	ND		ND	ND	ND	ND
o-Cresol	ND	1.15E-02	2.51E-03	1.40E-02	ND	3.51E-04			2.34E-04
o-Toluidine	ND	ND	ND	ND		ND	ND	ND	ND
o-Xylene	4.15E-04	2.74E-03	2.57E-03	5.32E-03	6.54E-04	3.70E-04			4.64E-04
Octane	1.22E-04	1.32E-03	9.95E-04	2.32E-03	2.97E-04	1.93E-04			2.28E-04
p-cymene	2.45E-04	4.02E-03	1.99E-03	6.01E-03	ND	1.67E-04			1.12E-04
p-Phenylenediamine	ND	ND	ND	ND		ND	ND	ND	ND
Phenol	3.61E-04	2.02E-02	7.81E-03	2.80E-02	ND	7.88E-03			5.25E-03
Propanal	ND	3.82E-03	1.87E-03	5.70E-03		ND	ND	ND	ND
Styrene	6.57E-05	3.53E-03	1.28E-03	4.81E-03	1.68E-04	5.60E-05			9.35E-05
Tetradecane	1.00E-04	1.30E-03	8.60E-04	2.16E-03	ND	7.89E-05			5.26E-05
Toluene	1.92E-03	1.31E-02	8.96E-03	2.21E-02	3.37E-03	2.07E-03			2.50E-03
Tridecane	2.56E-04	7.26E-03	1.92E-03	9.18E-03	2.18E-04	1.66E-04			1.83E-04
Undecane	8.49E-04	2.36E-02	6.34E-03	3.00E-02	1.00E-03	5.08E-04			6.72E-04
Valeraldehyde	ND	1.72E-03	9.05E-04	2.62E-03		ND	ND	ND	ND
Total POMs	7.96E-04	1.84E-02	3.70E-03	2.21E-02	2.08E-04	5.18E-04			4.15E-04

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

5.1.1.3 Cooling

The three mold lines had more cooling stacks than was practical to measure in the length of time allotted to the effort. For example, mold line 1 had about cooling 15 stacks. Consequently, emissions from only selected stacks on the cooling lines were actually measured, and emissions from the other cooling stacks were estimated. We did, however, measure the flows and other stack gas characteristics for every cooling stack.

Table 5.3 shows the emissions from Stack 32, one of the 21 cooling stacks on Line 3. Here, emissions were measured from Block 5 and from the flywheel. Note that the emissions from the 21 total cooling stacks would be far greater than the emissions reported in Table 5.3 for just one cooling stack.

Table 5.4 shows emissions data for each cooling stack measured on Line 1 and also shows which castings were being made during the sampling event. We tried to maximize the number of samples taken during engine block production, as can be seen in Table 5.4.

The species emitted during cooling for the two mold lines are similar, as can be seen by comparing emissions from Line 3 to those from Line 1. The emissions from Stack 32, located at 5-6 min into cooling on Line 3, can best be compared to emissions from Stack N, located 6 min into cooling on Line 1. Major species emitted from both mold lines at 6 min into cooling include benzene, toluene, xylene, and ethyl benzene.

Emissions from the various cooling stacks on Line 1 are shown in Figs. 5.3 – 5.7. Details on the estimated emissions from cooling stacks not measured can be found in Appendix C. Units for all these results are in lb HAP/ton iron poured. For additional data, see Appendix A. Figure 5.3 shows emissions of the major aromatic species benzene, toluene, xylenes, and phenol for every cooling stack, based on measurements for some stacks and calculated emissions for the other stacks; these results are averages over the engine block castings 1and 2. Benzene was by far the major species emitted. Figures 5.4 – 5.7 compare the major organic emissions from all the cooling stacks across the different parts: engine blocks and bearing caps. The figures show that, for the major species plotted, the emissions are similar, regardless of whether the casting being produced is an engine block or a bearing cap. For example, as seen in Figure 5.4, the polycyclic organic matter (POM) emissions are similar for both engine blocks even though one block is a 4-cylinder and the other is an 8-cylinder. Likewise, the emissions of benzene are similar for both the engine blocks and the bearing caps (See Fig. 5.5) even though the bearing caps would be expected to have very different surface areas from the engine blocks.

Table 5.5 shows the total cooling emissions for engine block production on Line 1. These results include both measured and estimated stacks. The sum of cooling emissions for all the cooling stacks is shown in the last column of Table 5.5.

Table 5.3. Volatile Organic Compound Emissions from Cooling Stack 32 on Line 3

Analyte	Average Block 5 Lb/ton Iron	Average Flywheel Lb/ton Iron
1,1,2-Trichloroethane	0.00E+00	0.00E+00
1,2,3-Trimethylbenzene	0.00E+00	0.00E+00
1,2,4-Trimethylbenzene	2.91E-04	5.99E-04
1,2-Diethylbenzene	0.00E+00	0.00E+00
1,3,5-Trimethylbenzene	2.37E-04	3.49E-04
1,3-Diethylbenzene	1.23E-04	1.80E-04
1,3-Diisopropylbenzene	0.00E+00	3.28E-05
1,3-Dimethylnaphthalene	0.00E+00	0.00E+00
1,4-Diethylbenzene	7.73E-05	2.81E-04
1,4-Dimethylnaphthalene	0.00E+00	0.00E+00
1,6-Dimethylnaphthalene	0.00E+00	0.00E+00
1,8-Dimethylnaphthalene	0.00E+00	0.00E+00
1-Methylnaphthalene	0.00E+00	8.65E-04
2,3,5-Trimethylnaphthalene	0.00E+00	0.00E+00
2,3,5-Trimethylphenol	0.00E+00	2.67E-05
2,3-Dimethylnaphthalene	0.00E+00	0.00E+00
2,3-Dimethylphenol	0.00E+00	0.00E+00
2,4,6-Trimethylphenol	0.00E+00	2.55E-04
2,4-Diaminobiphenyl	0.00E+00	0.00E+00
2,5-Dimethylphenol	0.00E+00	9.48E-05
2,6-Dimethylnaphthalene	0.00E+00	2.80E-04
2,6-Dimethylphenol	0.00E+00	2.06E-04
2,7-Dimethylnaphthalene	0.00E+00	0.00E+00
2-Ethyltoluene	1.23E-04	0.00E+00
2-Methylnaphthalene	0.00E+00	1.31E-03
3,3'-Dimethoxybenzidine	0.00E+00	0.00E+00
3,4-Dimethylphenol	0.00E+00	0.00E+00
3,5-Dimethylphenol	0.00E+00	5.47E-05
3-Ethyltoluene	2.43E-04	0.00E+00
4,4'-Methylene Bis (2-Chloroaniline)	0.00E+00	0.00E+00
4,4'-Methylenedianiline	0.00E+00	0.00E+00
4-Aminobiphenyl	0.00E+00	0.00E+00
4-Ethyltoluene	1.76E-04	0.00E+00
a-Methylstyrene	0.00E+00	1.31E-04
Acenaphthalene/1,2-Dimethylnaphthalene	0.00E+00	1.37E-04
Acetaldehyde	0.00E+00	2.84E-03
Acetone	1.91E-04	1.78E-03
Acetophenone	0.00E+00	0.00E+00
Acrolein	0.00E+00	0.00E+00
Aniline	0.00E+00	0.00E+00
Benzene	1.16E-02	7.79E-03
Benzidine	0.00E+00	0.00E+00
Benzofuran	0.00E+00	0.00E+00
Bibenzyl	0.00E+00	0.00E+00
Biphenyl	0.00E+00	0.00E+00

Table 5.3. (continued)

Analyte	Average Block 5 Lb/ton Iron	Average Flywheel Lb/ton Iron
Butanal/Benzaldehyde	0.00E+00	7.58E-04
Butylbenzene	0.00E+00	2.73E-04
Crotonaldehyde	0.00E+00	0.00E+00
Cumene	0.00E+00	2.07E-05
Cyclohexane	0.00E+00	0.00E+00
Decane	1.92E-04	3.58E-04
Dibenzofuran	0.00E+00	4.01E-05
Dodecane	1.44E-04	3.28E-05
Ethylbenzene	2.52E-04	1.05E-04
Formaldehyde	0.00E+00	4.23E-04
Heptane	2.19E-04	1.53E-04
Hexanal	0.00E+00	0.00E+00
Indan	5.02E-05	5.35E-05
Indene	0.00E+00	0.00E+00
Isobutylbenzene	3.90E-05	4.62E-05
m,p-Cresol	0.00E+00	0.00E+00
m,p-Xylene	1.42E-03	8.24E-04
m-Tolualdehyde	0.00E+00	5.38E-04
Methacrolein	0.00E+00	4.59E-04
Methyl Ethyl Ketone	0.00E+00	0.00E+00
Methyl Methacrylate	0.00E+00	0.00E+00
N,N-Dimethylaniline	0.00E+00	0.00E+00
N-Nitrosodimethylamine	0.00E+00	0.00E+00
n-Propylbenzene	2.03E-05	0.00E+00
Naphthalene	3.76E-05	1.57E-03
Nitrobenzene	0.00E+00	0.00E+00
Nonane	1.44E-04	1.01E-04
o-Anisidine	0.00E+00	0.00E+00
o-Cresol	1.25E-04	1.40E-03
o-Toluidine	0.00E+00	0.00E+00
o-Xylene	3.91E-04	2.77E-04
Octane	3.80E-04	4.05E-04
p-cymene	1.76E-04	1.73E-04
Phenol	0.00E+00	5.19E-03
p-Phenylenediamine	0.00E+00	0.00E+00
Propanal	0.00E+00	3.70E-04
Styrene	1.37E-04	1.54E-04
Tetradecane	2.37E-05	1.14E-04
Toluene	3.23E-03	2.41E-03
Tridecane	6.60E-05	2.82E-04
Undecane	2.74E-04	1.13E-03
Valeraldehyde	0.00E+00	1.98E-04
Total POMs	3.76E-05	4.16E-03

THIS PAGE INTENTIONALLY LEFT BLANK

Table 5.4. Measured VOC Emissions from Line 1 Cooling Stacks (Average Lb / Ton Metal Poured)

	Stack N				Stack Q				Stack T			Stack U			Stack V
Analyte Name	Bearing Cap 3	Bearing Cap 5	Block 1	Manifold 4	Bearing Cap 3	Bearing Cap 5	Block 1	Block 2	Block 1	Block 2	Manifold 2	Bearing Cap 2	Block 1	Block 2	Block 1
1,1,2-Trichloroethane	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
1,2,3-Trimethylbenzene	2.65E-04		5.32E-05		1.55E-04		ND	ND	1.43E-04	4.07E-04		3.00E-04	2.56E-04	3.46E-04	3.14E-04
1,2,4-Trimethylbenzene	ND		1.74E-04		4.15E-04		2.42E-04	2.23E-04	2.73E-04	8.54E-04		6.32E-04	3.80E-04	2.14E-04	6.13E-04
1,2-Diethylbenzene	ND		1.85E-05		ND		1.16E-05	ND	3.74E-05	1.15E-04		8.45E-05	ND	ND	2.61E-05
1,3,5-Trimethylbenzene	1.69E-04		8.06E-05		1.71E-04		1.44E-04	1.37E-04	1.52E-04	4.52E-04		3.15E-04	1.24E-04	1.07E-04	3.79E-04
1,3-Diethylbenzene	ND		ND		1.61E-05		5.28E-05	2.00E-05	1.35E-05	ND		6.41E-05	ND	ND	ND
1,3-Diisopropylbenzene	ND		2.31E-05		ND		1.37E-05	ND	1.78E-05	1.35E-04		9.03E-05	ND	ND	3.26E-05
1,3-Dimethylnaphthalene	6.87E-06		1.36E-05		1.24E-05		6.86E-06	ND	ND	2.52E-05		ND	1.80E-05	ND	2.53E-05
1,4-Diethylbenzene	ND		6.63E-05		1.41E-04		4.10E-05	7.65E-05	6.68E-05	ND		2.24E-04	7.54E-05	ND	2.20E-04
1,4-Dimethylnaphthalene	ND		3.20E-06		9.22E-06		3.60E-06	5.19E-06	ND	5.76E-06		ND	ND	ND	ND
1,6-Dimethylnaphthalene	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND		1.83E-06		ND		ND	ND	ND	1.31E-06		ND	1.38E-06	ND	ND
1-Methylnaphthalene	7.75E-05		1.57E-04		3.97E-05		1.69E-05	1.94E-05	2.09E-05	2.97E-04		ND	1.06E-04	2.65E-06	1.58E-04
2,3,5-Trimethylnaphthalene	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
2,3,5-Trimethylphenol	ND		1.91E-05		ND		1.34E-05	ND	2.48E-06	3.32E-05		6.41E-05	ND	ND	5.15E-05
2,3-Dimethylnaphthalene	ND		3.74E-06		ND		6.18E-06	7.89E-06	ND	2.23E-05		ND	1.36E-05	ND	2.37E-05
2,3-Dimethylphenol	ND		9.66E-05		ND		1.13E-04	ND	1.02E-04	4.90E-04		2.51E-04	ND	ND	1.30E-04
2,4,6-Trimethylphenol	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
2,5-Dimethylphenol	ND		ND		ND		ND	ND	ND	9.74E-04		ND	ND	6.45E-06	ND
2,6-Dimethylnaphthalene	ND		ND		ND		4.50E-06	ND	ND	ND		ND	ND	ND	ND
2,6-Dimethylphenol	ND		1.71E-05		ND		1.51E-05	ND	3.65E-05	3.34E-04		1.08E-04	ND	ND	ND
2,7-Dimethylnaphthalene	ND		3.15E-06		9.22E-06		ND	4.62E-06	ND	1.52E-05		ND	7.58E-06	ND	ND
2-Ethyltoluene	1.16E-04		3.67E-05		9.86E-05		2.92E-05	5.65E-05	6.81E-05	1.85E-04		1.51E-04	1.14E-04	1.87E-04	1.65E-04
2-Methylnaphthalene	1.16E-04		1.81E-04		5.57E-05		2.41E-05	2.90E-05	1.43E-05	3.17E-04		ND	1.10E-04	3.01E-06	1.81E-04
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
3,4-Dimethylphenol	ND		ND		ND		ND	ND	ND	9.02E-05		ND	ND	ND	ND
3,5-Dimethylphenol	ND		4.61E-05		ND		2.54E-05	ND	8.02E-05	2.88E-04		1.72E-04	ND	ND	1.83E-04
3-Ethyltoluene	1.96E-04		1.47E-04		2.34E-04		6.59E-05	ND	3.55E-05	ND		3.53E-04	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
4-Ethyltoluene	1.34E-04		6.70E-05		ND		1.27E-04	ND	1.07E-04	6.06E-04		2.13E-04	1.96E-04	1.20E-04	9.17E-05
a-Methylstyrene	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	ND		3.61E-06		4.50E-06		2.02E-06	3.08E-06	ND	7.69E-06		ND	4.46E-06	ND	ND
Acetaldehyde	2.40E-04	3.56E-04	1.81E-04	9.27E-05	3.92E-04	6.19E-04	1.43E-04	2.60E-04	2.51E-04	8.24E-04	7.98E-04		5.08E-04	6.85E-04	4.83E-04
Acetone	3.04E-04	3.31E-04	2.25E-04	3.66E-04	1.16E-03	1.04E-03	3.09E-04	2.61E-04	2.84E-04	9.30E-04	4.74E-04		5.98E-04	7.12E-04	5.18E-04
Acetophenone	ND		9.82E-06		ND		ND	ND	ND	3.56E-04		ND	ND	ND	ND
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Aniline	ND		ND		ND	ND	ND	ND	ND	ND			ND	ND	ND
Benzene	2.27E-03		1.51E-03		2.76E-03		3.07E-03	2.81E-03	2.67E-03	4.01E-03		5.68E-03	3.71E-03	1.66E-03	7.94E-03
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Benzofuran	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
Bibenzyl	ND		1.78E-06		ND		2.47E-06	ND	ND	1.59E-06		ND	ND	ND	ND
Biphenyl	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	ND	1.26E-04	ND	ND	ND	6.87E-05	1.73E-04	9.02E-05		1.39E-04	1.26E-04	1.24E-04
Butylbenzene	ND		1.66E-05		ND		5.54E-05	ND	2.61E-05	3.18E-04		ND	ND	ND	ND
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Cumene	2.14E-05		7.24E-06		1.74E-05		5.28E-06	ND	9.11E-06	3.48E-05		ND	1.91E-05	2.76E-05	2.77E-05
Cyclohexane	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
Decane	5.95E-04		1.95E-04		2.75E-04		2.34E-04	1.74E-04	2.21E-04	5.42E-04		3.90E-04	3.46E-04	4.47E-04	1.58E-04
Dibenzofuran	ND		2.37E-06		ND		4.16E-06	ND	ND	ND		ND	1.56E-06	ND	ND
Dodecane	6.13E-04		1.99E-04		2.97E-04		2.01E-04	1.92E-04	6.70E-05	5.44E-04		3.38E-04	3.60E-04	ND	5.45E-04
Ethylbenzene	1.83E-04		8.39E-05		2.12E-04		1.43E-04	1.07E-04	1.40E-04	3.79E-04		3.90E-04	2.65E-04	2.93E-04	3.79E-04
Formaldehyde	ND	3.46E-04	9.71E-05	1.17E-04	4.27E-04	1.18E-03	1.83E-04	2.00E-04	ND	1.08E-04	2.61E-04		1.31E-04	7.01E-05	3.50E-04
Heptane	1.12E-03		2.74E-04		7.73E-04		4.81E-04	3.49E-04	2.25E-04	3.86E-04		6.12E-04	3.05E-04	2.42E-04	5.51E-04
Hexanal	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.11E-05	ND		ND	4.29E-05	ND
Indan	1.00E-04		2.04E-05		6.58E-05		5.85E-05	2.40E-05	5.69E-05	1.24E-04		1.57E-04	ND	ND	1.29E-04
Indene	9.77E-05		1.98E-05		3.22E-05		3.29E-05	3.33E-05	3.57E-05	2.89E-04		1.08E-04	ND	ND	2.20E-04
Isobutylbenzene	4.96E-05		4.20E-06		2.36E-05		4.27E-06	ND	2.04E-05	8.26E-05		ND	ND	ND	1.79E-05
m,p-Cresol	ND		ND		ND		ND	ND	ND	ND		ND	ND	ND	ND
m,p-Xylene	9.09E-04		3.44E-04		8.25E-04		6.33E-04	5.07E-04	4.91E-04	8.62E-04		1.62E-03	1.26E-03	3.80E-04	1.69E-03
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Methacrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.05E-04	ND		3.94E-05	6.72E-05	ND
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Methyl Methacrylate	ND		ND		ND		ND	ND	ND	ND		5.24E-05	ND	ND	ND
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND		ND		ND		ND		ND		ND
n-Propylbenzene	ND		5.97E-07		4.12E-05		ND	ND	1.07E-05	ND		1.08E-04	ND	ND	ND
Naphthalene	2.36E-04		2.07E-04		1.61E-04		1.28E-04	9.96E-05	1.42E-04	9.69E-04		1.08E-04	2.01E-04	1.05E-04	4.56E-04
Nitrobenzene	ND		ND		ND		ND	ND	1.01E-05	ND		7.87E-05	ND	ND	ND
Nonane	4.98E-04		1.47E-04		3.84E-04		2.28E-04	2.05E-04	1.91E-04	4.09E-04		3.29E-04	1.66E-04	2.81E-04	4.15E-04
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
o-Cresol	ND		2.15E-05		ND		3.65E-05	1.96E-05	2.35E-05	ND		ND	ND	4.49E-05	4.17E-05
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
o-Xylene	3.80E-04		1.82E-04		3.67E-04		3.20E-04	2.56E-04	2.98E-04	6.88E-04		6.93E-04	4.88E-04	1.82E-04	8.08E-04
Octane	8.04E-04		1.56E-04		6.82E-04		3.03E-04	2.71E-04	2.04E-04	4.32E-04		3.67E-04	3.13E-04	2.79E-04	4.84E-04
p-cymene	5.81E-05		4.76E-05		2.92E-05		1.29E-04	9.23E-05	ND	ND		ND	ND	ND	ND
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Phenol	2.81E-04		2.67E-04		2.28E-04		2.17E-04	3.53E-04	3.48E-04	8.56E-04		ND	7.48E-04	1.22E-04	1.57E-03
Propanal	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.56E-05	ND		ND	ND	ND
Styrene	ND		1.65E-05		ND		4.78E-05	ND	3.44E-05	2.52E-04		9.32E-05	6.76E-05	1.28E-04	2.90E-05
Tetradecane	6.89E-05		5.28E-05		7.74E-05		2.14E-05	3.23E-05	ND	9.02E-05		ND	ND	ND	1.54E-04
Toluene	1.74E-03		7.79E-04		1.61E-03		1.46E-03	1.24E-03	1.26E-03	2.40E-03		3.25E-03	3.36E-03	9.16E-04	4.33E-03
Tridecane	3.25E-04		1.30E-04		2.46E-04		1.09E-04	8.79E-05	2.10E-05	4.15E-05		1.19E-04	3.91E-05	ND	4.33E-04
Undecane	9.67E-04		3.33E-04		3.86E-04		3.57E-04	2.91E-04	4.35E-04	1.35E-03		7.60E-04	6.03E-04	2.03E-04	7.49E-04
Valeraldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.12E-04	ND		4.20E-05	8.29E-05	ND
Total POMs	4.36E-04		5.78E-04		2.92E-04		1.98E-04	1.69E-04	1.77E-04	1.66E-03		1.08E-04	4.64E-04	1.11E-04	8.44E-04

Note:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

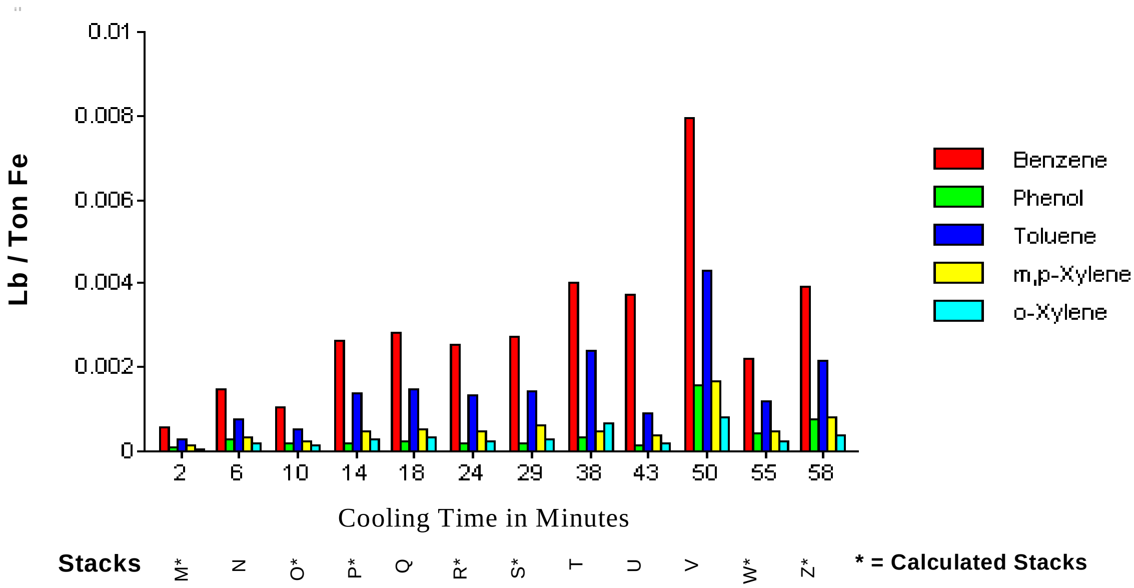


Figure 5.3. Average Lb/Ton Metal Over Cooling Stacks Blocks (1, 2, 3) – Specific Analytes

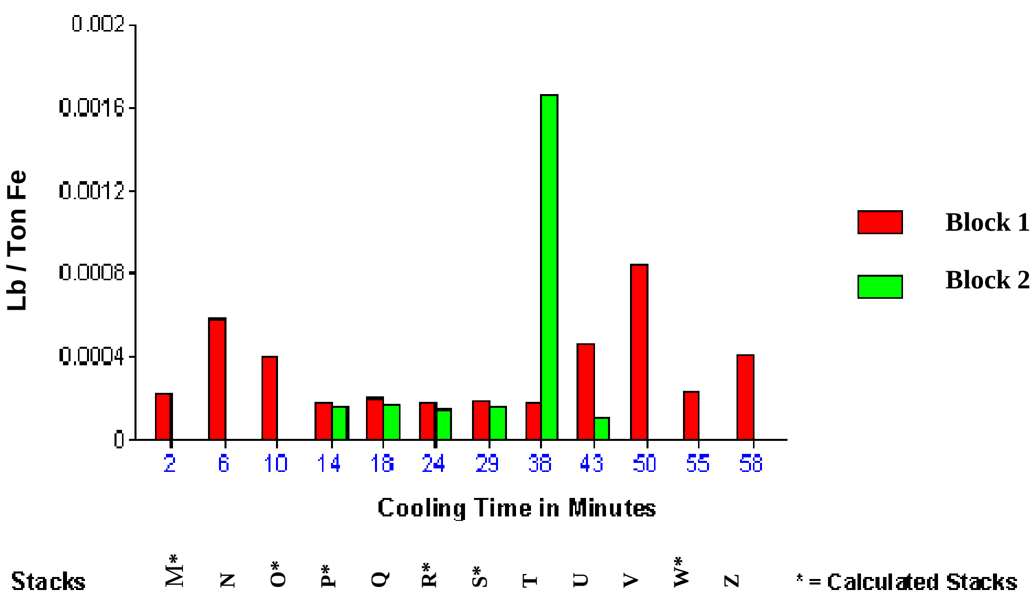


Figure 5.4. Average lb / ton Metal Over Cooling Stacks Blocks (1, 2) - POMs

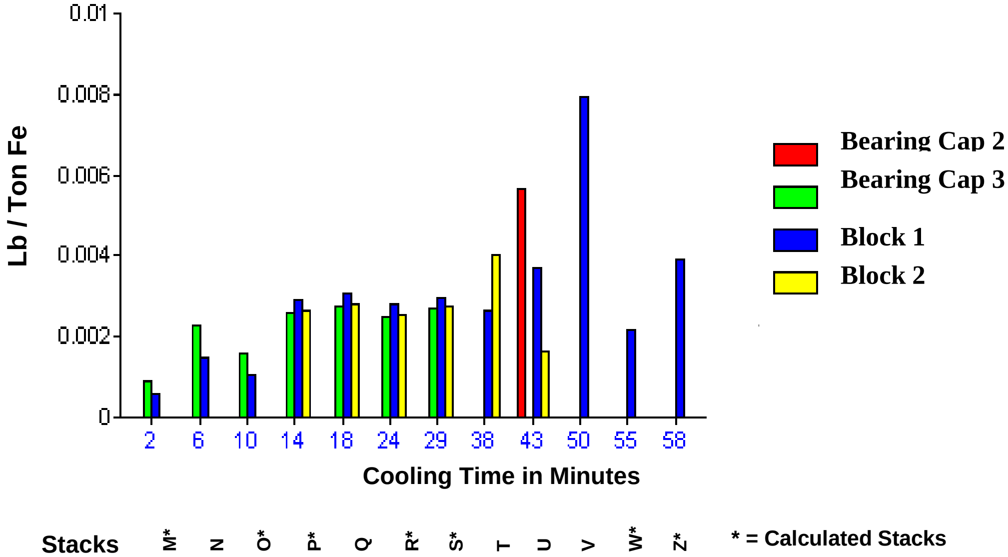


Figure 5.5. Average Lb/Ton Metal over Cooling Stacks
All Parts – Benzene

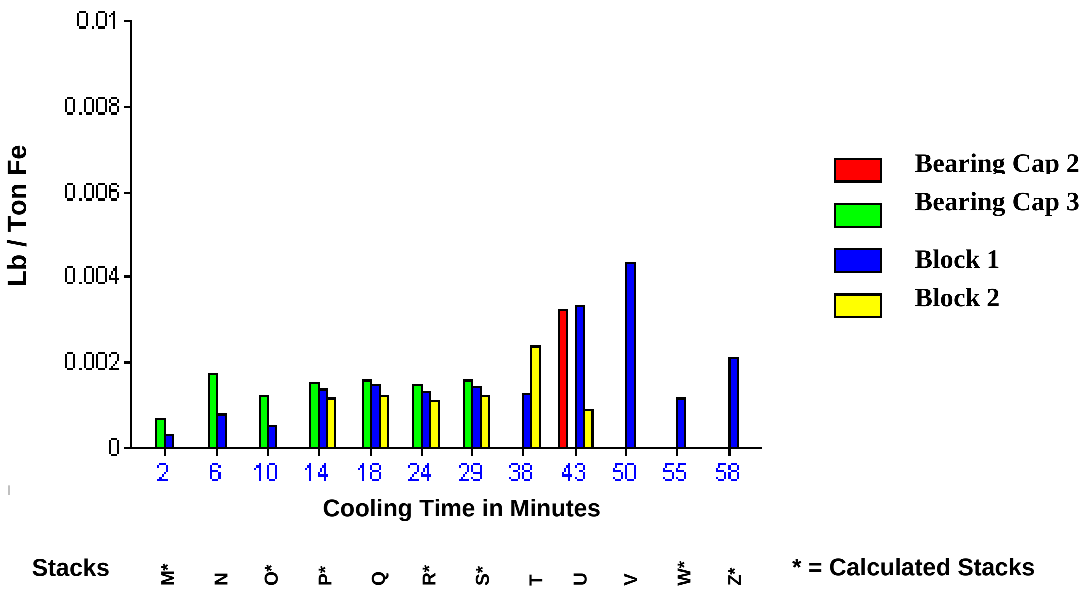


Figure 5.6. Average Lb/Ton Metal over Cooling Stacks
All Parts - Toluene

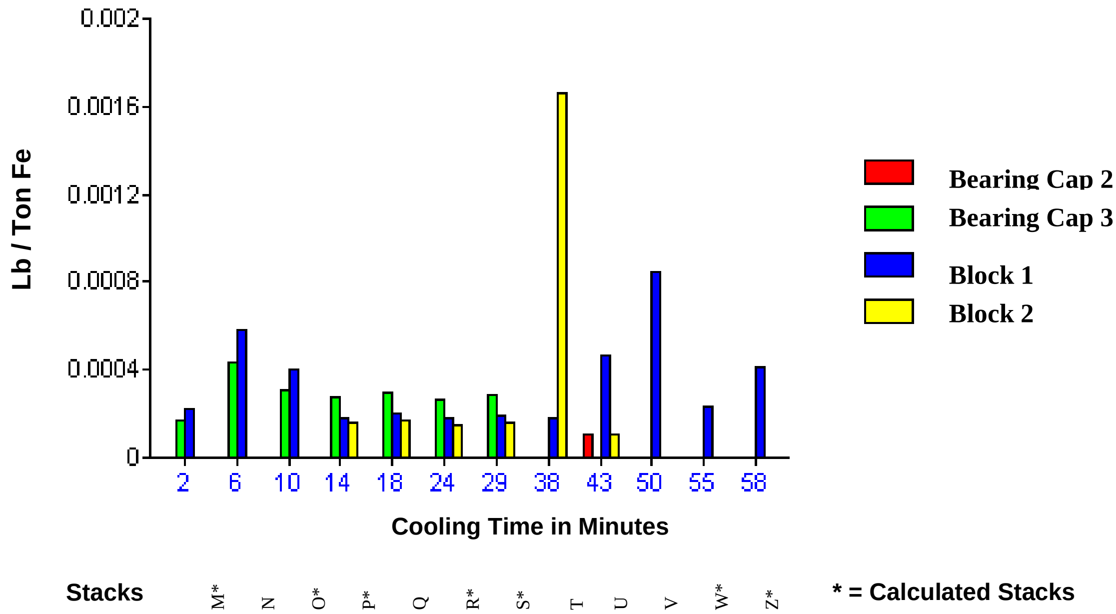


Figure 5.7. Average Lb/Ton Metal over Cooling Stacks
All Parts - POMs

Table 5.5. Measured & Calculated VOC Emissions From Line 1 Cooling Stacks - Blocks 1, 2, & 3
Average Lb / Ton Metal Poured

Analyte Name	M*	N	O*	P*	Q	R*	S*	T	U	V	W*	Z*	Σ Average
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	2.04E-05	5.32E-05	3.68E-05	ND	ND	ND	ND	2.75E-04	2.86E-04	3.14E-04	8.60E-05	1.55E-04	1.23E-03
1,2,4-Trimethylbenzene	6.63E-05	1.74E-04	1.20E-04	2.22E-04	2.36E-04	2.13E-04	2.28E-04	5.64E-04	3.25E-04	6.13E-04	1.68E-04	3.03E-04	3.23E-03
1,2-Diethylbenzene	7.03E-06	1.85E-05	1.27E-05	7.19E-06	7.72E-06	6.97E-06	7.42E-06	7.61E-05	ND	2.61E-05	7.15E-06	1.28E-05	1.90E-04
1,3,5-Trimethylbenzene	3.10E-05	8.06E-05	5.57E-05	1.32E-04	1.41E-04	1.28E-04	1.37E-04	3.02E-04	1.19E-04	3.79E-04	1.04E-04	1.87E-04	1.80E-03
1,3-Diethylbenzene	ND	ND	ND	3.79E-05	4.18E-05	3.77E-05	3.98E-05	6.74E-06	ND	ND	ND	ND	1.64E-04
1,3-Diisopropylbenzene	8.41E-06	2.31E-05	1.58E-05	8.54E-06	9.14E-06	8.24E-06	8.84E-06	7.65E-05	ND	3.26E-05	8.93E-06	1.61E-05	2.16E-04
1,3-Dimethylnaphthalene	4.44E-06	1.36E-05	9.36E-06	4.27E-06	4.57E-06	4.12E-06	4.42E-06	1.26E-05	1.20E-05	2.53E-05	6.71E-06	1.24E-05	1.14E-04
1,4-Diethylbenzene	2.54E-05	6.63E-05	4.59E-05	4.97E-05	5.29E-05	4.78E-05	5.13E-05	3.34E-05	5.03E-05	2.20E-04	6.00E-05	1.08E-04	8.11E-04
1,4-Dimethylnaphthalene	1.19E-06	3.20E-06	2.19E-06	3.85E-06	4.13E-06	3.64E-06	3.99E-06	2.88E-06	ND	ND	ND	ND	2.51E-05
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	6.85E-07	1.83E-06	1.23E-06	ND	ND	ND	ND	6.54E-07	9.23E-07	ND	ND	ND	5.32E-06
1-Methylnaphthalene	6.03E-05	1.57E-04	1.09E-04	1.67E-05	1.77E-05	1.59E-05	1.71E-05	1.59E-04	7.15E-05	1.58E-04	4.33E-05	7.81E-05	9.04E-04
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	7.30E-06	1.91E-05	1.32E-05	8.39E-06	8.92E-06	8.02E-06	8.62E-06	1.78E-05	ND	5.15E-05	1.41E-05	2.55E-05	1.82E-04
2,3-Dimethylnaphthalene	1.42E-06	3.74E-06	2.56E-06	6.26E-06	6.75E-06	6.04E-06	6.47E-06	1.11E-05	9.07E-06	2.37E-05	6.45E-06	1.16E-05	9.53E-05
2,3-Dimethylphenol	3.70E-05	9.66E-05	6.68E-05	6.93E-05	7.51E-05	6.80E-05	7.21E-05	2.96E-04	ND	1.30E-04	3.56E-05	6.42E-05	1.01E-03
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	4.87E-04	2.15E-06	ND	ND	ND	4.89E-04
2,6-Dimethylnaphthalene	ND	ND	ND	2.77E-06	3.00E-06	2.70E-06	2.85E-06	ND	ND	ND	ND	ND	1.13E-05
2,6-Dimethylphenol	6.53E-06	1.71E-05	1.18E-05	9.44E-06	1.00E-05	9.07E-06	9.74E-06	1.85E-04	ND	ND	ND	ND	2.59E-04
2,7-Dimethylnaphthalene	1.19E-06	3.15E-06	2.15E-06	1.41E-06	1.54E-06	1.35E-06	1.47E-06	7.59E-06	5.05E-06	ND	ND	ND	2.49E-05
2-Ethyltoluene	1.41E-05	3.67E-05	2.53E-05	3.60E-05	3.83E-05	3.47E-05	3.72E-05	1.27E-04	1.38E-04	1.65E-04	4.50E-05	8.14E-05	7.78E-04
2-Methylnaphthalene	6.90E-05	1.81E-04	1.25E-04	2.42E-05	2.57E-05	2.32E-05	2.49E-05	1.66E-04	7.46E-05	1.81E-04	4.94E-05	8.91E-05	1.03E-03
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	4.51E-05	ND	ND	ND	ND	4.51E-05
3,5-Dimethylphenol	1.76E-05	4.61E-05	3.19E-05	1.59E-05	1.69E-05	1.53E-05	1.64E-05	1.84E-04	ND	1.83E-04	5.01E-05	9.00E-05	6.67E-04
3-Ethyltoluene	5.59E-05	1.47E-04	1.01E-04	4.04E-05	4.40E-05	3.87E-05	4.22E-05	1.78E-05	ND	ND	ND	ND	4.87E-04
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	2.57E-05	6.70E-05	4.63E-05	7.90E-05	8.46E-05	7.60E-05	8.18E-05	3.56E-04	1.70E-04	9.17E-05	2.52E-05	4.53E-05	1.15E-03
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	1.30E-06	3.61E-06	2.45E-06	2.16E-06	2.37E-06	2.10E-06	2.24E-06	3.85E-06	2.98E-06	ND	ND	ND	2.30E-05
Acetaldehyde	6.93E-05	1.81E-04	1.25E-04	1.90E-04	2.02E-04	1.83E-04	1.96E-04	6.33E-04	5.67E-04	4.83E-04	1.32E-04	2.39E-04	3.20E-03
Acetone	8.65E-05	2.25E-04	1.56E-04	2.66E-04	2.85E-04	2.54E-04	2.75E-04	7.15E-04	6.36E-04	5.18E-04	1.15E-04	2.38E-04	3.77E-03
Acetophenone	3.02E-06	9.82E-06	6.80E-06	ND	ND	ND	ND	1.78E-04	ND	ND	ND	ND	1.98E-04
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	5.79E-04	1.51E-03	1.04E-03	2.81E-03	2.98E-03	2.70E-03	2.90E-03	3.34E-03	3.03E-03	7.94E-03	2.18E-03	3.92E-03	3.49E-02
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	6.39E-07	1.78E-06	1.23E-06	1.50E-06	1.65E-06	1.42E-06	1.57E-06	7.94E-07	ND	ND	ND	ND	1.06E-05
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	ND	ND	ND	ND	1.38E-04	1.35E-04	1.24E-04	3.37E-05	6.09E-05	4.91E-04
Butylbenzene	6.04E-06	1.66E-05	1.13E-05	3.34E-05	3.69E-05	3.34E-05	3.52E-05	1.72E-04	ND	ND	ND	ND	3.45E-04
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	2.74E-06	7.24E-06	4.98E-06	3.30E-06	3.52E-06	3.15E-06	3.37E-06	2.20E-05	2.20E-05	2.77E-05	7.33E-06	1.34E-05	1.21E-04
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	7.44E-05	1.95E-04	1.35E-04	2.00E-04	2.14E-04	1.93E-04	2.07E-04	3.81E-04	3.80E-04	1.58E-04	4.33E-05	7.80E-05	2.26E-03
Dibenzofuran	8.67E-07	2.37E-06	1.64E-06	2.55E-06	2.77E-06	2.47E-06	2.62E-06	ND	1.04E-06	ND	ND	ND	1.63E-05
Dodecane	7.57E-05	1.99E-04	1.37E-04	1.85E-04	1.98E-04	1.79E-04	1.91E-04	3.05E-04	2.40E-04	5.45E-04	1.49E-04	2.69E-04	2.67E-03
Ethylbenzene	3.18E-05	8.39E-05	5.75E-05	1.23E-04	1.31E-04	1.18E-04	1.27E-04	2.59E-04	2.74E-04	3.79E-04	1.04E-04	1.87E-04	1.87E-03
Formaldehyde	3.72E-05	9.71E-05	6.72E-05	1.80E-04	1.92E-04	1.74E-04	1.86E-04	7.21E-05	1.11E-04	3.50E-04	9.58E-05	1.73E-04	1.73E-03
Heptane	1.05E-04	2.74E-04	1.89E-04	4.11E-04	4.37E-04	3.96E-04	4.23E-04	3.06E-04	2.84E-04	5.51E-04	1.51E-04	2.72E-04	3.80E-03
Hexanal	ND	ND	ND	ND	ND	ND	ND	2.07E-05	1.43E-05	ND	ND	ND	3.50E-05
Indan	7.36E-06	2.04E-05	1.38E-05	4.40E-05	4.70E-05	4.15E-05	4.46E-05	9.06E-05	ND	1.29E-04	3.50E-05	6.35E-05	5.36E-04
Indene	7.58E-06	1.98E-05	1.36E-05	3.10E-05	3.30E-05	2.99E-05	3.20E-05	1.62E-04	ND	2.20E-04	6.03E-05	1.09E-04	7.18E-04
Isobutylbenzene	1.60E-06	4.20E-06	2.88E-06	2.62E-06	2.85E-06	2.55E-06	2.70E-06	5.15E-05	ND	1.79E-05	4.76E-06	8.78E-06	1.02E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	1.32E-04	3.44E-04	2.38E-04	5.56E-04	5.91E-04	5.34E-04	5.73E-04	6.77E-04	9.65E-04	1.69E-03	4.65E-04	8.37E-04	7.61E-03
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	ND	ND	ND	ND	7.01E-05	4.87E-05	ND	ND	ND	1.19E-04
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	2.17E-07	5.97E-07	4.07E-07	ND	ND	ND	ND	5.36E-06	ND	ND	ND	ND	6.58E-06
Naphthalene	7.93E-05	2.07E-04	1.43E-04	1.10E-04	1.18E-04	1.06E-04	1.14E-04	5.55E-04	1.69E-04	4.56E-04	1.25E-04	2.25E-04	2.41E-03
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND	5.03E-06	ND	ND	ND	ND	5.03E-06
Nonane	5.59E-05	1.47E-04	1.01E-04	2.06E-04	2.21E-04	2.00E-04	2.13E-04	3.00E-04	2.04E-04	4.15E-04	1.14E-04	2.05E-04	2.38E-03
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	8.20E-06	2.15E-05	1.48E-05	2.91E-05	3.09E-05	2.79E-05	2.99E-05	1.17E-05	1.50E-05	4.17E-04	1.14E-04	2.06E-04	9.27E-04
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	6.94E-05	1.82E-04	1.26E-04	2.79E-04	2.99E-04	2.70E-04	2.88E-04	4.93E-04	3.86E-04	8.08E-04	2.22E-04	3.99E-04	3.82E-03
Octane	5.95E-05	1.56E-04	1.08E-04	2.75E-04	2.92E-04	2.63E-04	2.84E-04	3.18E-04	3.02E-04	4.84E-04	1.33E-04	2.39E-04	2.91E-03
p-cymene	1.79E-05	4.76E-05	3.27E-05	1.10E-04	1.17E-04	1.06E-04	1.13E-04	ND	ND	ND	ND	ND	5.44E-04
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.02E-04	2.67E-04	1.85E-04	2.47E-04	2.63E-04	2.38E-04	2.55E-04	6.02E-04	5.39E-04	1.57E-03	4.32E-04	7.78E-04	5.48E-03
Propanal	ND	ND	ND	ND	ND	ND	ND	3.71E-05	ND	ND	ND	ND	3.71E-05
Styrene	6.32E-06	1.65E-05	1.13E-05	2.95E-05	3.19E-05	2.73E-05	2.98E-05	1.43E-04	8.76E-05	2.90E-05	7.89E-06	1.43E-05	4.35E-04
Tetradecane	1.95E-05	5.28E-05	3.62E-05	2.35E-05	2.50E-05	2.26E-05	2.42E-05	4.51E-05	ND	1.54E-04	4.22E-05	7.62E-05	5.22E-04
Toluene	2.99E-04	7.79E-04	5.39E-04	1.31E-03	1.39E-03	1.25E-03	1.34E-03	1.83E-03	2.54E-03	4.33E-03	1.19E-03	2.14E-03	1.89E-02
Tridecane	4.97E-05	1.30E-04	8.99E-05	9.46E-05	1.02E-04	9.06E-05	9.81E-05	3.13E-05	2.61E-05	4.33E-04	1.19E-04	2.14E-04	1.48E-03
Undecane	1.28E-04	3.33E-04	2.30E-04	3.15E-04	3.35E-04	3.03E-04	3.24E-04	8.92E-04	4.70E-04	7.49E-04	2.05E-04	3.70E-04	4.65E-03
Valeraldehyde	ND	ND	ND	ND	ND	ND	ND	7.45E-05	5.56E-05	ND	ND	ND	1.30E-04
Total POMs	2.20E-04	5.78E-04	3.99E-04	1.76E-04	1.88E-04	1.69E-04	1.82E-04	9.19E-04	3.46E-04	8.44E-04	2.31E-04	4.16E-04	4.67E-03

ND = not detected
Blank Spaces = not sampled
* = Calculated Averages. See Section 5.1

THIS PAGE INTENTIONALLY LEFT BLANK

5.1.1.4 Summary of VOC Emissions from Engine Block Production

This section summarizes emission factors for organic compounds from the pouring, cooling, and shakeout processes in the production of engine blocks. Using the data from Section 5.1 on pouring, cooling, and shakeout emissions, the total emissions can be calculated. Table 5.6 lists emission factors for blocks 1, 2, and 3 in terms of lb species/ton iron poured. The table shows the average emission factor, the maximum emission factor, and the standard deviation on the emission factor for each step: pouring, cooling, and shakeout. The last three columns of Table 5.6 show the same quantities for the total emissions (the sum of pouring, cooling, and shakeout). Major organic species emitted from pouring, cooling, and shakeout include benzene, xylenes, toluene, phenol, and polycyclic organic matter (POM). A definition of the species included in POM is shown in Table 2.1.

Again, it is important to remember that the shakeout emissions from engine block production on Line 1 are not completely captured. Therefore, the measurements from clutch housing production on Line 3 are the better choice for shakeout emission factors.

Appendix D includes emission factors in terms of other production parameters, including lb species/ton mold sand, lb species/ton core sand, and lb species/lb of resin, similar to Table 5.6.

THIS PAGE INTENTIONALLY LEFT BLANK

Table 5.6. VOC Emissions - Pouring, Cooling, & Shakeout. Summary of Engine Block Production
Lb / Ton Metal Poured

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	9.91E-05	4.01E-05	1.13E-04	1.23E-03	2.35E-04	1.74E-03	1.35E-04	2.34E-04	4.06E-04	1.46E-03	3.35E-04	2.26E-03
1,2,4-Trimethylbenzene	2.53E-04	1.38E-04	3.62E-04	3.23E-03	5.92E-04	4.46E-03	5.18E-04	1.91E-04	6.44E-04	4.00E-03	6.37E-04	5.46E-03
1,2-Diethylbenzene	7.65E-06	3.06E-05	3.06E-05	1.90E-04	7.31E-05	3.92E-04	1.27E-05	2.20E-05	3.81E-05	2.10E-04	8.22E-05	4.60E-04
1,3,5-Trimethylbenzene	1.20E-04	7.45E-05	1.74E-04	1.80E-03	2.87E-04	2.43E-03	2.41E-04	8.65E-05	3.07E-04	2.16E-03	3.09E-04	2.91E-03
1,3-Diethylbenzene	ND	ND	ND	1.64E-04	1.06E-04	4.23E-04	ND	ND	ND	1.64E-04	1.06E-04	4.23E-04
1,3-Diisopropylbenzene	7.27E-06	2.91E-05	2.91E-05	2.16E-04	9.90E-05	4.76E-04	4.26E-05	4.43E-05	8.85E-05	2.66E-04	1.12E-04	5.94E-04
1,3-Dimethylnaphthalene	4.33E-06	1.08E-05	1.32E-05	1.14E-04	5.58E-05	2.86E-04	ND	ND	ND	1.18E-04	5.68E-05	3.00E-04
1,4-Diethylbenzene	4.67E-05	6.70E-05	7.97E-05	8.11E-04	1.83E-04	1.32E-03	1.23E-04	1.31E-04	2.61E-04	9.81E-04	2.35E-04	1.66E-03
1,4-Dimethylnaphthalene	ND	ND	ND	2.51E-05	1.13E-05	6.10E-05	ND	ND	ND	2.51E-05	1.13E-05	6.10E-05
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	5.32E-06	5.06E-06	2.04E-05	ND	ND	ND	5.32E-06	5.06E-06	2.04E-05
1-Methylnaphthalene	7.69E-05	6.99E-05	1.20E-04	9.04E-04	3.58E-04	2.06E-03	3.65E-05	3.52E-05	7.02E-05	1.02E-03	3.66E-04	2.25E-03
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	6.37E-06	2.55E-05	2.55E-05	1.82E-04	1.03E-04	4.80E-04	1.56E-05	2.70E-05	4.67E-05	2.04E-04	1.09E-04	5.52E-04
2,3-Dimethylnaphthalene	ND	ND	ND	9.53E-05	4.62E-05	2.15E-04	1.07E-05	1.85E-05	3.20E-05	1.06E-04	4.98E-05	2.47E-04
2,3-Dimethylphenol	3.59E-05	8.40E-05	7.98E-05	1.01E-03	3.63E-04	1.85E-03	3.12E-04	1.53E-04	4.76E-04	1.36E-03	4.02E-04	2.40E-03
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	4.89E-04	6.05E-04	1.25E-03	ND	ND	ND	4.89E-04	6.05E-04	1.25E-03
2,6-Dimethylnaphthalene	ND	ND	ND	1.13E-05	9.81E-06	3.39E-05	ND	ND	ND	1.13E-05	9.81E-06	3.39E-05
2,6-Dimethylphenol	8.40E-06	3.36E-05	3.36E-05	2.59E-04	3.28E-04	9.24E-04	3.36E-05	5.82E-05	1.01E-04	3.01E-04	3.35E-04	1.06E-03
2,7-Dimethylnaphthalene	1.27E-06	5.07E-06	5.08E-06	2.49E-05	1.59E-05	7.78E-05	ND	ND	ND	2.62E-05	1.67E-05	8.28E-05
2-Ethyltoluene	4.62E-05	4.26E-05	7.48E-05	7.78E-04	1.34E-04	1.10E-03	1.28E-04	3.54E-05	1.58E-04	9.52E-04	1.45E-04	1.33E-03
2-Methylnaphthalene	9.10E-05	7.06E-05	1.37E-04	1.03E-03	3.89E-04	2.32E-03	4.65E-05	4.51E-05	9.00E-05	1.17E-03	3.98E-04	2.55E-03
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	4.57E-06	1.83E-05	1.83E-05	4.51E-05	5.22E-05	9.49E-05	9.31E-05	1.10E-04	2.15E-04	1.43E-04	1.23E-04	3.28E-04
3,5-Dimethylphenol	5.89E-05	1.39E-04	1.46E-04	6.67E-04	1.75E-04	1.14E-03	8.37E-05	8.63E-05	1.72E-04	8.09E-04	2.40E-04	1.46E-03
3-Ethyltoluene	1.32E-05	5.29E-05	5.29E-05	4.87E-04	4.02E-04	1.78E-03	9.24E-05	1.60E-04	2.77E-04	5.92E-04	4.35E-04	2.11E-03
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	3.99E-05	5.79E-05	6.85E-05	1.15E-03	4.24E-04	2.24E-03	2.37E-04	1.14E-04	3.17E-04	1.43E-03	4.43E-04	2.63E-03
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-	1.51E-06	4.26E-06	3.01E-06	2.30E-05	9.57E-06	4.93E-05	ND	ND	ND	2.46E-05	1.05E-05	5.23E-05
Acetaldehyde	2.94E-04	2.34E-04	4.18E-04	3.20E-03	4.24E-04	4.30E-03	4.88E-04	1.54E-04	6.34E-04	3.98E-03	5.08E-04	5.35E-03
Acetone	4.21E-04	2.94E-04	5.87E-04	3.77E-03	4.54E-04	4.64E-03	9.11E-04	3.12E-04	1.19E-03	5.10E-03	6.25E-04	6.42E-03
Acetophenone	ND	ND	ND	1.98E-04	3.57E-04	7.90E-04	ND	ND	ND	1.98E-04	3.57E-04	7.90E-04
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	2.19E-03	1.80E-03	3.48E-03	3.49E-02	3.95E-03	4.53E-02	2.82E-03	1.29E-03	4.12E-03	3.99E-02	4.53E-03	5.29E-02
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	1.06E-05	7.16E-06	3.62E-05	ND	ND	ND	1.06E-05	7.16E-06	3.62E-05
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	4.91E-04	7.21E-05	5.97E-04	4.43E-05	7.67E-05	1.33E-04	5.35E-04	1.05E-04	7.29E-04
Butylbenzene	ND	ND	ND	3.45E-04	2.12E-04	8.78E-04	8.25E-05	1.43E-04	2.48E-04	4.27E-04	2.56E-04	1.13E-03
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	6.00E-06	1.10E-05	1.33E-05	1.21E-04	2.52E-05	1.92E-04	ND	ND	ND	1.27E-04	2.75E-05	2.06E-04
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	4.62E-04	3.54E-04	7.35E-04	2.26E-03	3.72E-04	3.24E-03	3.69E-04	2.42E-04	6.44E-04	3.09E-03	5.68E-04	4.62E-03
Dibenzofuran	ND	ND	ND	1.63E-05	1.10E-05	5.39E-05	ND	ND	ND	1.63E-05	1.10E-05	5.39E-05
Dodecane	6.26E-04	5.04E-04	1.02E-03	2.67E-03	5.81E-04	4.03E-03	3.16E-04	1.10E-04	4.16E-04	3.62E-03	7.77E-04	5.47E-03
Ethylbenzene	1.01E-04	5.05E-05	1.38E-04	1.87E-03	2.18E-04	2.34E-03	2.47E-04	1.03E-04	3.57E-04	2.22E-03	2.46E-04	2.83E-03
Formaldehyde	1.38E-04	2.14E-04	2.61E-04	1.73E-03	3.15E-04	2.67E-03	5.43E-04	5.41E-04	1.16E-03	2.41E-03	6.62E-04	4.09E-03
Heptane	2.81E-04	2.67E-04	4.57E-04	3.80E-03	4.12E-04	5.08E-03	1.53E-03	1.91E-03	3.72E-03	5.61E-03	1.97E-03	9.25E-03
Hexanal	ND	ND	ND	3.50E-05	4.36E-05	1.05E-04	ND	ND	ND	3.50E-05	4.36E-05	1.05E-04
Indan	1.44E-05	3.38E-05	3.23E-05	5.36E-04	9.57E-05	8.04E-04	1.13E-04	8.44E-05	2.08E-04	6.64E-04	1.32E-04	1.04E-03
Indene	3.23E-05	5.19E-05	6.34E-05	7.18E-04	3.11E-04	1.51E-03	1.62E-04	6.22E-05	2.33E-04	9.12E-04	3.21E-04	1.80E-03
Isobutylbenzene	1.57E-06	6.30E-06	6.30E-06	1.02E-04	5.11E-05	2.15E-04	ND	ND	ND	1.04E-04	5.15E-05	2.21E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	4.22E-04	2.46E-04	6.10E-04	7.61E-03	9.02E-04	9.55E-03	9.69E-04	3.11E-04	1.27E-03	9.00E-03	9.85E-04	1.14E-02
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	1.19E-04	7.41E-05	1.84E-04	9.14E-05	1.58E-04	2.74E-04	2.10E-04	1.75E-04	4.59E-04
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	1.88E-04	3.26E-04	5.65E-04	1.88E-04	3.26E-04	5.65E-04
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	6.58E-06	1.08E-05	2.63E-05	4.29E-05	7.43E-05	1.29E-04	4.95E-05	7.51E-05	1.55E-04
Naphthalene	1.81E-04	1.34E-04	2.72E-04	2.41E-03	6.12E-04	3.87E-03	3.21E-04	1.50E-04	4.91E-04	2.91E-03	6.44E-04	4.63E-03
Nitrobenzene	ND	ND	ND	5.03E-06	1.01E-05	2.01E-05	ND	ND	ND	5.03E-06	1.01E-05	2.01E-05
Nonane	1.63E-04	1.57E-04	2.85E-04	2.38E-03	3.24E-04	3.26E-03	2.84E-04	1.59E-04	4.56E-04	2.83E-03	3.93E-04	4.00E-03
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	1.65E-06	6.60E-06	6.60E-06	9.27E-04	2.50E-04	1.51E-03	2.34E-04	2.26E-04	4.51E-04	1.16E-03	3.38E-04	1.97E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	1.90E-04	1.05E-04	2.70E-04	3.82E-03	4.74E-04	4.93E-03	4.64E-04	1.85E-04	6.54E-04	4.47E-03	5.19E-04	5.85E-03
Octane	1.64E-04	1.50E-04	2.76E-04	2.91E-03	3.02E-04	3.69E-03	2.28E-04	1.01E-04	2.97E-04	3.30E-03	3.52E-04	4.27E-03
p-cymene	1.27E-04	1.69E-04	2.52E-04	5.44E-04	1.08E-04	8.79E-04	1.12E-04	1.06E-04	2.10E-04	7.82E-04	2.27E-04	1.34E-03
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	2.86E-04	2.64E-04	4.60E-04	5.48E-03	1.25E-03	8.64E-03	5.25E-03	6.74E-03	1.29E-02	1.10E-02	6.86E-03	2.20E-02
Propanal	ND	ND	ND	3.71E-05	3.21E-05	5.68E-05	ND	ND	ND	3.71E-05	3.21E-05	5.68E-05
Styrene	5.31E-05	4.40E-05	8.28E-05	4.35E-04	1.68E-04	8.26E-04	9.35E-05	6.50E-05	1.68E-04	5.81E-04	1.86E-04	1.08E-03
Tetradecane	5.98E-05	5.84E-05	9.53E-05	5.22E-04	1.18E-04	7.81E-04	5.26E-05	5.34E-05	1.07E-04	6.34E-04	1.42E-04	9.83E-04
Toluene	1.05E-03	6.05E-04	1.52E-03	1.89E-02	2.50E-03	2.44E-02	2.50E-03	8.86E-04	3.37E-03	2.25E-02	2.72E-03	2.93E-02
Tridecane	2.75E-04	1.94E-04	4.06E-04	1.48E-03	2.38E-04	1.94E-03	1.83E-04	4.45E-05	2.18E-04	1.94E-03	3.11E-04	2.56E-03
Undecane	9.68E-04	8.31E-04	1.61E-03	4.65E-03	9.66E-04	7.14E-03	6.72E-04	3.43E-04	1.00E-03	6.29E-03	1.32E-03	9.75E-03
Valeraldehyde	ND	ND	ND	1.30E-04	8.15E-05	2.08E-04	ND	ND	ND	1.30E-04	8.15E-05	2.08E-04
Total POMs	3.56E-04		5.50E-04	4.64E-03		8.99E-03	4.15E-04		6.83E-04	5.41E-03		1.02E-02

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

5.1.2 Particulate Matter Emissions

The analysis of the particulate matter emissions is similar to that outlined above for the organic species. Again not all the cooling stacks were measured, and emissions for some were estimated as outlined in Appendix C. For Line 1, Table 5.7 shows both the estimated results for the individual cooling stacks as well as the resulting emissions for pouring, cooling, and shakeout. The results are plotted in Figure 5.8. For the induction furnace serving Line 3, the total PM emissions were measured at 5.57E-04 lb particles/ton metal melted. Results for total particulate matter (PM), particles less than or equal to 10 µm (PM_{10}), and particles less than or equal to 2.5 µm ($PM_{2.5}$) are all included. Note that by definition PM_{10} includes $PM_{2.5}$. Units are lb particles/ton iron poured. PM_{10} makes up about 30% of the total PM emissions from cooling, as can be seen in Figure 5.9.

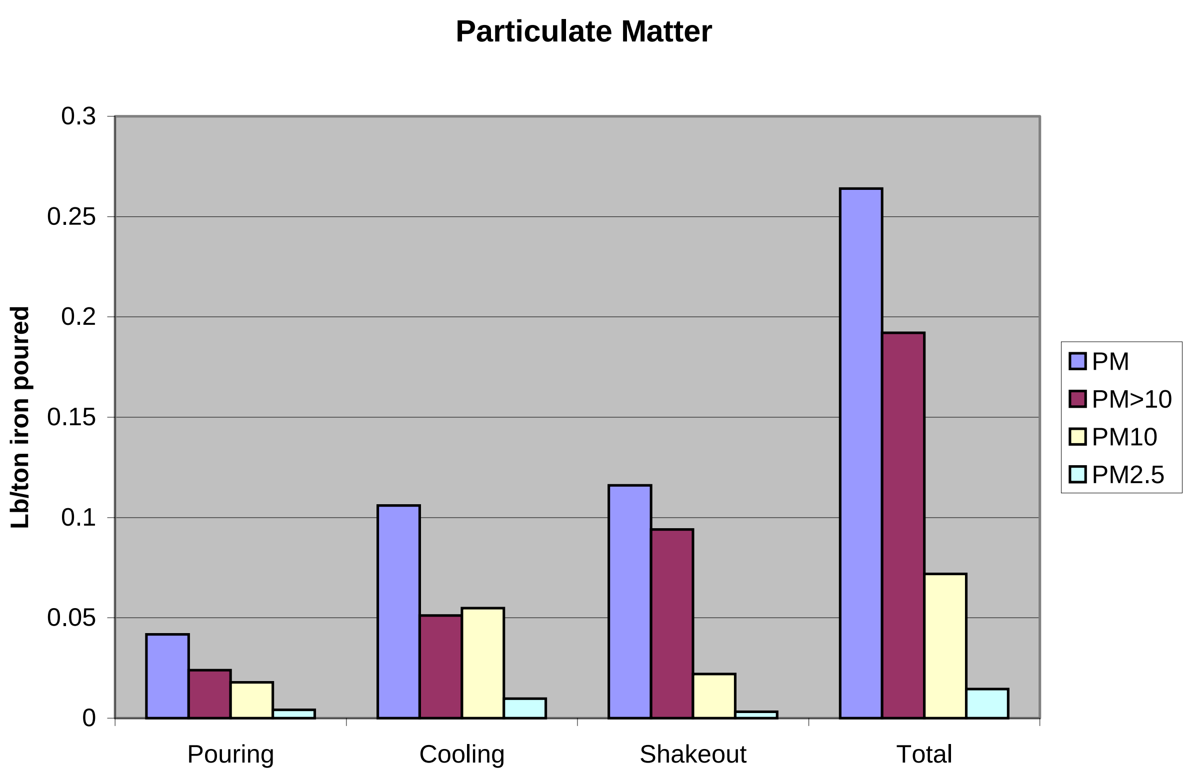


Figure 5.8. Particulate Matter Emissions from Pouring, Cooling, and Shakeout

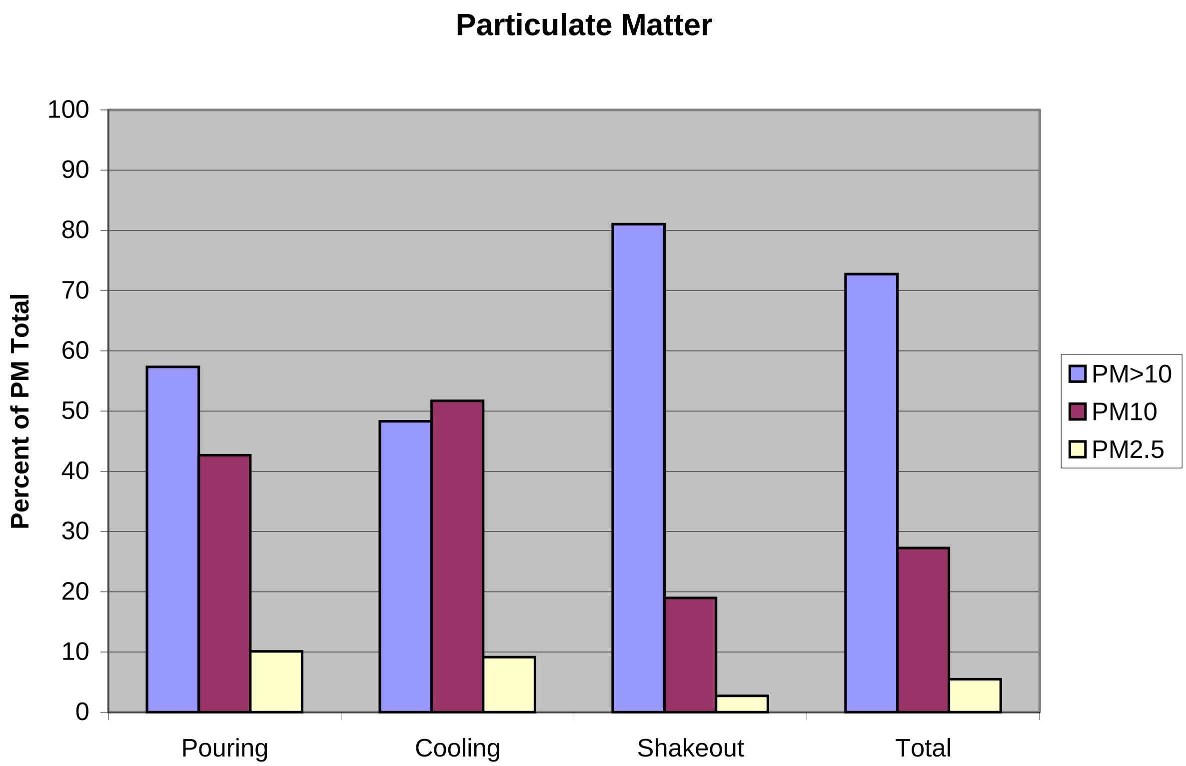


Figure 5.9. Relative Contributions to Total Particulate Matter from PM_{10} and $PM_{2.5}$

Table 5.7. Summary of Particulate Matter Emissions (Lb / Ton Metal) Line 1

	Cooling (line 1)												
	M*	**N**	**O***	**P***	**Q**	**R***	**S***	**T**	**U**	**V**	**W***	**Z***	**Cooling Sum PM**
Total PM	**1.34E-05**	**7.07E-02**	**1.67E-05**	**2.89E-05**	**5.57E-03**	**2.78E-05**	**5.41E-03**	**2.40E-03**	**8.78E-05**	**1.86E-05**	**9.31E-06**	**1.84E-05**	**1.06E-01**
PM_{10}	**5.99E-03**	**1.56E-02**	**1.08E-02**	**3.44E-03**	**3.65E-03**	**3.31E-03**	**3.54E-03**	**7.15E-03**	**1.35E-03**	**2.10E-03**	**8.94E-04**	**6.86E-04**	**5.85E-02**
$PM_{2.5}$	**4.54E-04**	**1.18E-03**	**8.17E-04**	**6.34E-04**	**6.73E-04**	**6.1E-04**	**6.53E-04**	**3.30E-03**	**1.35e-03**	**2.1E-03**	**8.94E-04**	**6.86E-04**	**1.33E-02**

* = Calculated Averages. See Secion 5.1

	Pouring			Cooling			Shakeout			Total		
Analyte	Avg	Std Dev	Max	Avg	Std Dev	Max	Avg	Std Dev	Max	Avg	Std Dev	Max
Total PM	4.17E-02	3.06E-01	5.77E-01	1.06E-01	1.11E-01	4.89E-01	1.16E-01	1.54E-01	5.31E-01	2.64E-01	5.72E-01	1.60E+00
PM_{10}	1.78E-02	3.81E-03	2.22E-02	5.85E-02	2.68E-02	7.80E-02	2.28E-02	1.27E-02	4.37E-02	9.91E-02	4.34E-02	1.44E-01
$PM_{2.5}$	4.21E-03	1.17E-03	5.55E-03	1.33E-02	1.15E-02	2.54E-02	3.17E-03	1.11E-03	4.35E-03	2.07E-02	1.38E-02	3.53E-02

Note:
Zero Values = non-detects
Blank Spaces = not sampled

5.1.3 Metal Emissions

Tables 5.8 – 5.10 list metal emissions in terms of lb metal/ton iron poured for pouring, shakeout, and cooling on Lines 1 and 3. For pouring, metal emissions from clutch housing production on Line 3 and block 4 production on Line 1 are similar for cadmium, chromium, and copper, and within a factor of two for most other metals. For shakeout, metal emissions from Line 1 and Line 3 are close for chromium, copper, iron, and manganese and within a factor of about two for aluminum, cadmium, and zinc. Again, the metal emissions from shakeout are incomplete from both Lines 1 and 3, due to incomplete capture of emissions. For cooling on Line 3, metal emissions from Stacks 32 and 46 near six and twenty-five minutes of cooling, respectively, are similar.

Table 5.11 shows the complete metal emissions from the cooling on Line 1. Again, emissions from some cooling stacks were estimated using the methodology in Appendix C.

Table 5.12 lists emission factors for metals from engine block production in terms of lb metal/ton iron poured for pouring, cooling, and shakeout for Line 1. Included in Table 5.12 are the average and maximum emission factors, as well as the standard deviations of the averages. Major metals emitted were aluminum, iron, manganese, and zinc. Manganese is used as an inoculant in the process and zinc emissions probably arise from the use of recycled galvanized metal scrap at the foundry. Due to some sampling difficulties and the application of Method 29 for metals analysis, problems with zero values were encountered. The results in Table 5.12 have not been zero-corrected. [Note, however, that other measurements such as the organic species were zero-corrected.]

Table 5.8. Average Metal Emissions From Pouring Operations (Lb / Ton Iron Poured)

Pouring	Line 3	Line 3	Line 1
	Block 5	Clutch Housing	Block 4
Aluminum	5.36E-04	1.81E-03	3.98E-03
Antimony	0	0	
Arsenic	0	0	1.91E-06
Barium	0	0	
Beryllium	0	0	
Cadmium	1.15E-06	3.9E-06	4.55E-06
Chromium	1.56E-05	4.86E-05	4.85E-05
Cobalt	3.11E-06	0	7.39E-04
Copper	2.17E-05	5.81E-05	5.71E-05
Iron	0.000645	0.001315	3.61E-03
Lead	3.04E-05	5.91E-05	1.79E-04
Manganese	2.41E-05	4.96E-05	8.37E-04
Mercury	0		1.16E-04
Nickel	3.49E-06	3.66E-05	
Selenium	0	0	
Silver	2.86E-07	0	1.95E-06
Zinc	2.39E-04	4.74E-04	9.74E-04

Table 5.9. Average Metal Emissions from Shakeout (Lb / Ton Iron Poured)

	Line 3 Stack 58	Line 3 Stack 58	Line 1 Stack G
	Block 5	Cylinder Head 1	Block 4
Aluminum	1.52E-02	2.04E-02	9.63E-03
Antimony	0	0	2.53E-06
Arsenic	0	0	
Barium	0	0	
Beryllium	0	0	
Cadmium	6.8E-06	5.57E-05	1.67E-05
Chromium	1.18E-04	1.98E-04	1.71E-04
Cobalt	0	0	8.62E-05
Copper	8.96E-05	1.40E-04	1.36E-04
Iron	9.80E-03	1.10E-02	1.83E-02
Lead	3.93E-04	1.12E-04	7.29E-05
Manganese	2.68E-04	3.50E-04	3.39E-04
Mercury		0	
Nickel	4.29E-06	3.24E-05	3.13E-04
Selenium	0	0	
Silver	6.46E-07	0	6.20E-06
Zinc	1.20E-03	5.05E-03	1.50E-03

Table 5.10. Average Metal Emissions from Cooling Stacks (Lb / Ton Iron)

	Line 3 Stack 32	Line 3 Stack 32	Line 3 Stack 46
	Clutch Housing	Fly Wheel	Clutch Housing
Aluminum	2.53E-03	1.26E-03	3.57E-03
Antimony	0	0	0
Arsenic	0	0	0
Barium	0	0	0
Beryllium	0	0	0
Cadmium	1.27E-05	3.91E-06	9.57E-06
Chromium	8.83E-05	3.4E-05	1.08E-04
Cobalt	1.53E-05	1.07E-05	9.67E-06
Copper	2.27E-04	4.51E-05	1.98E-04
Iron	1.77E-03	9.70E-04	2.50E-03
Lead	1.05E-04	3.89E-05	1.30E-04
Manganese	6.09E-05	3.29E-05	9.06E-05
Nickel	1.53E-04	8.79E-05	1.82E-04
Selenium	0	0	0
Silver	4.55E-05	0	7.95E-06
Zinc	8.61E-04	1.65E-04	2.07E-03

Table 5.11. Average Metal Emissions from Cooling During Engine Block Production
Lb Metal/Ton Iron Poured

Line 1

	202M*	202N	202O*	202P*	202Q	202R*	202S*	202T	202U	202V	202W*	202Z*	Cooling Sum Metals
Aluminum	7.75E-04	2.02E-03	9.67E-04	1.50E-03	1.59E-03	1.44E-03	1.54E-03	1.84E-03	1.19E-03	1.47E-03	4.35E-04	7.83E-04	1.56E-02
Antimony	0.00E+00	0.00E+00	0.00E+00	2.55E-06	2.71E-06	2.45E-06	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-05
Arsenic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Barium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beryllium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	3.04E-07	8.00E-07	3.81E-07	1.74E-06	1.85E-06	1.68E-06	1.80E-06	4.53E-06	2.43E-07	3.87E-06	1.09E-06	1.97E-06	2.03E-05
Chromium	9.20E-06	2.39E-05	1.15E-05	2.43E-05	2.58E-05	2.34E-05	2.50E-05	2.43E-05	1.41E-05	2.72E-05	8.07E-06	1.45E-05	2.31E-04
Cobalt	0.00E+00	0.00E+00	0.00E+00	9.41E-06	9.99E-06	9.05E-06	9.69E-06	1.51E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-05
Copper	8.32E-06	2.16E-05	1.04E-05	1.81E-05	1.92E-05	1.74E-05	1.86E-05	3.86E-05	6.00E-06	1.57E-05	4.80E-06	8.63E-06	1.87E-04
Iron	6.12E-04	1.59E-03	7.63E-04	1.80E-03	1.91E-03	1.73E-03	1.86E-03	2.90E-03	1.81E-03	2.21E-03	6.22E-04	1.12E-03	1.89E-02
Lead	1.49E-05	3.88E-05	1.86E-05	2.51E-05	2.67E-05	2.42E-05	2.59E-05	2.30E-05	4.88E-06	1.12E-05	3.23E-06	5.82E-06	2.22E-04
Manganese	1.46E-05	3.80E-05	1.82E-05	3.20E-05	3.39E-05	3.07E-05	3.29E-05	5.46E-05	3.91E-05	1.29E-04	3.53E-05	6.35E-05	5.21E-04
Nickel	2.24E-06	5.83E-06	2.80E-06	1.32E-05	1.40E-05	1.27E-05	1.36E-05	4.96E-05	1.00E-05	3.83E-05	1.05E-05	1.89E-05	1.92E-04
Selenium	0.00E+00	0.00E+00	0.00E+00	1.01E-06	1.07E-06	9.73E-07	1.04E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-06
Silver	3.03E-07	7.92E-07	3.79E-07	1.51E-06	1.60E-06	1.45E-06	1.56E-06	2.49E-07	2.92E-07	5.23E-07	1.43E-07	2.58E-07	9.06E-06
Zinc	4.03E-05	1.05E-04	5.02E-05	1.45E-03	1.54E-03	1.40E-03	1.50E-03	7.70E-03	3.39E-05	1.54E-04	4.48E-05	8.06E-05	1.41E-02

* = Calculated Averages. See Section 5.1

Table 5.12. Summary – Average Metal Emissions for All Parts
Lb / Ton Metal Poured

Line 1

Analyte Name	Pouring Avg	Pouring Std Dev	Pouring Max	Cooling Avg	Cooling Std Dev	Cooling Max	Shakeout Avg	Shakeout Std Dev	Shakeout Max	Totals Avg	Totals Std Dev	Totals Max
Aluminum	3.98E-03	4.53E-03	8.74E-03	1.56E-02	2.85E-03	2.85E-02	9.63E-03	7.16E-03	2.23E-02	2.92E-02	8.94E-03	5.96E-02
Antimony	0.00E+00	0.00E+00	0.00E+00	1.03E-05	1.27E-05	6.21E-05	2.53E-06	4.38E-06	7.59E-06	1.29E-05	1.34E-05	6.97E-05
Arsenic	1.91E-06	9.34E-06	1.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-06	9.34E-06	1.14E-05
Barium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beryllium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	4.55E-06	3.59E-06	8.81E-06	2.03E-05	7.32E-06	4.37E-05	1.67E-05	1.03E-05	3.21E-05	4.15E-05	1.32E-05	8.46E-05
Chromium	4.85E-05	2.36E-05	6.72E-05	2.31E-04	2.96E-05	3.12E-04	1.71E-04	9.11E-05	3.00E-04	4.51E-04	9.86E-05	6.79E-04
Cobalt	7.39E-04	3.86E-03	5.13E-03	5.33E-05	3.74E-05	1.72E-04	8.62E-05	9.57E-05	2.49E-04	8.78E-04	3.86E-03	5.55E-03
Copper	5.71E-05	3.38E-05	8.69E-05	1.87E-04	6.24E-05	4.21E-04	1.36E-04	7.96E-05	2.71E-04	3.80E-04	1.07E-04	7.79E-04
Iron	3.61E-03	2.25E-03	5.53E-03	1.89E-02	3.90E-03	3.54E-02	1.83E-02	1.86E-02	4.35E-02	4.08E-02	1.91E-02	8.45E-02
Lead	1.79E-04	2.41E-04	3.83E-04	2.22E-04	6.25E-05	4.79E-04	7.29E-05	2.98E-05	1.26E-04	4.75E-04	2.51E-04	9.88E-04
Manganese	8.37E-04	1.17E-03	2.04E-03	5.21E-04	1.58E-04	1.12E-03	3.39E-04	2.50E-04	7.47E-04	1.70E-03	1.21E-03	3.91E-03
Nickel	1.16E-04	1.94E-04	3.76E-04	1.92E-04	6.23E-05	4.32E-04	3.13E-04	2.01E-04	6.66E-04	6.20E-04	2.86E-04	1.47E-03
Selenium	0.00E+00	0.00E+00	0.00E+00	4.10E-06	5.03E-06	2.46E-05	0.00E+00	0.00E+00	0.00E+00	4.10E-06	5.03E-06	2.46E-05
Silver	1.95E-06	3.59E-06	5.96E-06	9.06E-06	4.12E-06	2.45E-05	6.20E-06	5.83E-06	1.69E-05	1.72E-05	7.99E-06	4.74E-05
Zinc	9.74E-04	7.69E-04	1.81E-03	1.41E-02	1.39E-02	5.00E-02	1.50E-03	9.87E-04	2.81E-03	1.66E-02	1.40E-02	5.46E-02

Notes:
Zero Values = non-detects
Blank Spaces = not sampled

5.2 Emission Factors – Core Making

5.2.1 VOC Emissions

This section provides estimated emission factors for hot box core machine operations. Table 5.13 lists the three basic resin contents used for the different cores. On average, about 2% phenolic formaldehyde resin was used. The exhaust stacks tested exhibited significant variability in stack velocities varying from 160 to 600 scfm. The capture efficiency of the exhaust system was also very poor. The variability of the stack velocities as well as the lack of specific core data make the emission results only approximations of the actual process emissions.

Approximately 11,000 lb. of core sand is processed per hour. Table 5.14 lists the number of samples taken for each test method. Table 5.15 lists the test results by species in pounds per ton of cores produced. The results for the two core machines vary by a factor of up to ten for the same species. This may be due to the poor capture efficiencies noted above.

Table 5.13. Core Sand Recipes

	Mixture A %	Mixture B %	Mixture C %
Resin	**1.8**	**2.2**	**2.0**

Table 5.14. Number of Samples Taken at Each Core Machine Stack

Method	Number of Samples		Total
	Source Id		
	204C	204Q	
Method 5 Particulate Matter	3		3
Method 18	3	3	6
Method NIOSH 2002	3	3	6
Method NIOSH 2010	3	3	6
Method OSHA 42	3	3	6
Method T011	3	3	6

Table 5.15. Emission Factors for Core Making (Average Lb / Ton Core Sand)

Analyte Name	Stack 204C	Stack 204Q
1,1,2-Trichloroethane	6.31E-07	3.55E-07
1,2,3-Trimethylbenzene	1.43E-04	3.52E-05
1,2,4-Trimethylbenzene	5.09E-05	9.49E-05
1,2-Diethylbenzene	6.73E-06	3.36E-06
1,3,5-Trimethylbenzene	2.28E-04	5.76E-05
1,3-Diethylbenzene	3.91E-05	9.54E-06
1,3-Diisopropylbenzene	1.56E-05	8.61E-06
1,3-Dimethylnaphthalene	1.07E-05	8.20E-06
1,4-Diethylbenzene	1.02E-04	4.33E-05
1,4-Dimethylnaphthalene	0.00E+00	6.47E-06
1,5-Dimethylnaphthalene	1.55E-06	6.25E-06
1,6-Dimethylnaphthalene	1.07E-05	0.00E+00
1,8-Dimethylnaphthalene	9.68E-06	4.03E-06
1-Methylnaphthalene	3.36E-05	1.74E-05
2,3,5-Trimethylnaphthalene	3.53E-06	1.62E-06
2,3,5-Trimethylphenol	3.42E-05	1.02E-05
2,3-Dimethylnaphthalene	1.41E-06	8.43E-06
2,3-Dimethylphenol	2.13E-04	5.43E-05
2,4,6-Trimethylphenol	0.00E+00	0.00E+00
2,4-Diaminobiphenyl	0.00E+00	0.00E+00
2,5-Dimethylphenol	0.00E+00	0.00E+00
2,6-Dimethylnaphthalene	1.02E-06	9.90E-06
2,6-Dimethylphenol	0.00E+00	8.03E-06
2,7-Dimethylnaphthalene	0.00E+00	1.19E-07
2-Ethyltoluene	1.60E-04	3.54E-05
2-Methylnaphthalene	4.50E-05	2.34E-05
3,3'-Dimethoxybenzidine	0.00E+00	0.00E+00
3,4-Dimethylphenol	0.00E+00	0.00E+00
3,5-Dimethylphenol	2.35E-05	2.56E-05
3-Ethyltoluene	4.69E-04	3.33E-05
4,4'-Methylene Bis (2-Chloroaniline)	0.00E+00	0.00E+00
4,4'-Methylenedianiline	0.00E+00	0.00E+00
4-Aminobiphenyl	0.00E+00	0.00E+00
4-Ethyltoluene	1.93E-04	4.76E-05
a-Methylstyrene	0.00E+00	0.00E+00
Acenaphthalene/1,2-Dimethylnaphthalene	8.77E-06	2.75E-06
Acetaldehyde	5.70E-04	8.94E-05
Acetone	1.11E-04	1.96E-04
Acetophenone	0.00E+00	0.00E+00
Acrolein	0.00E+00	0.00E+00
Aniline	0.00E+00	0.00E+00
Benzene	1.50E-05	2.23E-05
Benzidine	0.00E+00	0.00E+00
Benzofuran	7.15E-04	4.65E-05

Table 5.15. (continued)

Analyte Name	Stack 204C	Stack 204Q
Bibenzyl	1.75E-06	2.24E-06
Biphenyl	0.00E+00	0.00E+00
Butanal/Benzaldehyde	1.09E-05	0.00E+00
Butylbenzene	1.23E-04	0.00E+00
Crotonaldehyde	0.00E+00	0.00E+00
Cumene	6.84E-06	4.58E-06
Cyclohexane	0.00E+00	4.85E-07
Decane	0.00E+00	1.78E-05
Dibenzofuran	1.46E-06	3.44E-06
Dodecane	1.35E-05	3.90E-05
Ethylbenzene	4.08E-06	1.15E-05
Formaldehyde	8.32E-03	8.79E-04
Heptane	7.95E-05	1.52E-05
Hexanal	1.41E-05	0.00E+00
Indan	3.45E-05	1.28E-05
Indene	9.15E-05	2.02E-05
Isobutylbenzene	1.85E-05	2.60E-06
m,p-Cresol	0.00E+00	0.00E+00
m,p-Xylene	1.55E-05	4.02E-05
m-Tolualdehyde	4.49E-05	0.00E+00
Methacrolein	2.17E-03	4.98E-05
Methyl Ethyl Ketone	0.00E+00	0.00E+00
Methyl Methacrylate	2.18E-06	0.00E+00
N,N-Dimethylaniline	0.00E+00	0.00E+00
N-Nitrosodimethylamine	0.00E+00	0.00E+00
n-Propylbenzene	8.93E-05	1.98E-06
Naphthalene	1.63E-04	3.94E-05
Nitrobenzene	8.31E-05	4.97E-06
Nonane	1.94E-06	7.48E-06
o-Anisidine	0.00E+00	0.00E+00
o-Cresol	1.10E-04	6.13E-06
o-Toluidine	0.00E+00	0.00E+00
o-Xylene	4.05E-05	2.39E-05
Octane	2.33E-06	5.14E-06
p-cymene	0.00E+00	0.00E+00
p-Phenylenediamine	0.00E+00	0.00E+00
Phenol	6.18E-05	5.49E-04
Propanal	8.23E-06	0.00E+00
Styrene	3.59E-06	3.50E-06
Tetradecane	4.27E-06	2.83E-05
Toluene	2.62E-04	1.04E-04
Tridecane	5.97E-06	3.94E-05
Undecane	1.63E-04	4.06E-05
Valeraldehyde	0.00E+00	0.00E+00
Total POMs	2.89E-04	1.28E-04

5.3 Emission Factors - Metal Melting

5.3.1 Metals

Table 5.16 lists emission factors for metals from induction melting. Major species emitted from metal melting operations were aluminum, iron, lead, manganese, and zinc.

Table 5.16. Metal Emissions from Metal Melting Operations

	Line 3
	Stack 27
Species	**lb/ton metal melted**
Aluminum	2.09E-02
Antimony	0.00E+00
Arsenic	0.00E+00
Barium	0.00E+00
Beryllium	0.00E+00
Cadmium	1.02E-04
Chromium	7.40E-04
Cobalt	0.00E+00
Copper	8.52E-04
Iron	1.40E-01
Lead	5.58E-03
Manganese	1.40E-02
Mercury	0.00E+00
Nickel	8.97E-04
Selenium	0.00E+00
Silver	6.01E-05
Zinc	4.61E-02

Figure 5.10 shows a graph of the metals emitted during the melting operations. Major metals emitted were aluminum, iron, lead, manganese, and zinc. Manganese is used as an inoculant in the process and zinc emissions probably arise from the use of recycled galvanized metal scrap at the foundry.

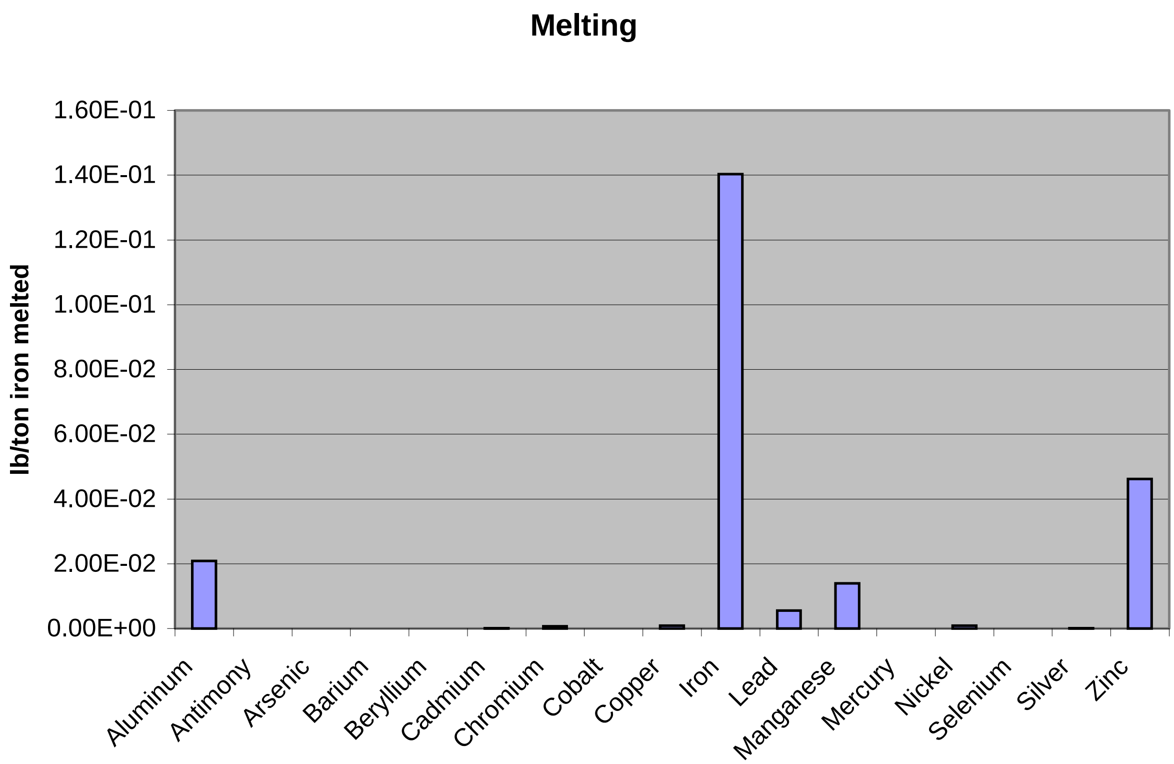


Figure 5.10. Major Metal Emissions from Melting Operations

5.4 Emission Factors - HAPs

5.4.1 Pouring, Cooling, and Shakeout (Engine Block Production)

This section provides in Table 5.17 emission factors for only the Hazardous Air Pollutants (HAPs) emitted from pouring, cooling, and shakeout. These data were assembled from Table 5.6 using the list of HAP species from Table 2.1. Results are reported only for the engine blocks 1, 2, and 3. Note that the table includes HAPs for which testing was made, but none was detected. Both organic HAPs and metal HAPs have been combined in these tables.

Similar tables covering emission factors in terms of other production data can be found in Appendix D.

Table 5.17. HAP Emissions for Blocks (1, 2, 3)
Average Lb / Ton Metal Poured

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetaldehyde	2.94E-04	2.34E-04	4.18E-04	3.20E-03	4.24E-04	4.30E-03	4.88E-04	1.54E-04	6.34E-04	3.98E-03	5.08E-04	5.35E-03
Acetophenone	ND	ND	ND	1.98E-04	3.57E-04	7.90E-04	ND	ND	ND	1.98E-04	3.57E-04	7.90E-04
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	2.19E-03	1.80E-03	3.48E-03	3.49E-02	3.95E-03	4.53E-02	2.82E-03	1.29E-03	4.12E-03	3.99E-02	4.53E-03	5.29E-02
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	4.55E-06	3.59E-06	8.81E-06	2.03E-05	7.32E-06	4.37E-05	1.67E-05	1.03E-05	3.21E-05	4.15E-05	1.32E-05	8.46E-05
Chromium	4.85E-05	2.36E-05	6.72E-05	2.31E-04	2.96E-05	3.12E-04	1.71E-04	9.11E-05	3.00E-04	4.51E-04	9.86E-05	6.79E-04
Copper	5.71E-05	3.38E-05	8.69E-05	1.87E-04	6.24E-05	4.21E-04	1.36E-04	7.96E-05	2.71E-04	3.80E-04	1.07E-04	7.79E-04
Cumene	6.00E-06	1.10E-05	1.33E-05	1.21E-04	2.52E-05	1.92E-04	ND	ND	ND	1.27E-04	2.75E-05	2.06E-04
Dibenzofuran	ND	ND	ND	1.63E-05	1.10E-05	5.39E-05	ND	ND	ND	1.63E-05	1.10E-05	5.39E-05
Ethylbenzene	1.01E-04	5.05E-05	1.38E-04	1.87E-03	2.18E-04	2.34E-03	2.47E-04	1.03E-04	3.57E-04	2.22E-03	2.46E-04	2.83E-03
Formaldehyde	1.38E-04	2.14E-04	2.61E-04	1.73E-03	3.15E-04	2.67E-03	5.43E-04	5.41E-04	1.16E-03	2.41E-03	6.62E-04	4.09E-03
Lead	1.79E-04	2.41E-04	3.83E-04	2.22E-04	6.25E-05	4.79E-04	7.29E-05	2.98E-05	1.26E-04	4.75E-04	2.51E-04	9.88E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	4.22E-04	2.46E-04	6.10E-04	7.61E-03	9.02E-04	9.55E-03	9.69E-04	3.11E-04	1.27E-03	9.00E-03	9.85E-04	1.14E-02
Manganese	8.37E-04	1.17E-03	2.04E-03	5.21E-04	1.58E-04	1.12E-03	3.39E-04	2.50E-04	7.47E-04	1.70E-03	1.21E-03	3.91E-03
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	1.88E-04	3.26E-04	5.65E-04	1.88E-04	3.26E-04	5.65E-04
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	1.81E-04	1.34E-04	2.72E-04	2.41E-03	6.12E-04	3.87E-03	3.21E-04	1.50E-04	4.91E-04	2.91E-03	6.44E-04	4.63E-03
Nitrobenzene	ND	ND	ND	5.03E-06	1.01E-05	2.01E-05	ND	ND	ND	5.03E-06	1.01E-05	2.01E-05
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	1.65E-06	6.60E-06	6.60E-06	9.27E-04	2.50E-04	1.51E-03	2.34E-04	2.26E-04	4.51E-04	1.16E-03	3.38E-04	1.97E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	1.90E-04	1.05E-04	2.70E-04	3.82E-03	4.74E-04	4.93E-03	4.64E-04	1.85E-04	6.54E-04	4.47E-03	5.19E-04	5.85E-03
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	2.86E-04	2.64E-04	4.60E-04	5.48E-03	1.25E-03	8.64E-03	5.25E-03	6.74E-03	1.29E-02	1.10E-02	6.86E-03	2.20E-02
Propanal	ND	ND	ND	3.71E-05	3.21E-05	5.68E-05	ND	ND	ND	3.71E-05	3.21E-05	5.68E-05
Selenium	ND	ND	ND	4.10E-06	5.03E-06	2.46E-05	ND	ND	ND	4.10E-06	5.03E-06	2.46E-05
Styrene	5.31E-05	4.40E-05	8.28E-05	4.35E-04	1.68E-04	8.26E-04	9.35E-05	6.50E-05	1.68E-04	5.81E-04	1.86E-04	1.08E-03
Toluene	1.05E-03	6.05E-04	1.52E-03	1.89E-02	2.50E-03	2.44E-02	2.50E-03	8.86E-04	3.37E-03	2.25E-02	2.72E-03	2.93E-02
Total POMs	3.56E-04		5.50E-04	4.64E-03		8.99E-03	4.15E-04		6.83E-04	5.41E-03		1.02E-02

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

5.4.2 Core Making

Table 5.18 shows the nonzero HAP emission factors for VOCs from core making operations. Neither metal HAPs nor PM were tested for on these stacks.

Table 5.18. Nonzero HAP Emissions from Core Making
Average Lb / Ton Core Sand

Analyte Name	Stack 204C	Stack 204Q
1,1,2-Trichloroethane	6.31E-07	3.55E-07
Acetaldehyde	5.70E-04	8.94E-05
Benzene	1.50E-05	2.23E-05
Benzofuran	7.15E-04	4.65E-05
Cumene	6.84E-06	4.58E-06
Dibenzofuran	1.46E-06	3.44E-06
Ethylbenzene	4.08E-06	1.15E-05
Formaldehyde	8.32E-03	8.79E-04
m,p-Xylene	1.55E-05	4.02E-05
Methyl Methacrylate	2.18E-06	0.00E+00
Naphthalene	1.63E-04	3.94E-05
Nitrobenzene	8.31E-05	4.97E-06
o-Cresol	1.10E-04	6.13E-06
o-Xylene	4.05E-05	2.39E-05
Phenol	6.18E-05	5.49E-04
Propanal	8.23E-06	0.00E+00
Styrene	3.59E-06	3.50E-06
Toluene	2.62E-04	1.04E-04
Total POMs	2.89E-04	1.28E-04
1,3-Dimethylnaphthalene	1.07E-05	8.20E-06
1,4-Dimethylnaphthalene	0.00E+00	6.47E-06
1,5-Dimethylnaphthalene	1.55E-06	6.25E-06
1,6-Dimethylnaphthalene	1.07E-05	0.00E+00
1,8-Dimethylnaphthalene	9.68E-06	4.03E-06
1-Methylnaphthalene	3.36E-05	1.74E-05
2,3,5-Trimethylnaphthalene	3.53E-06	1.62E-06
2,3-Dimethylnaphthalene	1.41E-06	8.43E-06
2,6-Dimethylnaphthalene	1.02E-06	9.90E-06
2,7-Dimethylnaphthalene	0.00E+00	1.19E-07
2-Methylnaphthalene	4.50E-05	2.34E-05
Acenaphthalene/1,2-Dimethylnaphthalene	8.77E-06	2.75E-06
Naphthalene	1.63E-04	3.94E-05

5.4.3 Metal Melting

This section provides in Table 5.19 emission factors for only the nonzero Hazardous Air Pollutants (HAPs) emitted from melting.

Table 5.19. Nonzero Metal HAP Emissions from Melting Operations Blocks

Analyte	Lb/Ton Metal Melted
Cadmium	1.02E-04
Chromium	7.40E-04
Lead	5.58E-03
Manganese	1.40E-02
Nickel	8.97E-04

6.0. Conclusions

This study focused on measuring emissions from the production of grey-iron engine blocks using a green sand system. Process steps investigated were pouring, cooling, and shakeout as well as core making operations. These are expected to be the major sources of air emissions and HAP generation in iron foundries.

These results are probably the best data set in existence detailing emissions of the U.S. EPA list of 189 HAPs from iron foundry processes. The measured emissions showed that the major HAPs emitted were acetaldehydes, benzene, toluene, xylenes, phenol, polycyclic organic matter (POM), and manganese. Many compounds on the list of 189 HAPs were not detected in this study; indeed, only 24 HAPs out of the total were detected from pouring, cooling, and shakeout.

Our best estimate for emissions of HAPs from pouring, cooling, and shakeout are shown in Table 6.1. These include the pouring and cooling results for engine block production on Line 1 and the shakeout results for clutch housings on Line 3. The results for the clutch housings were used instead of the blocks for shakeout because the emissions from shakeout on Line 1 were not completely captured by the stack ventilation system. Organic HAP contributions to shakeout emissions are taken from the results for clutch housing production on Line 3. Metal HAP contributions to shakeout are taken from the block results, since metal emissions from shakeout were not measured on Line 3. Figure 6.1 shows the emission factors for the major HAP species emitted from pouring, cooling, and shakeout. The contribution from shakeout dominates most of the organic HAP emissions.

Table 6.1 also includes the speciated emissions of polycyclic organic matter (POM). Figure 6.2 shows this speciated distribution across pouring, cooling, and shakeout. As shown in Figure 6.2, the POMs emitted at the highest rate are naphthalene and the monomethylated naphthalenes (1-methylnaphthalene and 2-methylnaphthalene). These three POMs account for 80% of the total POM emissions from pouring, cooling, and shakeout. Many of the recognized carcinogenic POMs were not even detected; for example, benzo[a]pyrene (BaP), benz[a]anthracene, and chrysene. Thus, the use of BaP as a surrogate for POM would be incorrect for pouring, cooling, and shakeout emissions.

We also report here for the first time emissions information on particulate matter sized less than or equal to 10 μm (PM_{10}) and less than or equal to 2.5 μm ($PM_{2.5}$). Obviously, by this definition, PM_{10} will include $PM_{2.5}$. Table 5.7 shows that PM_{10} is about 50% of the total PM emissions from cooling, but less than 30% of the total PM from pouring, cooling, and shakeout combined. As noted above, however, not all the emissions from shakeout were captured, yet shakeout is one of the process steps in which particulate matter emissions are high. Size-segregated information on PM emissions from foundries has not been available to the scientific community and will be invaluable in determining the impact of future $PM_{2.5}$ regulations on the foundry industry.

Table 6.1. Best Estimates of Nonzero HAP Emissions from Pouring, Cooling, and Shakeout. (lb / ton Metal Poured)

Analyte	Pouring[1]	Cooling[1]	Shakeout[2]	Totals
Acetaldehyde	2.94E-04	3.20E-03	5.78E-02	6.13E-02
Acetophenone	ND	1.98E-04	7.92E-04	9.90E-04
Benzene	2.19E-03	3.49E-02	2.68E-02	6.39E-02
Cadmium	4.55E-06	2.03E-05	1.67E-05	4.16E-05
Chromium	4.85E-05	2.31E-04	1.71E-04	4.51E-04
Copper	5.71E-05	1.87E-04	1.36E-04	3.80E-04
Cumene	6.00E-06	1.21E-04	3.82E-04	5.09E-04
Dibenzofuran	ND	1.63E-05	3.34E-04	3.50E-04
Ethylbenzene	1.01E-04	1.87E-03	2.91E-03	4.88E-03
Formaldehyde	1.38E-04	1.73E-03	2.57E-02	2.76E-02
Lead	1.79E-04	2.22E-04	7.29E-05	4.74E-04
m,p-Xylene	4.22E-04	7.61E-03	1.25E-02	2.05E-02
Manganese	8.37E-04	5.21E-04	3.39E-04	1.70E-03
Naphthalene	1.81E-04	2.41E-03	8.37E-03	1.10E-02
Nitrobenzene	ND	5.03E-06	ND	5.03E-06
o-Cresol	1.65E-06	9.27E-04	1.40E-02	1.49E-02
o-Xylene	1.90E-04	3.82E-03	5.32E-03	9.33E-03
Phenol	2.86E-04	5.48E-03	2.80E-02	3.38E-02
POMs	3.56E-04	4.64E-03	2.21E-02	2.71E-02
1,3-Dimethylnaphthalene	4.33E-06	1.14E-04	1.03E-03	1.15E-03
1,4-Dimethylnaphthalene	ND	2.51E-05	4.64E-04	4.89E-04
1,6-Dimethylnaphthalene	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	5.32E-06	1.06E-03	1.07E-03
1-Methylnaphthalene	7.69E-05	9.04E-04	3.41E-03	4.39E-03
2,3,5-Trimethylnaphthalene	ND	ND	7.14E-04	7.14E-04
2,3-Dimethylnaphthalene	ND	9.53E-05	6.50E-04	7.45E-04
2,6-Dimethylnaphthalene	ND	1.13E-05	5.68E-04	5.79E-04
2,7-Dimethylnaphthalene	1.27E-06	2.49E-05	4.10E-04	4.36E-04
2-Methylnaphthalene	9.10E-05	1.03E-03	5.22E-03	6.34E-03
Acenaphthalene/1,2-Dimethylnaphthalene	1.51E-06	2.30E-05	2.20E-04	2.45E-04
Naphthalene	1.81E-04	2.41E-03	8.37E-03	1.10E-02
Propanal	ND	3.71E-05	5.70E-03	5.74E-03
Selenium	ND	4.10E-06	ND	4.10E-06
Styrene	5.31E-05	4.35E-04	4.81E-03	5.30E-03
Toluene	1.05E-03	1.89E-02	2.21E-02	4.21E-02
Xylenes	6.12E-04	1.14E-02	1.78E-02	2.99E-02

[1]Pouring and cooling contributions are taken from the results for engine block production on Line 1.
[2]Shakeout VOC HAP contributions are taken from the results for clutch housing production on Line 3. Metal HAP contributions are from the block results, since metal emissions from shakeout were not measured on Line 3.

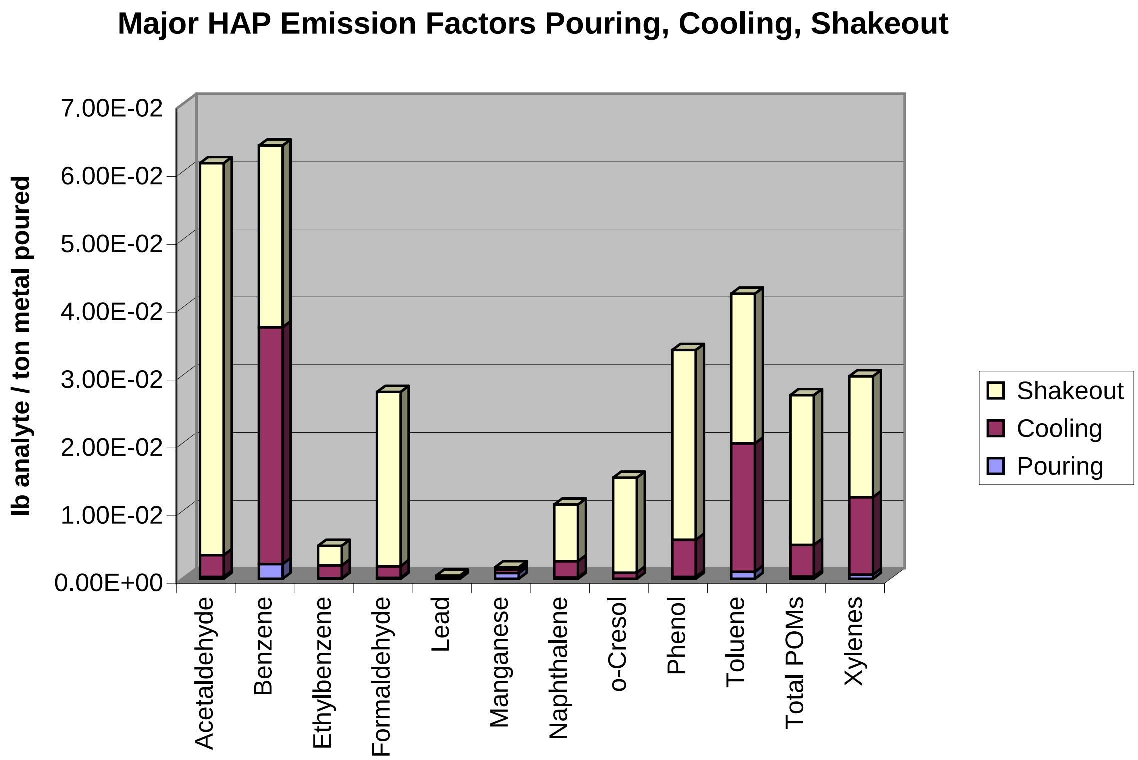


Figure 6.1 - Major Hazardous Air Pollutant Emissions From Pouring, Cooling, and Shakeout

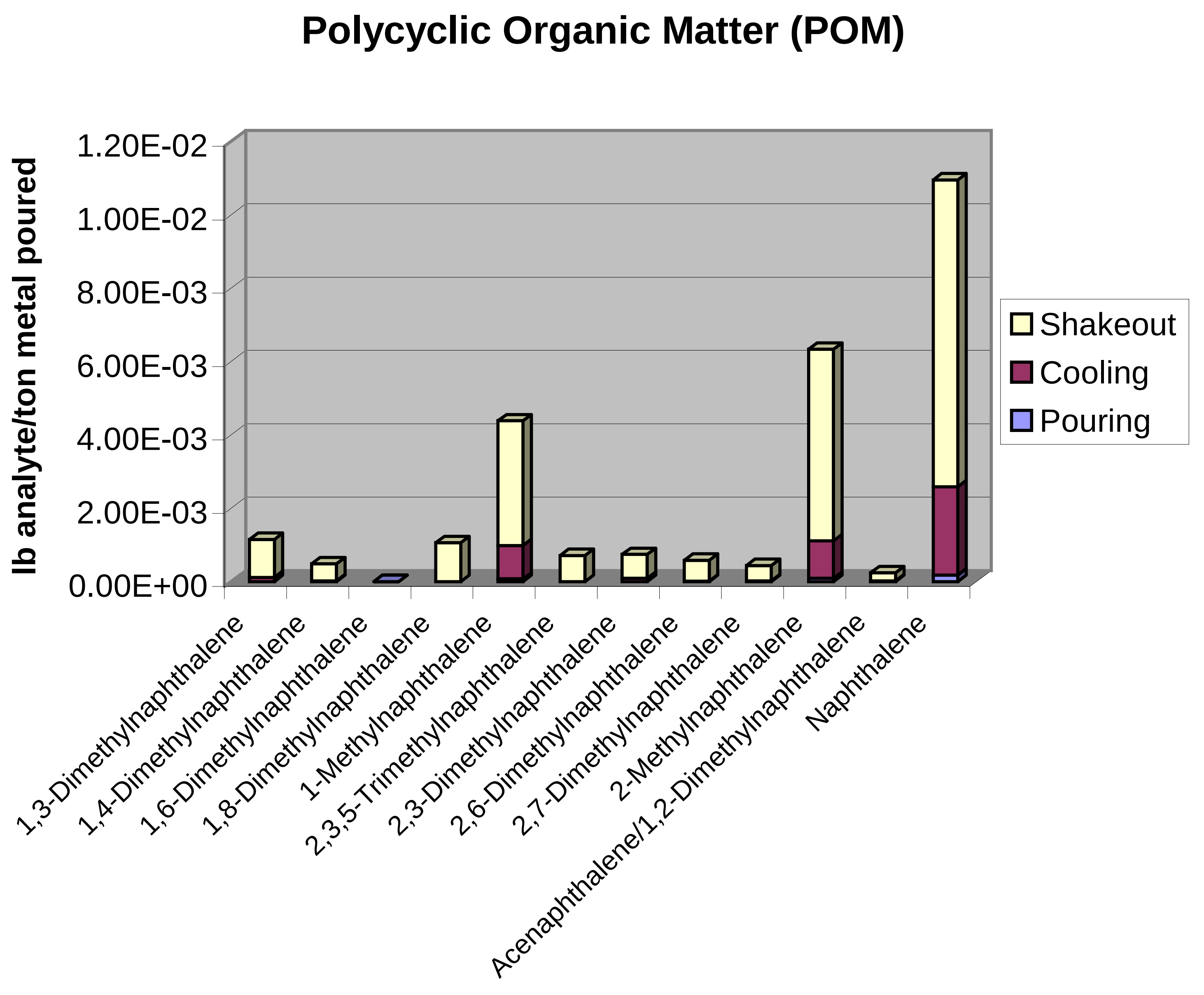


Figure 6.2. Speciated Polycyclic Organic Matter (POM) Emission Factors from Pouring, Cooling, and Shakeout

Appendix A. Mass Emission Rates for Stacks Measured

Emission rates in lb/hr are collected here for Lines 1, 2, and 3 for all the measurements made in this sampling program. Tables A.1 – A.4 show the emission rates in lb/hr measured for the processes on Line 1. Table A.5 shows the emission rates for Line 2. Table A.6 shows the emission rates for Line 3, as well as the emission rates for the melting furnace that serviced Line 3.

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.1. Line 1 Pouring
Lb/Hr

Analyte Name	Bearing Cap 2	Bearing Cap 3	Bearing Cap 5	Block 1	Block 2	Block 3	Manifold 4
1,1,2-Trichloroethane	ND			ND		ND	
1,2,3-Trimethylbenzene	2.94E-03			ND		2.22E-03	
1,2,4-Trimethylbenzene	4.41E-03			2.49E-03		5.61E-03	
1,2-Diethylbenzene	ND			4.40E-04		ND	
1,3,5-Trimethylbenzene	2.33E-03			1.16E-03		2.74E-03	
1,3-Diethylbenzene	ND			ND		ND	
1,3-Diisopropylbenzene	5.80E-04			4.18E-04		ND	
1,3-Dimethylnaphthalene	ND			ND		1.43E-04	
1,4-Diethylbenzene	2.40E-03			1.41E-03		8.42E-04	
1,4-Dimethylnaphthalene	ND			ND		ND	
1,5-Dimethylnaphthalene							
1,6-Dimethylnaphthalene	ND			ND		ND	
1,8-Dimethylnaphthalene	ND			ND		ND	
1-Methylnaphthalene	6.77E-04			2.24E-04		1.89E-03	
2,3,5-Trimethylnaphthalene	ND			ND		ND	
2,3,5-Trimethylphenol	ND			3.67E-04		ND	
2,3-Dimethylnaphthalene	ND			ND		ND	
2,3-Dimethylphenol	ND			1.92E-03		ND	
2,4,6-Trimethylphenol	ND			ND		ND	
2,4-Diaminobiphenyl	ND			ND		ND	
2,5-Dimethylphenol	ND			ND		ND	
2,6-Dimethylnaphthalene	ND			ND		ND	
2,6-Dimethylphenol	ND			4.83E-04		ND	
2,7-Dimethylnaphthalene	7.75E-05			ND		5.36E-05	
2-Ethyltoluene	7.87E-04			2.37E-04		1.17E-03	
2-Methylnaphthalene	1.03E-03			3.06E-04		2.32E-03	
3,3'-Dimethoxybenzidine	ND			ND		ND	
3,4-Dimethylphenol	ND			2.63E-04		ND	
3,5-Dimethylphenol	ND			8.02E-04		9.84E-04	
3-Ethyltoluene	2.42E-03			6.37E-04		ND	
4,4'-Methylene Bis (2-Chloroaniline)	ND			ND		ND	
4,4'-Methylenedianiline	ND			ND		ND	
4-Aminobiphenyl	ND			ND		ND	
4-Ethyltoluene	6.76E-04			1.19E-03		7.23E-04	
a-Methylstyrene	ND			ND		ND	
Acenaphthalene/1,2-Dimethylnaphthalene	ND			ND		3.49E-05	
Acetaldehyde	4.70E-03			2.22E-03		6.57E-03	
Acetone	6.18E-03			4.31E-03		8.92E-03	
Acetophenone	ND			ND		ND	
Acrolein	ND			ND		ND	
Aluminum	1.32E-01	8.07E-02	1.18E-02	3.77E-02	2.68E-02	3.65E-02	1.57E-02
Aniline	ND			ND		ND	
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	3.41E-04	ND	ND	ND
Barium	ND	ND	ND	ND	ND	ND	ND
Benzene	4.50E-02			1.16E-02		5.48E-02	
Benzidine	ND			ND		ND	
Benzofuran	ND			ND		ND	
Beryllium	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND			ND		ND	
Biphenyl	ND			ND		ND	
Butanal/Benzaldehyde	ND			ND		ND	
Butylbenzene	ND			ND		ND	
Cadmium	9.75E-05	1.19E-04	1.75E-05	1.47E-04	3.51E-05	3.83E-05	5.20E-05
Chromium	1.17E-03	9.46E-04	2.39E-04	5.78E-04	4.90E-04	6.27E-04	3.26E-04
Cobalt	1.90E-04	2.79E-04	ND	ND	ND	3.95E-02	ND
Copper	1.32E-03	9.93E-04	5.90E-04	6.06E-04	4.98E-04	8.42E-04	2.48E-04
Crotonaldehyde	ND			ND		ND	
Cumene	1.50E-04			ND		1.77E-04	
Cyclohexane	ND			ND		ND	
Decane	7.51E-03			4.15E-03		1.06E-02	
Dibenzofuran	ND			ND		ND	
Dodecane	7.45E-03			3.67E-03		1.51E-02	
Ethylbenzene	2.90E-03			1.12E-03		2.22E-03	
Formaldehyde	ND			ND		3.38E-03	
Heptane	1.22E-02			3.36E-03		6.01E-03	
Hexanal	ND			ND		ND	
Indan	1.14E-03			3.67E-04		3.40E-04	
Indene	1.28E-03			5.04E-04		7.91E-04	
Iron	9.91E-02	9.79E-02	1.32E-02	5.34E-02	3.67E-02	2.92E-02	1.38E-02
Isobutylbenzene	3.31E-04			9.05E-05		ND	
Lead	4.53E-03	1.29E-03	3.37E-04	3.14E-03	1.26E-03	3.52E-03	4.20E-04
m,p-Cresol	ND			ND		ND	
m,p-Xylene	1.27E-02			3.90E-03		9.69E-03	
m-Tolualdehyde	ND			ND		ND	
Manganese	5.58E-03	3.66E-02	2.97E-04	2.67E-02	1.56E-02	4.70E-03	1.91E-03
Mercury	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND			ND		ND	
Methyl Ethyl Ketone	ND			ND		ND	
Methyl Methacrylate	ND			ND		ND	
N,N-Dimethylaniline	ND			ND		ND	
N-Nitrosodimethylamine	ND			ND		ND	
n-Propylbenzene	8.21E-04			ND		ND	
Naphthalene	1.97E-03			1.16E-03		4.45E-03	
Nickel	6.02E-03	8.12E-04	ND	2.27E-03	1.81E-03	9.96E-04	6.22E-04
Nitrobenzene	ND			ND		ND	
Non-Condensable Particulate Matter	3.18E-03	1.81E-03	4.98E-04	3.44E+00	1.11E-03	5.69E-04	5.08E-04
Nonane	5.92E-03			2.57E-03		3.43E-03	
o-Anisidine	ND			ND		ND	
o-Cresol	ND			9.49E-05		ND	
o-Toluidine	ND			ND		ND	
o-Xylene	5.41E-03			2.17E-03		4.18E-03	
Octane	7.14E-03			1.24E-03		4.03E-03	
p-cymene	4.45E-04			2.00E-03		2.92E-03	
p-Phenylenediamine	ND			ND		ND	
Phenol	3.71E-03			1.49E-03		7.32E-03	
Propanal	ND			ND		ND	
Selenium	ND	ND	ND	ND	ND	ND	ND
Silver	4.61E-05	2.09E-05	ND	2.16E-05	6.01E-05	ND	5.84E-05
Styrene	4.91E-04			1.68E-04		1.36E-03	
Tetradecane	8.42E-04			3.02E-04		1.56E-03	
Toluene	2.92E-02			9.08E-03		2.42E-02	
Tridecane	3.61E-03			1.80E-03		6.69E-03	
Undecane	1.29E-02			6.79E-03		2.32E-02	
Valeraldehyde	ND			ND		ND	
Zinc	2.50E-02	1.26E-02	2.88E-03	2.42E-02	1.43E-02	8.58E-03	5.84E-03
Particulate Matter (PM_{10})				1.45E-01			
Particulate Matter ($PM_{2.5}$)				4.42E-02			
Total POMs	3.75E-03			1.69E-03		8.89E-03	

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.2. Line 1 Cooling
Lb/Hr

Analyte Name	Bearing Cap 2	Bearing Cap 3	Bearing Cap 5	Block 1	Block 2	Block 3	Crankshaft 1	Manifold 2	Manifold 4	WaterPump 1
1,1,2-Trichloroethane	ND	ND		ND	ND					
1,2,3-Trimethylbenzene	2.31E-03	3.74E-03		7.45E-03	8.46E-03					
1,2,4-Trimethylbenzene	4.86E-03	3.56E-03		1.63E-02	1.41E-02					
1,2-Diethylbenzene	6.50E-04	ND		1.02E-03	1.27E-03					
1,3,5-Trimethylbenzene	2.42E-03	3.01E-03		7.40E-03	7.56E-03					
1,3-Diethylbenzene	4.93E-04	1.38E-04		4.79E-04	1.99E-04					
1,3-Diisopropylbenzene	6.95E-04	ND		8.48E-04	1.50E-03					
1,3-Dimethylnaphthalene	ND	1.69E-04		5.83E-04	2.87E-04					
1,4-Diethylbenzene	1.73E-03	1.21E-03		3.96E-03	7.62E-04					
1,4-Dimethylnaphthalene	ND	7.90E-05		5.62E-05	1.18E-04					
1,5-Dimethylnaphthalene										
1,6-Dimethylnaphthalene	ND	ND		ND	ND					
1,8-Dimethylnaphthalene	ND	ND		3.20E-05	1.67E-05					
1-Methylnaphthalene	ND	1.05E-03		4.56E-03	3.56E-03					
2,3,5-Trimethylnaphthalene	ND	ND		ND	ND					
2,3,5-Trimethylphenol	4.93E-04	ND		7.64E-04	3.72E-04					
2,3-Dimethylnaphthalene	ND	ND		4.01E-04	3.31E-04					
2,3-Dimethylphenol	1.93E-03	ND		4.28E-03	5.45E-03					
2,4,6-Trimethylphenol	ND	ND		ND	ND					
2,4-Diaminobiphenyl		ND	ND	ND	ND		ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND		ND	1.13E-02					
2,6-Dimethylnaphthalene	ND	ND		4.19E-05	ND					
2,6-Dimethylphenol	8.29E-04	ND		7.17E-04	3.08E-03					
2,7-Dimethylnaphthalene	ND	7.90E-05		1.26E-04	2.20E-04					
2-Ethyltoluene	1.17E-03	1.90E-03		3.89E-03	4.74E-03					
2-Methylnaphthalene	ND	1.54E-03		5.01E-03	3.94E-03					
3,3'-Dimethoxybenzidine		ND	ND	ND	ND		ND	ND	ND	ND
3,4-Dimethylphenol	ND	ND		ND	1.00E-03					
3,5-Dimethylphenol	1.32E-03	ND		2.88E-03	3.19E-03					
3-Ethyltoluene	2.71E-03	3.79E-03		2.50E-03	ND					
4,4'-Methylene Bis (2-Chloroaniline)		ND	ND	ND	ND		ND	ND	ND	ND
4,4'-Methylenedianiline		ND	ND	ND	ND		ND	ND	ND	ND
4-Aminobiphenyl		ND	ND	ND	ND		ND	ND	ND	ND
4-Ethyltoluene	1.64E-03	1.22E-03		6.41E-03	7.86E-03					
a-Methylstyrene	ND	ND		ND	ND					
Acenaphthalene/1,2-Dimethylnaphthalene	ND	3.86E-05		1.08E-04	1.18E-04					
Acetaldehyde		4.49E-03	3.53E-03	1.56E-02	1.93E-02			2.70E-03	1.23E-03	2.28E-03
Acetone		8.91E-03	4.36E-03	1.93E-02	2.08E-02			1.65E-03	4.69E-03	1.24E-03
Acetophenone	ND	ND		1.08E-04	4.55E-03					
Acrolein		ND	ND	ND	ND			ND	ND	ND
Aluminum	2.70E-02	1.18E-02		7.01E-02	4.78E-02					
Aniline		ND	ND	ND	ND					
Antimony	ND	ND		ND	2.25E-04					
Arsenic	ND	ND		ND	ND					
Barium	ND	ND		ND	ND					
Benzene	4.37E-02	4.44E-02		1.63E-01	9.09E-02					
Benzidine		ND	ND	ND	ND		ND	ND	ND	ND
Benzofuran	ND	ND		ND	ND					
Beryllium	ND	ND		ND	ND					
Bibenzyl	ND	ND		3.57E-05	1.46E-05					
Biphenyl	ND	ND		ND	ND					
Butanal/Benzaldehyde		7.46E-04	ND	3.31E-03	3.34E-03			3.52E-04	ND	ND
Butylbenzene	ND	ND		8.84E-04	3.51E-03					
Cadmium	1.31E-05	3.11E-05		1.01E-04	2.37E-05					
Chromium	3.63E-04	2.76E-04		1.07E-03	5.30E-04					
Cobalt	2.81E-04	4.50E-05		1.76E-04	ND					
Copper	2.34E-04	3.54E-04		7.23E-04	3.99E-04					
Crotonaldehyde		ND	ND	ND	ND			ND	ND	ND
Cumene	ND	3.44E-04		6.25E-04	6.99E-04					
Cyclohexane	ND	ND		ND	ND					
Decane	3.00E-03	7.79E-03		1.17E-02	1.28E-02					
Dibenzofuran	ND	ND		7.70E-05	ND					
Dodecane	2.60E-03	8.13E-03		1.29E-02	8.04E-03					
Ethylbenzene	3.00E-03	3.48E-03		9.20E-03	8.60E-03					
Formaldehyde		2.49E-03	4.76E-03	6.57E-03	3.81E-03			8.76E-04	1.54E-03	1.09E-03
Heptane	4.71E-03	1.68E-02		1.59E-02	1.05E-02					
Hexanal		ND	ND	ND	8.88E-04			ND	ND	ND
Indan	1.21E-03	1.48E-03		2.20E-03	1.61E-03					
Indene	8.29E-04	1.17E-03		2.39E-03	2.99E-03					
Iron	3.14E-02	1.86E-02		8.98E-02	5.45E-02					
Isobutylbenzene	ND	6.54E-04		4.88E-04	9.04E-04					
Lead	3.71E-04	5.19E-04		1.18E-03	3.53E-04					
m,p-Cresol	ND	ND		ND	ND					
m,p-Xylene	1.25E-02	1.54E-02		4.00E-02	1.88E-02					
m-Tolualdehyde		ND	ND	ND	ND			ND	ND	ND
Manganese	7.25E-04	1.60E-04		3.32E-03	6.39E-04					
Mercury	ND	ND		ND	ND					
Methacrolein		ND	ND	5.40E-04	1.92E-03			ND	ND	ND
Methyl Ethyl Ketone		ND	ND	ND	ND			ND	ND	ND
Methyl Methacrylate	4.03E-04	ND		ND	ND					
N,N-Dimethylaniline		ND	ND	ND	ND		ND	ND	ND	ND
N-Nitrosodimethylamine		ND	ND	ND	ND		ND	ND	ND	ND
n-Propylbenzene	8.29E-04	3.53E-04		1.62E-04	ND					
Naphthalene	8.29E-04	3.53E-03		9.64E-03	1.28E-02					
Nickel	2.77E-04	1.35E-04		1.07E-03	7.41E-05					
Nitrobenzene	6.05E-04	ND		1.45E-04	ND					
Non-Condensable Particulate Matter	5.01E-04	1.70E+00	1.73E+00	5.03E-01	1.03E+00	ND				
Nonane	2.53E-03	7.83E-03		9.72E-03	9.76E-03					
o-Anisidine		ND	ND	ND	ND		ND	ND	ND	ND
o-Cresol	ND	ND		3.60E-03	7.09E-04					
o-Toluidine		ND	ND	ND	ND		ND	ND	ND	ND
o-Xylene	5.33E-03	6.61E-03		1.88E-02	1.22E-02					
Octane	2.82E-03	1.32E-02		1.29E-02	1.06E-02					
p-cymene	ND	7.79E-04		1.36E-03	9.19E-04					
p-Phenylenediamine		ND	ND	ND	ND		ND	ND	ND	ND
Phenol	ND	4.52E-03		2.62E-02	1.43E-02					
Propanal		ND	ND	ND	6.13E-04			ND	ND	ND
Selenium	ND	ND		3.49E-05	ND					
Silver	8.50E-06	2.65E-05		4.50E-05	1.64E-05					
Styrene	7.17E-04	ND		2.11E-03	4.28E-03					
Tetradecane	ND	1.29E-03		1.72E-03	1.33E-03					
Toluene	2.50E-02	2.96E-02		1.01E-01	4.94E-02					
Tridecane	9.19E-04	5.07E-03		5.78E-03	1.35E-03					
Undecane	5.85E-03	1.21E-02		2.48E-02	2.06E-02					
Valeraldehyde		ND	ND	5.75E-04	2.20E-03			ND	ND	ND
Zinc	5.55E-03	5.41E-02		6.00E-02	1.39E-02					
Particulate Matter (PM_{10})		1.49E-01	1.62E-01	1.75E-01	1.61E-01	ND				
Particulate Matter ($PM_{2.5}$)		8.64E-03	7.35E-03	6.43E-02	4.96E-02	1.66E-02				
Total POMs	8.29E-04	6.48E-03		2.06E-02	2.14E-02					

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.3. Line 1 Shakeout
Lb/Hr

	SHAKEOUT		
Analyte Name	Bearing Cap 1	Bearing Cap 4	Combo 3
1,1,2-Trichloroethane			
1,2,3-Trimethylbenzene			
1,2,4-Trimethylbenzene			
1,2-Diethylbenzene			
1,3,5-Trimethylbenzene			
1,3-Diethylbenzene			
1,3-Diisopropylbenzene			
1,3-Dimethylnaphthalene			
1,4-Diethylbenzene			
1,4-Dimethylnaphthalene			
1,5-Dimethylnaphthalene			
1,6-Dimethylnaphthalene			
1,8-Dimethylnaphthalene			
1-Methylnaphthalene			
2,3,5-Trimethylnaphthalene			
2,3,5-Trimethylphenol			
2,3-Dimethylnaphthalene			
2,3-Dimethylphenol			
2,4,6-Trimethylphenol			
2,4-Diaminobiphenyl	ND	ND	ND
2,5-Dimethylphenol			
2,6-Dimethylnaphthalene			
2,6-Dimethylphenol			
2,7-Dimethylnaphthalene			
2-Ethyltoluene			
2-Methylnaphthalene			
3,3'-Dimethoxybenzidine	ND	ND	ND
3,4-Dimethylphenol			
3,5-Dimethylphenol			
3-Ethyltoluene			
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND
4-Ethyltoluene			
a-Methylstyrene			
Acenaphthalene/1,2-Dimethylnaphthalene			
Acetaldehyde	8.93E-03	4.91E-03	5.18E-03
Acetone	5.67E-03	5.81E-03	2.80E-03
Acetophenone			
Acrolein	ND	ND	ND
Aluminum	1.47E-02		1.63E-02
Aniline			
Antimony	ND		6.24E-05
Arsenic	ND		ND
Barium	ND		ND
Benzene			
Benzidine	ND	ND	ND
Benzofuran			
Beryllium	ND		ND
Bibenzyl			
Biphenyl			
Butanal/Benzaldehyde	ND	ND	ND
Butylbenzene			
Cadmium	5.33E-05		7.36E-05
Chromium	2.33E-04		3.96E-04
Cobalt	ND		6.76E-05
Copper	9.68E-05		4.54E-04
Crotonaldehyde	ND	ND	ND
Cumene			
Cyclohexane			
Decane			
Dibenzofuran			
Dodecane			
Ethylbenzene			
Formaldehyde	ND	ND	1.43E-03
Heptane			
Hexanal	ND	ND	ND
Indan			
Indene			
Iron	1.42E-02		2.11E-02
Isobutylbenzene			
Lead	7.52E-05		1.52E-04
m,p-Cresol			
m,p-Xylene			
m-Tolualdehyde	ND	ND	ND
Manganese	3.23E-04		9.77E-04
Mercury	ND		ND
Methacrolein	ND	ND	ND
Methyl Ethyl Ketone	ND	ND	ND
Methyl Methacrylate			
N,N-Dimethylaniline	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND
n-Propylbenzene			
Naphthalene			
Nickel	3.26E-04		8.24E-04
Nitrobenzene			
Non-Condensable Particulate Matter	7.05E-01		5.13E-04
Nonane			
o-Anisidine	ND	ND	ND
o-Cresol			
o-Toluidine	ND	ND	ND
o-Xylene			
Octane			
p-cymene			
p-Phenylenediamine	ND	ND	ND
Phenol			
Propanal	ND	ND	ND
Selenium	ND		ND
Silver	1.98E-05		5.28E-06
Styrene			
Tetradecane			
Toluene			
Tridecane			
Undecane			
Valeraldehyde	ND	ND	ND
Zinc	1.89E-03		4.65E-03
Particulate Matter (PM_{10})	1.59E-01		
Particulate Matter ($PM_{2.5}$)	4.48E-03		
Total POMs			

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.4. Line 1 Totals
Lb/Hr

Analyte Name	Bearing Cap 1	Bearing Cap 2	Bearing Cap 3	Bearing Cap 4	Bearing Cap 5	Block 1	Block 2	Block 3	Combo 3	Crankshaft 1	Manifold 2	Manifold 4	Water Pump 1
1,1,2-Trichloroethane		ND	ND			ND	ND	ND					
1,2,3-Trimethylbenzene		5.25E-03	3.74E-03			7.45E-03	8.46E-03	2.22E-03					
1,2,4-Trimethylbenzene		9.28E-03	3.56E-03			1.88E-02	1.41E-02	5.61E-03					
1,2-Diethylbenzene		6.50E-04	ND			1.46E-03	1.27E-03	ND					
1,3,5-Trimethylbenzene		4.75E-03	3.01E-03			8.56E-03	7.56E-03	2.74E-03					
1,3-Diethylbenzene		4.93E-04	1.38E-04			4.79E-04	1.99E-04	ND					
1,3-Diisopropylbenzene		1.27E-03	ND			1.27E-03	1.50E-03	ND					
1,3-Dimethylnaphthalene		ND	1.69E-04			5.83E-04	2.87E-04	1.43E-04					
1,4-Diethylbenzene		4.12E-03	1.21E-03			5.37E-03	7.62E-04	8.42E-04					
1,4-Dimethylnaphthalene		ND	7.90E-05			5.62E-05	1.18E-04	ND					
1,5-Dimethylnaphthalene													
1,6-Dimethylnaphthalene		ND	ND			ND	ND	ND					
1,8-Dimethylnaphthalene		ND	ND			3.20E-05	1.67E-05	ND					
1-Methylnaphthalene		6.77E-04	1.05E-03			4.79E-03	3.56E-03	1.89E-03					
2,3,5-Trimethylnaphthalene		ND	ND			ND	ND	ND					
2,3,5-Trimethylphenol		4.93E-04	ND			1.13E-03	3.72E-04	ND					
2,3-Dimethylnaphthalene		ND	ND			4.01E-04	3.31E-04	ND					
2,3-Dimethylphenol		1.93E-03	ND			6.20E-03	5.45E-03	ND					
2,4,6-Trimethylphenol		ND	ND			ND	ND	ND					
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol		ND	ND			ND	1.13E-02	ND					
2,6-Dimethylnaphthalene		ND	ND			4.19E-05	ND	ND					
2,6-Dimethylphenol		8.29E-04	ND			1.20E-03	3.08E-03	ND					
2,7-Dimethylnaphthalene		7.75E-05	7.90E-05			1.26E-04	2.20E-04	5.36E-05					
2-Ethyltoluene		1.95E-03	1.90E-03			4.13E-03	4.74E-03	1.17E-03					
2-Methylnaphthalene		1.03E-03	1.54E-03			5.31E-03	3.94E-03	2.32E-03					
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol		ND	ND			2.63E-04	1.00E-03	ND					
3,5-Dimethylphenol		1.32E-03	ND			3.68E-03	3.19E-03	9.84E-04					
3-Ethyltoluene		5.13E-03	3.79E-03			3.14E-03	ND	ND					
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene		2.31E-03	1.22E-03			7.60E-03	7.86E-03	7.23E-04					
a-Methylstyrene		ND	ND			ND	ND	ND					
Acenaphthalene/1,2-Dimethylnaphthalene		ND	3.86E-05			1.08E-04	1.18E-04	3.49E-05					
Acetaldehyde	8.93E-03	4.70E-03	4.49E-03	4.91E-03	3.53E-03	1.78E-02	1.93E-02	6.57E-03	5.18E-03		2.70E-03	1.23E-03	2.28E-03
Acetone	5.67E-03	6.18E-03	8.91E-03	5.81E-03	4.36E-03	2.36E-02	2.08E-02	8.92E-03	2.80E-03		1.65E-03	4.69E-03	1.24E-03
Acetophenone		ND	ND			1.08E-04	4.55E-03	ND					
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Aluminum	1.47E-02	1.59E-01	9.25E-02		1.18E-02	1.08E-01	7.46E-02	3.65E-02	1.63E-02			1.57E-02	
Aniline		ND	ND		ND	ND	ND	ND					
Antimony	ND	ND	ND		ND	ND	2.25E-04	ND	6.24E-05			ND	
Arsenic	ND	ND	ND		ND	3.41E-04	ND	ND	ND			ND	
Barium	ND	ND	ND		ND	ND	ND	ND	ND			ND	
Benzene		8.87E-02	4.44E-02			1.74E-01	9.09E-02	5.48E-02					
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran		ND	ND			ND	ND	ND					
Beryllium	ND	ND	ND		ND	ND	ND	ND	ND			ND	
Bibenzyl		ND	ND			3.57E-05	1.46E-05	ND					
Biphenyl		ND	ND			ND	ND	ND					
Butanal/Benzaldehyde	ND	ND	7.46E-04	ND	ND	3.31E-03	3.34E-03	ND	ND		3.52E-04	ND	ND
Butylbenzene		ND	ND			8.84E-04	3.51E-03	ND					
Cadmium	5.33E-05	1.11E-04	1.50E-04		1.75E-05	2.48E-04	5.88E-05	3.83E-05	7.36E-05			5.20E-05	
Chromium	2.33E-04	1.53E-03	1.22E-03		2.39E-04	1.65E-03	1.02E-03	6.27E-04	3.96E-04			3.26E-04	
Cobalt	ND	4.71E-04	3.24E-04		ND	1.76E-04	ND	3.95E-02	6.76E-05			ND	
Copper	9.68E-05	1.56E-03	1.35E-03		5.90E-04	1.33E-03	8.97E-04	8.42E-04	4.54E-04			2.48E-04	
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Cumene		1.50E-04	3.44E-04			6.25E-04	6.99E-04	1.77E-04					
Cyclohexane		ND	ND			ND	ND	ND					
Decane		1.05E-02	7.79E-03			1.58E-02	1.28E-02	1.06E-02					
Dibenzofuran		ND	ND			7.70E-05	ND	ND					
Dodecane		1.01E-02	8.13E-03			1.66E-02	8.04E-03	1.51E-02					
Ethylbenzene		5.90E-03	3.48E-03			1.03E-02	8.60E-03	2.22E-03					
Formaldehyde	ND	ND	2.49E-03	ND	4.76E-03	6.57E-03	3.81E-03	3.38E-03	1.43E-03		8.76E-04	1.54E-03	1.09E-03
Heptane		1.69E-02	1.68E-02			1.92E-02	1.05E-02	6.01E-03					
Hexanal	ND	ND	ND	ND	ND	ND	8.88E-04	ND	ND		ND	ND	ND
Indan		2.35E-03	1.48E-03			2.57E-03	1.61E-03	3.40E-04					
Indene		2.11E-03	1.17E-03			2.89E-03	2.99E-03	7.91E-04					
Iron	1.42E-02	1.30E-01	1.17E-01		1.32E-02	1.43E-01	9.12E-02	2.92E-02	2.11E-02			1.38E-02	
Isobutylbenzene		3.31E-04	6.54E-04			5.78E-04	9.04E-04	ND					
Lead	7.52E-05	4.90E-03	1.81E-03		3.37E-04	4.33E-03	1.61E-03	3.52E-03	1.52E-04			4.20E-04	
m,p-Cresol		ND	ND			ND	ND	ND					
m,p-Xylene		2.52E-02	1.54E-02			4.39E-02	1.88E-02	9.69E-03					
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Manganese	3.23E-04	6.30E-03	3.68E-02		2.97E-04	3.00E-02	1.62E-02	4.70E-03	9.77E-04			1.91E-03	
Mercury	ND	ND	ND		ND	ND	ND	ND	ND			ND	
Methacrolein	ND	ND	ND	ND	ND	5.40E-04	1.92E-03	ND	ND		ND	ND	ND
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND
Methyl Methacrylate		4.03E-04	ND			ND	ND	ND					
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene		1.65E-03	3.53E-04			1.62E-04	ND	ND					
Naphthalene		2.80E-03	3.53E-03			1.08E-02	1.28E-02	4.45E-03					
Nickel	3.26E-04	6.30E-03	9.47E-04		ND	3.34E-03	1.89E-03	9.96E-04	8.24E-04			6.22E-04	
Nitrobenzene		6.05E-04	ND			1.45E-04	ND	ND					
Non-Condensable Particulate Matter	7.05E-01	3.68E-03	1.70E+00		1.73E+00	3.95E+00	1.03E+00	5.69E-04	5.13E-04			5.08E-04	
Nonane		8.45E-03	7.83E-03			1.23E-02	9.76E-03	3.43E-03					
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol		ND	ND			3.69E-03	7.09E-04	ND					
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene		1.07E-02	6.61E-03			2.10E-02	1.22E-02	4.18E-03					
Octane		9.97E-03	1.32E-02			1.41E-02	1.06E-02	4.03E-03					
p-cymene		4.45E-04	7.79E-04			3.36E-03	9.19E-04	2.92E-03					
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol		3.71E-03	4.52E-03			2.77E-02	1.43E-02	7.32E-03					
Propanal	ND	ND	ND	ND	ND	ND	6.13E-04	ND	ND		ND	ND	ND
Selenium	ND	ND	ND		ND	3.49E-05	ND	ND	ND			ND	
Silver	1.98E-05	5.46E-05	4.73E-05		ND	6.66E-05	7.65E-05	ND	5.28E-06			5.84E-05	
Styrene		1.21E-03	ND			2.27E-03	4.28E-03	1.36E-03					
Tetradecane		8.42E-04	1.29E-03			2.02E-03	1.33E-03	1.56E-03					
Toluene		5.42E-02	2.96E-02			1.10E-01	4.94E-02	2.42E-02					
Tridecane		4.53E-03	5.07E-03			7.58E-03	1.35E-03	6.69E-03					
Undecane		1.87E-02	1.21E-02			3.16E-02	2.06E-02	2.32E-02					
Valeraldehyde	ND	ND	ND	ND	ND	5.75E-04	2.20E-03	ND	ND		ND	ND	ND
Zinc	1.89E-03	3.06E-02	6.68E-02		2.88E-03	8.42E-02	2.82E-02	8.58E-03	4.65E-03			5.84E-03	
Particulate Matter (PM_{10})	1.59E-01		1.49E-01		1.62E-01	3.21E-01	1.61E-01	ND					
Particulate Matter ($PM_{2.5}$)	4.48E-03		8.64E-03		7.35E-03	1.09E-01	4.96E-02	1.66E-02					
Total POMs		4.58E-03	6.48E-03			2.23E-02	2.14E-02	8.89E-03					

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.5. Line 2 Cooling & Shakeout
Lb/Hr

	COOLING		SHAKEOUT		
Analyte Name	Crankshaft 1	Manifold 3	Bearing Cap 1	Bearing Cap 4	Combo 3
1,1,2-Trichloroethane		4.76E-04			
1,2,3-Trimethylbenzene		ND			
1,2,4-Trimethylbenzene		1.40E-02			
1,2-Diethylbenzene		3.88E-03			
1,3,5-Trimethylbenzene		8.97E-03			
1,3-Diethylbenzene		2.30E-03			
1,3-Diisopropylbenzene		2.88E-03			
1,3-Dimethylnaphthalene		ND			
1,4-Diethylbenzene		3.46E-03			
1,4-Dimethylnaphthalene		ND			
1,6-Dimethylnaphthalene		ND			
1,8-Dimethylnaphthalene		ND			
1-Methylnaphthalene		ND			
2,3,5-Trimethylnaphthalene		8.65E-04			
2,3,5-Trimethylphenol		2.51E-03			
2,3-Dimethylnaphthalene		ND			
2,3-Dimethylphenol		8.22E-03			
2,4,6-Trimethylphenol		ND			
2,4-Diaminobiphenyl	ND		ND	ND	ND
2,5-Dimethylphenol		ND			
2,6-Dimethylnaphthalene		ND			
2,6-Dimethylphenol		ND			
2,7-Dimethylnaphthalene		ND			
2-Ethyltoluene		2.85E-03			
2-Methylnaphthalene		3.18E-03			
3,3'-Dimethoxybenzidine	ND		ND	ND	ND
3,4-Dimethylphenol		2.72E-03			
3,5-Dimethylphenol		5.77E-03			
3-Ethyltoluene		9.02E-03			
4,4'-Methylene Bis (2-Chloroaniline)	ND		ND	ND	ND
4,4'-Methylenedianiline	ND		ND	ND	ND
4-Aminobiphenyl	ND		ND	ND	ND
4-Ethyltoluene		8.24E-03			
Acenaphthalene/1,2-Dimethylnaphthalene		ND			
Acetaldehyde			8.93E-03	4.91E-03	5.18E-03
Acetone			5.67E-03	5.81E-03	2.80E-03
Acetophenone		ND			
Acrolein			ND	ND	ND
Aluminum			1.47E-02		1.63E-02
a-Methylstyrene		ND			
Antimony			ND		6.24E-05
Arsenic			ND		ND
Barium			ND		ND
Benzene		9.36E-02			
Benzidine	ND		ND	ND	ND
Benzofuran		ND			
Beryllium			ND		ND
Bibenzyl		ND			
Biphenyl		ND			
Butanal/Benzaldehyde			ND	ND	ND
Butylbenzene		4.45E-03			
Cadmium			5.33E-05		7.36E-05
Chromium			2.33E-04		3.96E-04
Cobalt			ND		6.76E-05
Copper			9.68E-05		4.54E-04
Crotonaldehyde			ND	ND	ND
Cumene		ND			
Cyclohexane		ND			
Decane		1.87E-02			
Dibenzofuran		ND			
Dodecane		2.10E-02			
Ethylbenzene		4.05E-03			
Formaldehyde			ND	ND	1.43E-03
Heptane		1.00E-02			
Hexanal			ND	ND	ND
Indan		3.23E-03			
Indene		2.26E-03			
Iron			1.42E-02		2.11E-02
Isobutylbenzene		4.69E-04			
Lead			7.52E-05		1.52E-04
m,p-Cresol		ND			
m,p-Xylene		2.27E-02			
Manganese			3.23E-04		9.77E-04
Mercury			ND		ND
Methacrolein			ND	ND	ND
Methyl Ethyl Ketone			ND	ND	ND
Methyl Methacrylate		ND			
m-Tolualdehyde			ND	ND	ND
N,N-Dimethylaniline	ND		ND	ND	ND
Naphthalene		1.63E-03			
Nickel			3.26E-04		8.24E-04
Nitrobenzene		7.05E-04			
N-Nitrosodimethylamine	ND		ND	ND	ND
Nonane		8.23E-03			
Non-Condensable Particulate Matter			7.05E-01		5.13E-04
n-Propylbenzene		1.26E-03			
o-Anisidine	ND		ND	ND	ND
o-Cresol		1.76E-03			
Octane		7.52E-03			
o-Toluidine	ND		ND	ND	ND
o-Xylene		9.67E-03			
Particulate Matter (PM_{10})			1.59E-01		
Particulate Matter ($PM_{2.5}$)			4.48E-03		
p-cymene		8.91E-03			
Phenol		ND			
p-Phenylenediamine	ND		ND	ND	ND
Propanal			ND	ND	ND
Selenium			ND		ND
Silver			1.98E-05		5.28E-06
Styrene		7.81E-04			
Tetradecane		1.28E-03			
Toluene		4.22E-02			
Tridecane		5.84E-03			
Undecane		4.72E-02			
Valeraldehyde			ND	ND	ND
Zinc			1.89E-03		4.65E-03
Total POMs		5.68E-03	ND		ND

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Table A.6. Line 3 Melting, Pouring, Cooling, and Shakeout
Lb/Hr

Analyte	MELTING	POURING		COOLING				SHAKEOUT			
		Block 5	Clutch	Block 5	Clutch	Cylinder	Fly Wheel	Block 5	Clutch	Cylinder	Fly Wheel
1,1,2-Trichloroethane			ND	ND			ND	ND	ND	ND	
1,2,3-Trimethylbenzene			ND	ND			ND	ND	9.14E-04	ND	
1,2,4-Trimethylbenzene			8.59E-04	3.03E-03			3.92E-03	3.18E-01	4.34E-03	4.46E-03	
1,2-Diethylbenzene			ND	ND			2.80E-04	4.38E-02	1.76E-03	9.17E-05	
1,3,5-Trimethylbenzene			1.72E-04	2.46E-03			3.04E-03	1.76E-01	3.09E-03	4.13E-03	
1,3-Diethylbenzene			2.63E-04	1.27E-03			5.08E-04	3.66E-02	5.66E-04	4.13E-04	
1,3-Diisopropylbenzene			3.66E-04	ND			6.32E-04	4.80E-02	1.11E-03	ND	
1,3-Dimethylnaphthalene			3.32E-04	ND			2.96E-04	ND	9.37E-04	ND	
1,4-Diethylbenzene			9.73E-04	7.75E-04			1.64E-03	1.42E-01	2.84E-03	2.91E-04	
1,5-Dimethylnaphthalene			ND	ND			1.04E-04	ND	4.10E-04	ND	
1,6-Dimethylnaphthalene			ND	ND			ND	ND	ND	ND	
1,8-Dimethylnaphthalene			ND	ND			8.00E-05	ND	1.23E-03	ND	
1-Methylnaphthalene			1.27E-03	ND			4.47E-03	5.66E-02	2.77E-03	8.17E-04	
2,3,5-Trimethylnaphthalene			ND	ND			ND	ND	8.22E-04	ND	
2,3,5-Trimethylphenol			3.43E-04	ND			8.66E-04	1.63E-02	2.49E-03	2.37E-04	
2,3-Dimethylnaphthalene			2.40E-04	ND			2.30E-04	ND	5.87E-04	1.89E-04	
2,3-Dimethylphenol			ND	ND			2.53E-03	ND	6.19E-03	2.29E-04	
2,4,6-Trimethylphenol			ND	ND			7.20E-04	ND	ND	ND	
2,4-Diaminobiphenyl			ND	ND			ND	ND	ND	ND	
2,5-Dimethylphenol			7.44E-04	ND			2.68E-04	ND	2.72E-03	ND	
2,6-Dimethylnaphthalene			2.52E-04	ND			7.89E-04	9.15E-04	3.22E-04	1.07E-04	
2,6-Dimethylphenol			ND	ND			8.06E-04	ND	7.84E-04	2.98E-04	
2,7-Dimethylnaphthalene			ND	ND			2.22E-04	ND	5.94E-04	ND	
2-Ethyltoluene			2.06E-04	1.26E-03			5.08E-04	7.55E-02	2.16E-03	3.54E-04	
2-Methylnaphthalene			2.07E-03	ND			6.63E-03	4.91E-02	4.39E-03	1.43E-03	
3,3'-Dimethoxybenzidine			ND	ND			ND	ND	ND	ND	
3,4-Dimethylphenol			ND	ND			1.29E-03	ND	3.04E-03	2.52E-04	
3,5-Dimethylphenol			2.98E-04	ND			1.04E-03	5.59E-02	3.53E-03	ND	
3-Ethyltoluene			ND	2.51E-03			1.77E-03	1.67E-01	1.68E-03	6.11E-03	
4,4'-Methylene Bis (2-Chloroaniline)			ND	ND			ND	ND	ND	ND	
4,4'-Methylenedianiline			ND	ND			ND	ND	ND	ND	
4-Aminobiphenyl			ND	ND			ND	ND	ND	ND	
4-Ethyltoluene			ND	1.83E-03			1.20E-03	1.26E-01	4.40E-03	4.81E-03	
a-Methylstyrene			ND	ND			5.43E-04	ND	ND	4.48E-04	
Acenaphthalene/1,2-Dimethylnaphthalene			ND	ND			5.10E-04	1.18E-03	2.01E-04	1.71E-04	
Acetaldehyde			4.86E-03	ND			1.17E-02	1.06E-01	8.79E-02	3.00E-03	
Acetone			2.97E-02	1.91E-03			7.27E-03	6.31E-02	5.75E-02	7.16E-03	
Acetophenone			ND	ND			9.27E-04	ND	1.14E-03	2.06E-04	
Acrolein			ND	ND			ND	8.40E-03	4.43E-04	ND	
Aluminum	4.59E-02	5.64E-03	6.02E-03		1.04E-02		7.36E-03	1.25E+00		1.50E-01	
Aniline			ND	ND			ND	ND	ND	ND	
Antimony	ND	ND	ND		ND		ND	ND		ND	
Arsenic	ND	ND	ND		ND		ND	ND		ND	
Barium	ND	ND	ND		ND		ND	ND		ND	
Benzene			1.09E-02	1.21E-01			7.43E-02	2.24E+00	2.27E-02	2.47E-02	
Benzidine			ND	ND			ND	ND	ND	ND	
Benzofuran			ND	ND			ND	ND	2.54E-03	ND	
Beryllium	ND	ND	ND		ND		ND	ND		ND	
Bibenzyl			ND	ND			6.20E-05	8.50E-04	1.04E-04	ND	
Biphenyl			ND	ND			ND	ND	6.83E-04	ND	
Butanal/Benzaldehyde			1.18E-03	ND			3.10E-03	1.62E-02	1.96E-02	1.34E-03	
Butylbenzene			ND	ND			6.82E-04	3.25E-02	1.92E-03	ND	
Cadmium	2.23E-04	1.22E-05	1.30E-05		3.80E-05		2.26E-05	7.43E-05		4.09E-04	
Chromium	1.63E-03	1.64E-04	1.62E-04		3.34E-04		1.98E-04	1.30E-03		1.45E-03	
Cobalt	ND	3.16E-05	ND		4.38E-05		6.33E-05	ND		ND	
Copper	1.87E-03	2.30E-04	1.95E-04		7.24E-04		2.60E-04	9.70E-04		1.03E-03	
Crotonaldehyde			ND	ND			ND	2.15E-02	ND	ND	
Cumene			ND	ND			2.06E-04	1.48E-02	3.13E-04	ND	
Cyclohexane			ND	ND			ND	ND	ND	ND	
Decane			9.16E-04	1.97E-03			3.37E-03	2.26E-01	8.45E-03	2.34E-03	
Dibenzofuran			ND	ND			2.67E-04	ND	2.75E-04	ND	
Dodecane			2.23E-03	1.47E-03			3.45E-03	1.04E-01	1.24E-02	3.84E-03	
Ethylbenzene			3.21E-04	2.53E-03			1.45E-03	1.73E-01	2.52E-03	1.85E-03	
Formaldehyde			2.63E-03	ND			1.69E-03	9.53E-02	3.85E-02	3.79E-04	
Heptane			4.69E-04	2.26E-03			3.17E-03	2.37E-01	1.09E-03	6.40E-04	
Hexanal			ND	ND			ND	5.70E-03	2.49E-03	ND	
Indan			2.75E-04	5.02E-04			5.15E-04	7.11E-02	1.74E-03	6.71E-04	
Indene			ND	ND			1.79E-03	3.78E-02	2.60E-03	1.62E-03	
Iron	3.09E-01	6.84E-03	4.49E-03		7.26E-03		5.86E-03	1.06E-01		8.05E-02	
Isobutylbenzene			1.49E-04	4.08E-04			2.22E-04	2.41E-02	4.37E-04	9.94E-05	
Lead	1.23E-02	3.31E-04	2.00E-04		3.97E-04		2.31E-04	4.39E-03		8.25E-04	
m,p-Cresol			7.21E-04	ND			ND	ND	8.65E-04	ND	
m,p-Xylene			1.51E-03	1.44E-02			7.54E-03	8.02E-01	1.06E-02	9.71E-03	
m-Tolualdehyde			1.22E-03	ND			2.30E-03	3.57E-02	3.11E-02	ND	
Manganese	3.08E-02	2.58E-04	1.66E-04		2.57E-04		1.95E-04	2.90E-03		2.57E-03	
Mercury	ND	ND								ND	
Methacrolein			1.42E-03	ND			1.96E-03	1.66E-02	2.73E-02	ND	
Methyl Ethyl Ketone			ND	ND			ND	ND	ND	ND	
Methyl Methacrylate			ND	ND			ND	ND	ND	ND	
N,N-Dimethylaniline			ND	ND			ND	ND	ND	ND	
N-Nitrosodimethylamine			ND	ND			ND	ND	ND	ND	
n-Propylbenzene			ND	1.96E-04			ND	1.85E-04	ND	2.88E-04	
Naphthalene			2.98E-03	3.87E-04			7.07E-03	2.92E-01	6.81E-03	3.77E-03	
Nickel	1.97E-03	3.83E-05	1.23E-04		5.66E-04		5.09E-04	4.81E-05		2.38E-04	
Nitrobenzene			ND	ND			ND	ND	ND	ND	
Non-Condensable Particulate Matter	1.23E-03	1.95E-04	1.37E+00	4.26E+00	2.49E-04	1.57E+00	1.95E-04	6.27E-03	ND	3.96E-03	5.32E+00
Nonane			4.01E-04	1.48E-03			1.78E-03	2.11E-01	3.84E-03	3.36E-04	
o-Anisidine			ND	ND			ND	ND	ND	ND	
o-Cresol			4.28E-03	1.36E-03			5.33E-03	2.33E-01	1.22E-02	ND	
o-Toluidine			ND	ND			ND	ND	ND	ND	
o-Xylene			7.90E-04	3.99E-03			2.36E-03	3.19E-01	4.62E-03	3.37E-03	
Octane			4.01E-04	3.92E-03			3.68E-03	2.17E-01	2.06E-03	9.65E-04	
p-cymene			5.61E-04	1.81E-03			1.50E-03	1.54E-01	4.23E-03	1.94E-03	
p-Phenylenediamine			ND	ND			ND	ND	ND	ND	
Particulate Matter (PM-2.5)			5.30E-03	9.68E-02		3.05E-02			ND		1.45E-01
Phenol			ND	ND			2.13E-02	5.74E-01	1.87E-02	3.04E-03	
Propanal			ND	ND			1.52E-03	7.53E-03	8.59E-03	ND	
Selenium	ND	ND	ND		ND		ND	ND		ND	
Silver	1.32E-04	2.91E-06	ND		9.26E-05		ND	7.25E-06		ND	
Styrene			3.78E-04	1.42E-03			1.93E-03	4.22E-02	4.05E-03	5.47E-04	
Tetradecane			7.10E-04	2.28E-04			1.38E-03	6.47E-03	1.37E-03	8.32E-04	
Toluene			3.69E-03	3.34E-02			2.32E-02	2.16E+00	1.84E-02	1.56E-02	
Tridecane			1.84E-03	6.58E-04			3.15E-03	8.94E-03	7.22E-03	2.10E-03	
Triethylamine			ND	ND			ND	ND	ND	ND	
Undecane			3.71E-03	2.81E-03			7.38E-03	5.04E-01	2.16E-02	6.91E-03	
Valeraldehyde			ND	ND			8.15E-04	4.14E-03	4.07E-03	ND	
Zinc	1.02E-01	2.51E-03	1.55E-03		4.90E-03		9.50E-04	1.33E-02		3.71E-02	

ND = not detected

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix B. Quality Assurance / Quality Control Procedures

1.0 Quality Assurance / Quality Control Procedures

The Casting Emissions Reduction Program (CERP) has established procedures to document the accuracy of the reported sampling and analytical results. These procedures are found in the respective stationary source test methods, the CERP Field Quality Assurance Plan, and the CERP Laboratory Quality Assurance Plan. These QA procedures include test equipment calibration intervals and methods, sample custody procedures, and sampling and analytical QA procedures. The purpose of this quality assurance/quality control (QA/QC) program is to assure that a known quality is produced and is properly and consistently assessed to satisfy the project and data quality objectives. The QA/QC program shall:

- Provide a mechanism for ongoing control and evaluation of measurement data quality; and
- Provide an estimate of data quality in terms of accuracy, precision, completeness, representativeness, and comparability, for use in data interpretation.

The data quality objectives (DQO) for the CERP project are:

- To ensure that enough data points are collected at each foundry and from each process at the foundry so that an estimate of total foundry emissions can be made. The total emissions baseline will be helpful to the U. S. EPA for setting Maximum Achievable Control Technology (MACT) standards. The results can be compared to the CERP pilot foundry emissions.
- To ensure that the proper analytical methods are used for detection of organic and inorganic compounds.

The quality assurance objectives (QAO) for the CERP project are:

- To monitor and maintain the performance parameters of the analytical instruments.
- To monitor the analysis through the use of laboratory control samples for accuracy and precision.
- Representation and comparability will be maintained by matching the matrix of the field samples in the preparation of laboratory control samples.
- Completeness through auditing the data base to ensure every analysis is complete, each stack is complete, and each foundry is complete. A computer flagging system is used for timeliness that will be monitored by the laboratory and the CERP office data base management team.

1.1 Equipment Inspection

Each item of equipment used for emissions sampling or in support of emissions sampling is inspected before and after field use. Unserviceable items are repaired, reconditioned or replaced as necessary.

1.2 Equipment Calibration

Emissions sampling equipment requiring calibration receive calibrations at intervals which meet or exceed CERP requirements. All calibrations are performed according to procedures contained in the applicable CERP and US EPA documents and test methods. Equipment suspected of substandard performance is immediately removed from service and recalibrated.

1.3 Sample Custody

Each sample will be uniquely identified by means of a label containing a specific sample number.

The CERP Emissions Source test team Leader and all laboratory receivers are required to maintain a sample logbook. Each laboratory is required to maintain its own internal chain-of-custody record for each sample received for this project. The sample integrity is the responsibility of each sample custodian until the sample is transferred to another person. If any samples are damaged or the sample integrity is questionable, the sample receiver is required to annotate the sample chain-of-custody form and the receiver's log book with a description of the condition.

1.4 Sampling QA

All sampling is performed in accordance with referenced test methods. Each test method contains specific QA procedures to ensure data consistency and validity. The following general QA procedures are performed during emissions testing:

- All sample control modules, filter heater boxes, probe heaters and Pitot tubes are inspected and calibrated (if necessary) prior to use.
- Both the emissions team coordinator and the team leader independently calculate sample traverse point location and isokinetic sampling parameters before collecting samples.

- Any anomalies noted during sampling are annotated on the appropriate data forms.

1.5 Analytical QA

All sample analysis are performed according to the laboratory and analytical protocols and standard operating procedures contained in each reference test method. Adherence to the reference methods will ensure the validity and consistence of reported analytical results. Specific data acceptance criteria are incorporated into many stationary source test methods. These criteria include sample to blank ratio, GC/MS signal to noise ratio, internal standard recovery, spiked sample recovery and matrix spike recovery.

2.0 Reporting

A final report will be presented to the foundry after all testing and analytical work is complete. This report will include the following topics:

- Summary of Test Program
  - Key Personnel
  - Test Emission Points and Sampling Location Descriptions
  - Process Description

- Summary and Discussion of Results
  - Objectives and Test Matrix
  - Summarized Reports of Results
  - Field Test Changes and Problems

- Sampling and Analytical Procedures
  - Emission Test Methods

- Results and Calculations
  - Raw Field Data and Calibration Data Sheets
  - Sampling Log and Chain-of-Custody Records
  - Analytical Data Sheets
  - Audit Data Sheets
  - Chromatograms

3.0 Method Summaries

3.1 Method 5. Determination of Particulate Matter Emissions

Principle: Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a specified temperature. The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water.

Media/Solution Needed

- 85 mm glass fiber filters
- Silica gel
- Deionized distilled water (if impinger solution is analyzed); distilled water is fine if water is not analyzed.
- Acetone

Preparation of Sampling Train

- During preparation and assembly of train, keep all opening covered with Teflon® film or aluminum foil to avoid contamination.
- All parts of the sample collection portion of the train (e.g., probe, nozzle, filter holder, impinger glassware) must be cleaned properly and then rinsed with acetone.
- Impingers: The first, third, and fourth are Modified Greenburg-Smiths; the second is a standard Greenburg-Smith.
- Place 100 mL of water in each of the first two impingers.
- Leave the third empty.
- Put silica gel (approximately 200-300 grams) into the fourth impinger.
- Weigh all impingers to the nearest 0.5g and record information on data sheet.
- Place a labeled and weighed filter in the filter holder.

Assembly of train

- Install selected nozzle: Viton-A for stack temperatures < 260°C; woven glass-fiber for temperature > 260°C.
- A glass cyclone may be used between the probe and filter holder when the total particulate catch is expected to be > 100 mg or when droplets are present in the stack gas.
- Connect temperature sensors to appropriate potentiometer/display unit. Check temperature sensors at ambient temperatures.
- Place crushed ice around impingers.
- Set probe heating system at desired temperature.
- Perform pre-test leak check.
- If a component change is necessary during the sampling run, a leak check must be conducted immediately after the interruption of the sampling and before the change is made.
- If the leakage rate is unacceptably high, the sampling run must be voided.
- Acceptable: leakage rate £ 0.0057 m^3/min (0.02 cfm) or 4% of the average sampling rate, whichever is less.
- A leak check similar to the pre-test leak check must be performed immediately after a component change and before sampling is restarted.

Sample Recovery

- Take care to avoid contamination by collection of particulate material on train components.
- Note any abnormal conditions encountered during disassembly of train (i.e., unusual color or smell).
- Save aliquots of any washing solutions for use as a reagent blank.
- Cool probe; cover all openings to prevent contamination.
- Before moving train to recovery area, remove probe and umbilical and cap off any open inlets or outlets.

Sample Containers

- Pre-weigh all sample containers. Record the initial weight in a logbook.

Container 1: Filter

- Carefully remove filter and place in its prelabeled petri dish. Transfer any PM and/or filter fibers that adhere to the filter gasket by using a dry Nylon brush and/or a sharp-edged blade.

Container 2: Front half rinse

- All the rinses described below should be collected in the same glass sample container.
- Remove probe nozzle; rinse with acetone, and brush with a Nylon bristle brush. Brush until the acetone rinse show no visible particles, then rinse once more.
- Rinse probe liner with acetone, and scrub with a Nylon brush. Brush the probe at least three times or until no visible PM is carried out with the acetone rinse, then rinse once more.
- Rinse the brush with acetone.
- Rinse front half of filter holder with acetone, and scrub at least three times with a Nylon brush. Make a final rinse of the holder and brush.
- If a cyclone is used, rinse out with acetone.
- Tighten lid of container 1 so no leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. LABEL CONTAINER CLEARLY.

Container 3: Impinger water

- Measure and record the weight of liquid in the first three impingers. This information is required to calculate the moisture content of the gas stream. Discard the liquid unless analysis of the impinger solution is required.

Note: Check the color of the silica gel to see if it is completely spent; note its condition. Measure and record the weight of the silica gel (used for determination of moisture content). Pour silica gel into a "spent" silica gel container.

Container 4: Acetone reagent blank

- Take 200 ml of acetone directly from the wash bottle being used, and place it in a glass container. Weigh, tape, and label.

Note: If impinger solution is to be analyzed, collect an aliquot of deionized distilled water for a reagent blank.

QC Sampling

- Collect a field blank (reagents and filter) for every 21 samples collected. This sample should be handled in the same manner as a normal sample (leak checked at stack) but no air is drawn through it.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: Position sample containers vertically in cooler, and shield from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.2 Method 5/Method 29. Determination of Particulate Matter and Metals Emissions

DRAFT: DO NOT QUOTE OR CITE

Principle: Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a specified temperature. The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water. The gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide (analyzed for all metals including Hg) and an aqueous acidic solution of potassium permanganate (analyzed only for Hg).

Sampling Apparatus

- Nozzle - glass or quartz
- Probe - glass
- Filter holder - glass with teflon frit

Sampling Media/Solution Needed

- 85 mm quartz fiber filters
- Silica gel
- 0.1 N HNO_3
- 10% HNO_3 (for glassware cleaning)
- 5% HNO_3/10% H_2O_2 absorbing solution
- Distilled water (ASTM Type II)
- Acetone

Pretest Preparation

- Wash all sampling train glassware in warm soapy water. Rinse 3 times with hot tap water and then three times with DI water.
- Soak all glassware in a 10% HNO_3 solution for a minimum of 4 hours.
- Rinse three times with DI water.
- Rinse a final time with acetone and allow to air dry.
- Cover all glassware openings until sampling train is assembled for sampling.

Preparation of Sampling Train

Impingers: All seven impingers are of the Modified Greenburg-Smith design with the following exceptions: the first impinger is a knock-out impinger (short stem) and the third impinger is a standard Greenburg-Smith. The first impinger can be eliminated if the moisture content of the stack gas is low.

- The first and second impingers each contain 100 mLs of the 5% HNO_3/10% H_2O_2 absorbing solution.
- The third impinger is empty.
- The fourth impinger contains approximately 200-300 grams os silica gel.
- Weigh all impingers to the nearest 0.5g and record information on data sheet.
- Place a labeled and weighed filter in the filter holder.

Assembly of Train

- Connect temperature sensors to appropriate potentiometer/display unit. Check temperature sensors at ambient temperatures.
- Place crushed ice around impingers.
- Set probe heating system at desired temperature.
- Perform pre-test leak check.

NOTE: If a component change is necessary during the sampling run, a leak check must be conducted immediately after the interruption of the sampling and before the change is made.

- If the leakage rate is unacceptably high, the sampling run must be voided.
- Acceptable: leakage rate of 0.0057 m^3/min (0.02 cfm) or 4% of the average sampling rate, whichever is less.
- A leak check similar to the pre-test leak check must be performed immediately after a component change and before sampling is restarted.

Sample Recovery

- Do not use any metal-containing material when recovering this train (i.e., metal tweezers, metal brushes).
- The method specifies using 100 mL of solution when recovering components of the sampling train. This is necessary for subsequent blank correction procedures.
- Take care to avoid contamination by collection of particulate material on train components.
- Note any abnormal conditions encountered during disassembly of train (i.e., unusual color or smell).
- Save aliquots of any washing solutions for use as a reagent blank.
- Cool probe; cover all openings to prevent contamination.
- Before moving train to recovery area, remove probe and umbilical and cap off any open inlets or outlets.

Sample Containers

- Pre-weigh all sample containers. Record the initial weight in a logbook.

Container 1: Filter

- Carefully remove filter and place in its prelabeled petri dish. To handle the filter use acid-washed polypropylene gloves or Teflon® coated tweezers. Transfer any PM and/or filter fibers that adhere to the filter gasket by using a dry (acid cleaned) Teflon brush.

Container 2: Acetone front- half rinse

- Perform this rinse only if particulate analysis is necessary.
- All the rinses described below should be performed using only a total of 100 mL of acetone. Collect all rinses in the same glass sample container.
- Remove probe nozzle; rinse with acetone, and brush with a Teflon® brush. Brush until the acetone rinse shows no visible particles, then rinse once more.
- Rinse probe liner with acetone, and scrub with a Teflon® brush. Brush the probe at least three times or until no visible PM is carried out with the acetone rinse, then rinse once more.
- Rinse the brush with acetone.
- Rinse front half of filter holder with acetone, and scrub at least three times with a Teflon® brush. Make a final rinse of the holder and brush.
- Tighten lid of container 2 so no leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.

Container 3: 0.1 N HNO_3 front-half rinse

- Rinse from the nozzle to the front-half of the filter holder with a total of 100 mL of 0.1 N HNO_3.
- Tighten lid of container 3 so no leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.

Container 4: Impingers 1 through 3

- Measure and record the weight of liquid in the first three impingers to within 0.5 mL using a graduated cylinder. This information is required to calculate the moisture content of the gas stream.
- Clean all impingers, the filter support, filter housing, and connecting glassware with 100 mL of 0.1 N HNO_3.

- Tighten lid of container 4 so no leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.

Container 5: Silica gel

- Check the color of the silica gel to see if it is completely spent; note its condition.
- Measure and record the weight of the silica gel (used for determination of moisture content).
- Pour silica gel into a "spent" silica gel container.

Container 6: Acetone reagent blank

- Take 100 mL of acetone directly from the wash bottle being used, and place it in a glass container. Weigh and record final weight. Seal with Teflon® tape and label.

Container 7: 0.1 N HNO_3 reagent blank

- Take 300 mL of 0.1 N HNO_3 directly from the wash bottle being used, and place it in a container. Weigh and record final weight. Seal with Teflon® tape and label.

Container 8: Water reagent blank

- Take 100 mL of 0.1 N HNO_3 directly from the wash bottle being used, and place it in a container. Weigh and record final weight. Seal with Teflon® tape and label.

Container 9: 5% HNO_3/10% H_2O_2 reagent blank

- Take 200 mL of solution directly from the wash bottle being used, and place it in a container. Weigh and record final weight. Seal with Teflon® tape and label.

Container 10: Filter blank

- Place three filters into a petri dish. Seal with Teflon® tape and label.

QC Sampling

- Collect a field blank (reagents and filter) for every 21 samples collected. This sample should be handled in the same manner as a normal sample (leak checked at stack) but no air is drawn through it.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: Position sample containers vertically in cooler, and shield from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.
- Hazardous shipping regulations need to be followed.

Solution Preparation

5% HNO_3/10 H_2O_2 Absorbing Solution

- Add 50 mL of concentrated HNO_3 to a 1000-mL volumetric flask containing approximately 500 mL of H_2O.
- Carefully add 333 mL of 30% H_2O_2.
- Dilute to volume with water. Mix well.

0.1 N HNO_3

- Add 6.3 mL of concentrated HNO_3 to a 1000-mL volumetric flask containing approximately 900 mL of H_2O.
- Dilute to 1000 mL.

10% HNO_3

- Add 500 mL of concentrated HNO_3 to a 5000-mL volumetric flask containing approximately 4000 mL of H_2O.
- Dilute to 5000 mL.

3.3 Method 201A/202. Determination of PM_{10} and $PM_{2.5}$ Emissions

(Constant Sampling Rate Procedure)

Principle: A gas sample is extracted at a constant flow rate through an in-stack sizing device, which separates PM greater than PM_{10}. The particulate mass is determined gravimetrically after removal of uncombined water. The condensable particulate mass is collected in the impinger portion of the sampling train.

Media/solution needed

- Glass fiber filters
- Silica gel
- Deionized distilled water
- Acetone
- Methylene chloride

Preparation of Sampling Train

- During preparation and assembly of train, keep all opening covered with Teflon® film or aluminum foil to avoid contamination.
- Prior to sampling, all parts of the sample collection portion of the train must be cleaned with soap and water and rinsed using tap water, DI water, acetone, and finally, methylene chloride.
- Impingers: The first and second are Modified Greenburg-Smiths; the third and fourth are standard Greenburg-Smiths.
- Place 100 mL of deionized water in each of the first three impingers.
- Put approximately 200-300 grams of silica gel into the fourth impinger.
- Weigh all impingers to the nearest 0.5g and record information on data sheet.
- Place a labeled and weighed filter in the filter holder.

Assembly of train

- Install selected nozzle
- Connect temperature sensors to appropriate potentiometer/display unit. Check temperature sensors at ambient temperatures.
- Place crushed ice around impingers.
- Set probe heating system at desired temperature.
- Perform pre-test leak check.

If a component change is necessary during the sampling run, a leak check must be conducted immediately after the interruption of the sampling and before the change is made.

- If the leakage rate is unacceptably high, the sampling run must be voided.
- Acceptable: leakage rate of 0.0057 m^3/min (0.02 cfm) or 4% of the average sampling rate, whichever is less.
- A leak check similar to the pre-test leak check must be performed immediately after a component change and before sampling is restarted.

Sample Recovery

- Take care to avoid contamination by collection of particulate material on train components.
- Note any abnormal conditions encountered during disassembly of train (i.e., unusual color, smell).
- Save aliquots of any washing solutions for use as a reagent blank.
- Cool probe; cover all openings to prevent contamination.
- Before moving train to recovery area, remove probe and umbilical and cap off any open inlets or outlets.

Sample Containers

- Pre-weigh all sample containers. Record the initial weight in a logbook.

Container 1: In-stack filter $PM_{2.5}$

- Carefully remove filter and place in its prelabeled petri dish. Transfer any PM and/or filter fibers that adhere to the filter gasket by using a dry Nylon brush and/or a sharp-edged blade.

Container 2: Cyclone or large PM catch

- This step is optional.
- Disassemble the cyclone and remove the nozzle to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and cyclone, excluding the "turn around" cup and the interior surfaces of the exit tube into a glass container. Rinse with acetone and brush with a Nylon bristle brush. Brush until the acetone rinse shows no visible particles, then rinse once more.
- Tighten lid of container 2 so no leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container.

Container 3: PM_{10}

- Quantitatively recover the **PM_{10}** from all of the surfaces from the second cyclone exit to the front half of the in-stack filter holder, including the "turn around" cup, inside the first cyclone, and the interior surfaces of the exit tube into the second cyclone. Rinse with acetone and brush with a Nylon bristle brush. Brush until the acetone rinse show no visible particles, then rinse once more.
- Tighten lid of container 3 so not leakage will occur when sample is shipped to the laboratory. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.

Container 4: Impinger Water and Methylene Chloride Rinse

- Measure and record the weight of liquid in the first three impingers to within 0.5 g. This information is necessary to determine the moisture content of the gas stream. Transfer this liquid into a sample container; rinse each impinger and the connecting glassware twice with water. Add to sample bottle. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.
- Follow the water rinse of the impingers and connecting glassware with two rinses of methylene chloride; add to container. Mark the height of the fluid in the container so leakage can be detected upon receipt at the laboratory. Weigh the container and record final weight in logbook. Seal container with Teflon® tape. Label container clearly.

Note: Check the color of the silica gel to see if it is completely spent; note its condition. Measure and record the weight of the silica gel (used for determination of moisture content). Pour silica gel into a "spent" silica gel container.

Container 5: Acetone reagent blank

Take 200 ml of acetone directly from the wash bottle being used, and place it in a glass container. Weigh and record final weight. Seal container with Teflon® tape. Label container clearly.

Container 6: Water reagent blank

- Take 500 ml of water directly from the wash bottle being used, and place it in a glass or plastic container. Weigh and record final weight. Seal container with Teflon® tape. Label container clearly.

Container 7: Methylene chloride reagent blank

- Place in a glass jar a volume of methylene chloride approximately equal to the volume used to rinse the impingers. Weigh and record final weight. Seal container with Teflon® tape. Label container clearly.

QC Sampling

- Collect a field blank (reagents and filter) for every 21 samples collected. This sample should be handled in the same manner as a normal sample (leak checked at the stack) but no air is drawn through it.

Sample storage/shipment to the laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: Position sample containers vertically in cooler, and shield from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.
- Measure and record the weight of liquid in impingers 2, 3 and 4. This information is required to calculate the moisture content of the gas stream. Discard the liquid unless analysis of the impinger solution is required.

Note: Check the color of the silica gel to see if it is completely spent; note its condition. Measure and record the weight of the silica gel (used for determination of moisture content). Pour silica gel into a "spent" silica gel container.

Container 7: Methanol/methylene chloride reagent blank

- Take 200 ml of methanol/methylene chloride solution directly from the wash bottle being used, and place it in a glass container. Weigh and record the final weight. Seal with Teflon tape. Label container clearly.

Container 8: Type II water reagent blank

- Collect reagent blank if water is used as a recovery solution (section 7.2.2) or if impinger solution is analyzed.
- Take 200 ml of the Type II water directly from the wash bottle being used, and place it in a glass container. Weigh and record the final weight. Seal with Teflon tape. Label container clearly.

QC Sampling

- Collect a field blank for **every** sample collected (reagents and filter). This sample should be handled in the same manner as a normal sample (leak checked at stack) but no air is drawn through it.

Sample storage/shipment to the laboratory

- Samples must be stored (and shipped) on ice.
- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- It is recommended that ice baggies (ice placed in ziplock bags) be used for sample storage and shipment.
- Shipping: Position sample containers vertically in cooler, and shield from breakage. Use ice baggies to keep samples cold. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler.

3.4 EPA Method 18. Determination of Volatile and Semivolatile Emissions

Principle: Samples are collected by drawing air through stainless steel traps loaded with 60/80 mesh Carbotrap B.

Sampling Apparatus/Media Needed

- Sampling system capable of sampling 50 mL/min of ambient air.
- Stainless steel traps loaded with 60/80 mesh Carbotrap B.

Sampling Technique

- System is calibrated using "dummy" traps.
- Leak check the system.
- Calibrate sample-metering valves to within ± 5% of the recommended flow rate (10-50 ml/min) for a total air volume to be determined by the pre-survey team.
- Using polyethylene gloves remove inlet and outlet caps from a new trap.
- Attach the trap between sampling wand and umbilical cord (grooved end of trap towards wand). Attach the other end of the umbilical cord to the flow metering valve.
- Start sampling, adjust the final flow rate if necessary. Note time started and time stopped; check flow rate and note every ten minutes. Using total time and **average flow rate** determine sample volume.
- Leak check the system.
- After sampling remove the filter, attach the caps and store in marked (Sample Id) vials for shipping. Samples should be kept cold until analysis.

QC Sampling

- Collect a field blank for every 21 samples collected. This sample should be handled in the same manner as a normal sample but no air is drawn through it.
- Collect a duplicate sample for every 21 samples collected. This sample should be handled in the same manner as a normal sample.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: All organic samples can be placed inside one large plastic baggie with their individual Sample ID numbers in the cooler, and shielded from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. All the organic samples are considered NON Hazardous. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.5 TO11. Determination of Formaldehyde and Other Aldehydes in Ambient Air

Principle: Samples are collected by drawing air through an adsorbent tube coated with DNPH solution.

Sampling Apparatus/Media Needed

- Sampling system capable of sampling 500 mL/min of ambient air.
- Prepackaged silica gel cartridge coated in situ with DNPH.

Sampling Technique

- System is calibrated using a "dummy" cartridge.
- Leak check the system.
- Calibrate sample-metering valves to within ± 5% of the recommended flow rate (300 ml/min) for a total volume of 18 liters.
- Before sampling, the DNPH cartridge should warm to ambient temperature.
- Using polyethylene gloves remove inlet and outlet caps from a new cartridge.
- Attach the DNPH cartridge between sampling wand and umbilical cord (big end of cartridge towards wand). Attach the other end of the umbilical cord to the flow-metering valve.
- Start sampling, adjust the final flow rate if necessary. Note time started and time stopped; check flow rate and note every ten minutes. Using total time and **average flow rate** determine sample volume.
- Leak check the system.
- After sampling remove the filter, attach the caps and store in marked (Sample Id) vials containing granular charcoal for shipping. Samples should be kept cold until analysis.

QC Sampling

- Collect a field blank for every 21 samples collected. This sample should be handled in the same manner as a normal sample but no air is drawn through it.
- Collect a duplicate sample for every 21 samples collected. This sample should be handled in the same manner as a normal sample.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: All organic samples can be placed inside one large plastic baggie with their individual Sample ID numbers in the cooler, and shielded from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler.

Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. All the organic samples are considered NON Hazardous. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.6 OSHA 42. Determination of Diisoycyanates Emissions

Principle: Samples are collected by drawing air through glass fiber filters coated with either 0.1 mg or 1.0 mg of 1-(2_pyridyl)piperazine.

Sampling Apparatus/Media Needed

- Sampling system capable of sampling 1000 mL/min of ambient air.
- Glass fiber filters coated with either 0.1 mg or 1.0 mg of 1-(2_pyridyl)piperazine.

Sampling Technique

- System is calibrated using a "dummy" three-piece cassette.
- Leak check the system.
- Calibrate sample-metering valves to within ± 5% of the recommended flow rate (1000 ml/min) for a total volume of 60 liters.
- Using polyethylene gloves remove inlet and outlet caps from a new three piece cassette.
- Attach cassette between sampling wand and umbilical cord (filter towards wand). Attach the other end of the umbilical cord to the flow metering valve.
- Start sampling, adjust the final flow rate if necessary. Note time started and time stopped; check flow rate and note every ten minutes. Using total time and **average flow rate** determine sample volume.
- Leak check the system.
- After sampling remove the cassette and reinstall the small plug inlet covers and store in marked (Sample Id) baggies for shipping. Samples should be kept cold.

QC Sampling

- Collect a field blank for every 21 samples collected. This sample should be handled in the same manner as a normal sample but no air is drawn through it.
- Collect a duplicate sample for every 21 samples collected. This sample should be handled in the same manner as a normal sample.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: All organic samples can be placed inside one large plastic baggie with their individual Sample ID numbers in the cooler, and shielded from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. All the organic samples are considered NON Hazardous. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.7 NIOSH Method 2002. Determination of Aromatic Amines

Principle: Samples are collected by drawing air through a silica gel sorbent tube.

Sampling Apparatus/Media Needed

- Sampling system capable of sampling 250 mL/min of ambient air.
- Silica gel sorbent tubes.

Sampling Technique

- System is calibrated using a "dummy" cartridge.
- Leak check the system.
- Calibrate sample metering valves to within ± 5% of the recommended flow rate (250 ml/min) for a total volume of 15 liters.
- Before sampling, the silica jell sorbent tube should warm to ambient temperature.
- Using polyethylene gloves break the inlet and outlet glass ends from a new tube (use a glass cutter).
- Attach the silica tube between sampling wand and umbilical cord (arrow shows direction of flow). Attach the other end of the umbilical cord to the flow-metering valve.
- Start sampling, adjust the final flow rate if necessary. Note time started and time stopped; check flow rate and note every ten minutes. Using total time and **average flow rate** determine sample volume.
- Leak check the system.
- After sampling remove the filter, attach the caps and store in marked (Sample Id) vials containing granular charcoal for shipping. Samples should be kept cold until analysis.

QC Sampling

- Collect a field blank for every 21 samples collected. This sample should be handled in the same manner as a normal sample but no air is drawn through it.
- Collect a duplicate sample for every 21 samples collected. This sample should be handled in the same manner as a normal sample.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: All organic samples can be placed inside one large plastic baggie with their individual Sample ID numbers in the cooler, and shielded from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler.

Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. All the organic samples are considered NON Hazardous. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.8 NIOSH Method 2010. Determination of Aliphatic Amines

Principle: Samples are collected by drawing air through a catbotrap (20/40) sorbent tube.

Sampling Apparatus/Media Needed

- Sampling system capable of sampling 250 ml/min of ambient air.
- Silica gel sorbent tubes.

Sampling Technique

- System is calibrated using a "dummy" cartridge.
- Leak check the system.
- Calibrate sample metering valves to within ± 5% of the recommended flow rate (250 ml/min) for a total volume of 15 liters.
- Before sampling, the Carbotrap (20/40) sorbent tube should warm to ambient temperature.
- Using polyethylene gloves break the inlet and outlet glass ends from a new tube (use a glass cutter).
- Attach the Carbotrap tube between sampling wand and umbilical cord (arrow shows direction of flow). Attach the other end of the umbilical cord to the flow metering valve.
- Start sampling, adjust the final flow rate if necessary. Note time started and time stopped; check flow rate and note every ten minutes. Using total time and **average flow rate** determine sample volume.
- Leak check the system.
- After sampling remove the filter, attach the caps and store in marked (Sample Id) vials containing granular charcoal for shipping. Samples should be kept cold until analysis.

QC Sampling

- Collect a field blank for every 21 samples collected. This sample should be handled in the same manner as a normal sample but no air is drawn through it.
- Collect a duplicate sample for every 21 samples collected. This sample should be handled in the same manner as a normal sample.

Sample Storage/Shipment to the Laboratory

- When waiting to ship samples, coolers that contain samples should be sealed with a chain-of-custody (C-O-C) seal.
- Shipping: All organic samples can be placed inside one large plastic baggie with their individual Sample ID numbers in the cooler, and shielded from breakage. Place C-O-C in a baggie and tape to the inside lid of the cooler. Place a C-O-C seal on cooler. Tape shut. Place shipping form on top of cooler. All the organic samples are considered NON Hazardous. Refer to the Source Testing Field Project Plan Section 5.7.3 for additional shipping information.

3.9 Carbon Monoxide, Sulfur Dioxide, Nitrogen Oxide, Nitrogen Dioxide and Oxygen Determination Using the ENERAC 3000 Analyzer

Note: In Mexico, the Enerac was use to test only for Oxygen.

Principle: A stack sample is withdrawn from the source via the internal pump of the sampler using the organic sampling train probe, filter, and umbilical cord. The gaseous emission is then continuously analyzed using electro-chemical cell for carbon monoxide, sulfur dioxide, nitrogen oxide, nitrogen dioxide and oxygen determination.

Sampling Apparatus

- **Organic sampling train -** Withdraws and filters sample.
- **ENERAC 3000** - analyzer, uses a electro-chemical to detect carbon monoxide, sulfur dioxide, nitrogen oxide, nitrogen dioxide and oxygen.
- **Compaq computer** - records the analog signals and converts it to digital data points.

Sampling Technique

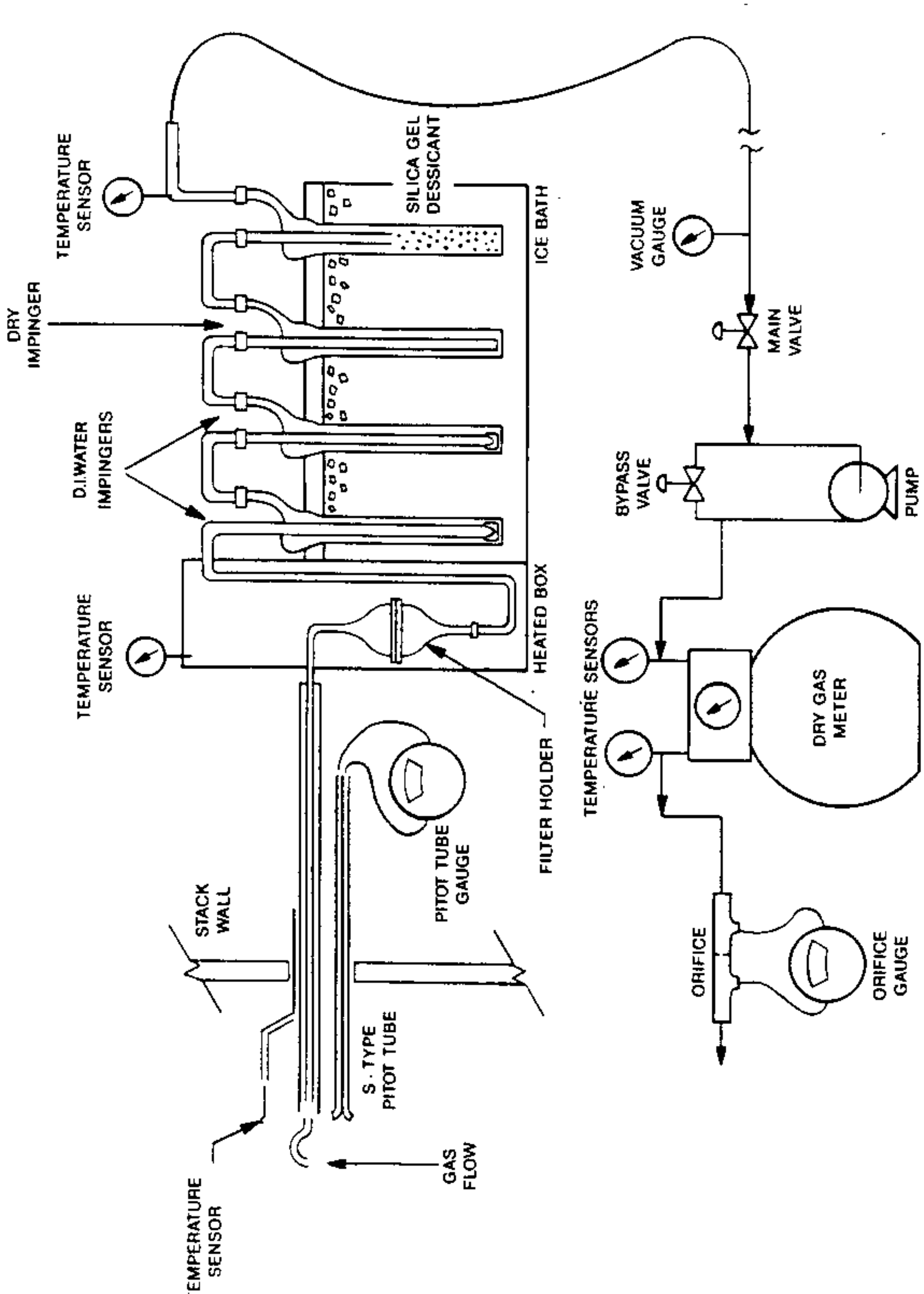
- System is calibrated using a gas manifold system at the mobile laboratory. See SOP for procedure.
- Connect the input of the analyzer to the output of the organic sampling train (umbilical cord).
- Connect the computer to the analyzer's output DB connector.
- Program the computer to establish a file to receive the data.
- Warm up the analyzer.
- Program the analyzer per SOP instructions.
- Turn on the pump. The analyzer is continuously analyzing the emissions from the stack and the Compaq computer is continuously recording the data.
- At end of testing. Leak check the organic train system.
- Down load data from the computer to a portable A drive and then to the main computer at end of day.

QC Sampling

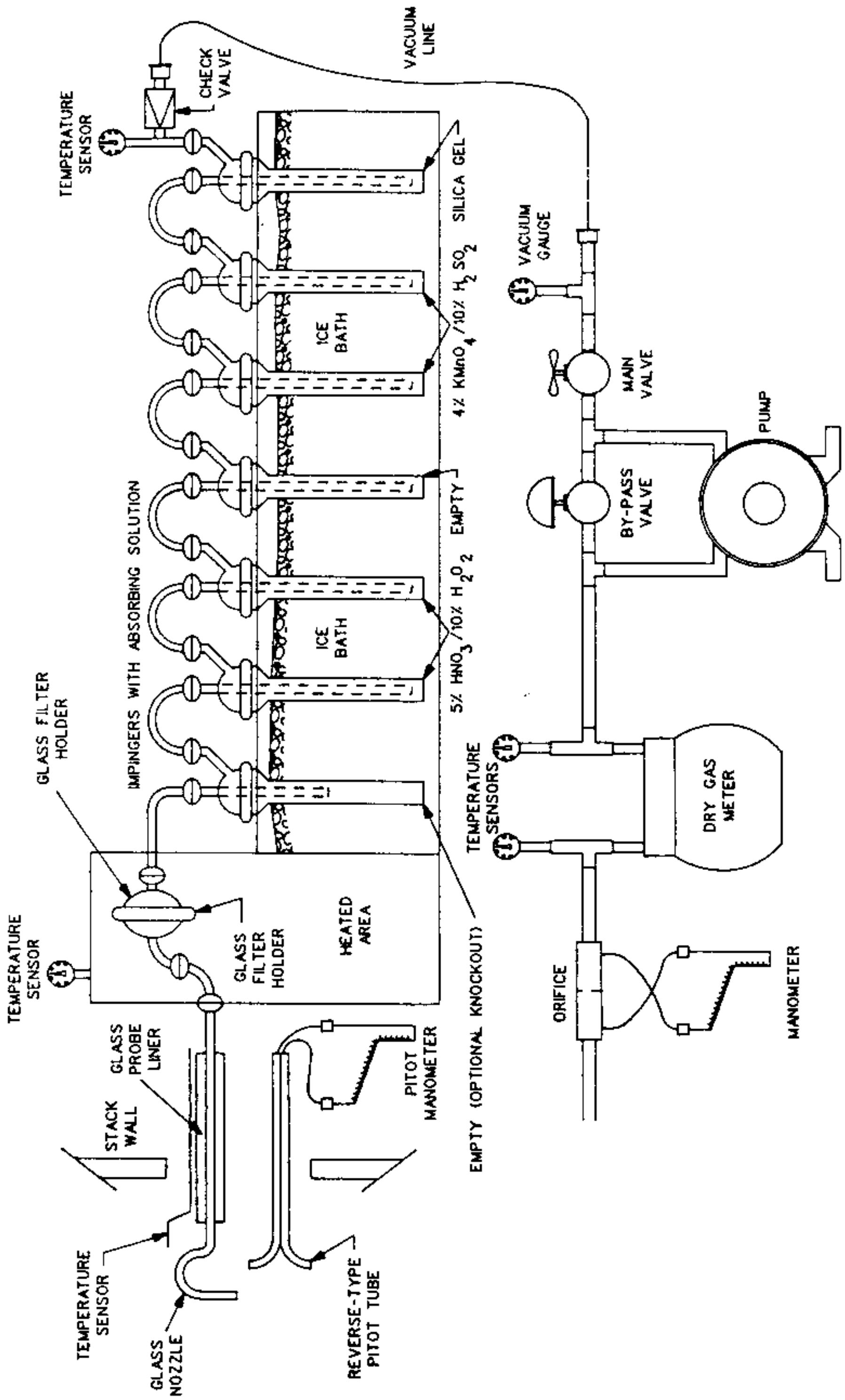
- Mid standard check daily.

4.0 Schematics of Sampling Equipment

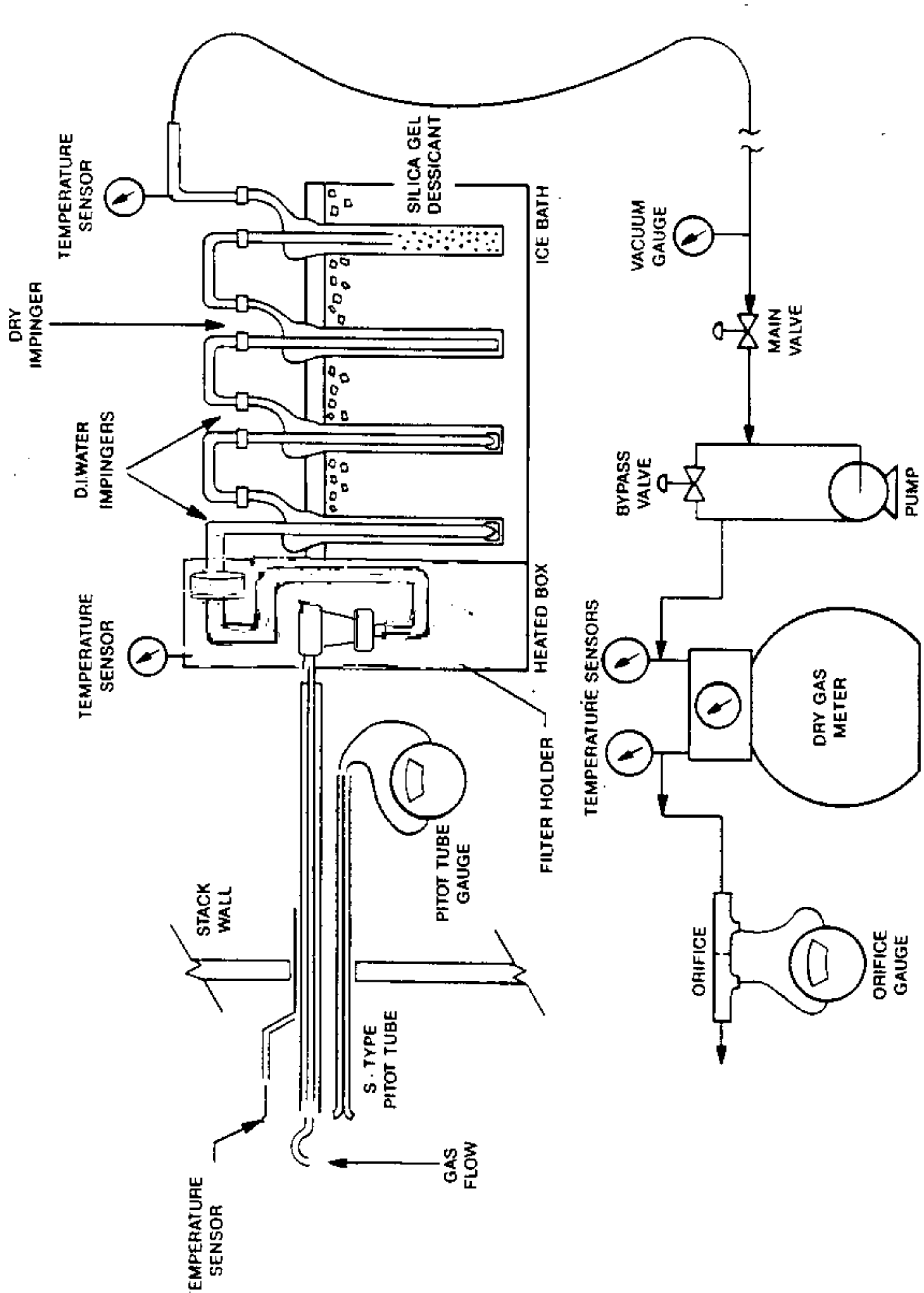
4.1 Method 5 Sampling Train



4.2 Method 29 Sampling Train



4.3 Method 201A Sampling Train



Appendix C. Estimation of Cooling Stacks Not Sampled (Line 1)

As noted earlier, the three mold lines had more cooling stacks than was practical to measure in the length of time allotted to the effort. For example, mold line 1 had about cooling 15 stacks. Consequently, emissions from only selected stacks on the cooling lines were actually measured, and emissions from the other cooling stacks were estimated. We did, however, measure the flows and other stack gas characteristics for every cooling stack.

One complication was that the measured flow rates through the various stacks showed some variability across different tests on the same stacks, and some of the measured flows were quite different from engineering estimates supplied by the plant. Therefore, best estimates were made for the flow from each stack based on all the available data. Figures C.1 – C.3 show the best estimates of the stack flows for each cooling stack on the three mold lines.

To assess the complete cooling emissions, we concentrated on mold line 1 during the times in which engine blocks were being produced. We used the flow ratios to estimate emissions for stacks not measured using emissions measurements from nearby cooling stacks. Estimates for the emissions from the stacks not sampled on line 1 were calculated according to the formulas shown below in Table C.1.

Table C.1. Formulas for Estimating Cooling Stack Emissions

Stack	Calculation
M	$Emissions_N * (Stack\ Flow_M / Stack\ Flow_N)$
O	$Emissions_N * (Stack\ Flow_O / Stack\ Flow_N)$
P	$Emissions_Q * (Stack\ Flow_P / Stack\ Flow_Q)$
R	$Emissions_Q * (Stack\ Flow_R / Stack\ Flow_Q)$
S	$Emissions_Q * (Stack\ Flow_S / Stack\ Flow_Q)$
W	$Emissions_V * (Stack\ Flow_W / Stack\ Flow_V)$
Z	$Emissions_V * (Stack\ Flow_Z / Stack\ Flow_V)$

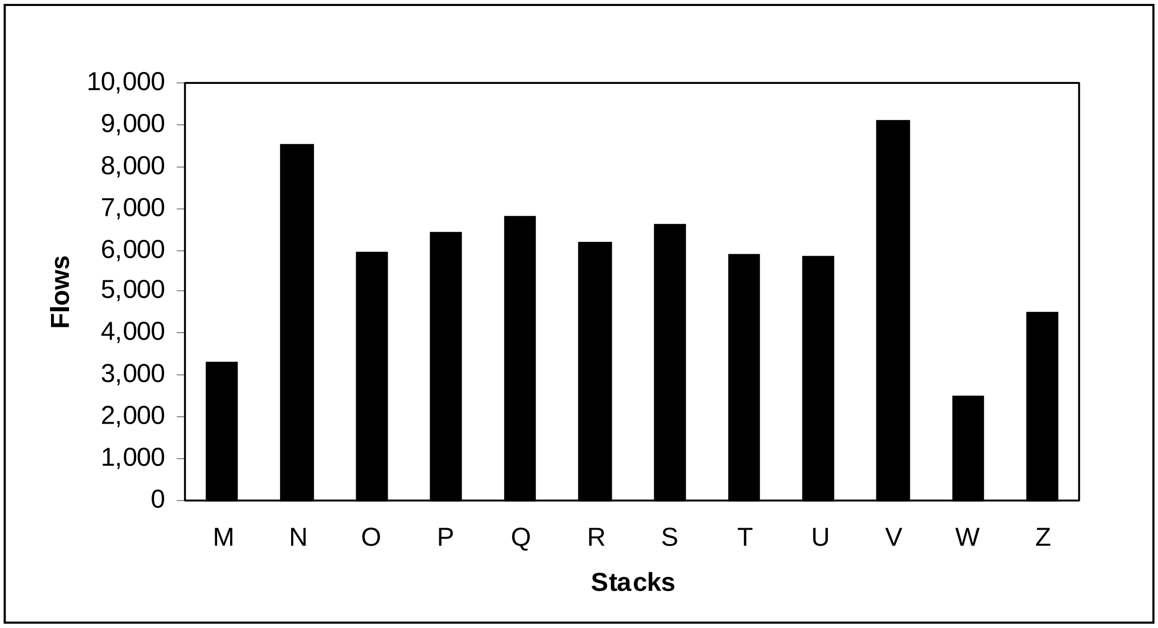


Figure C.1. Best Estimates of Flows for Mold Line 1

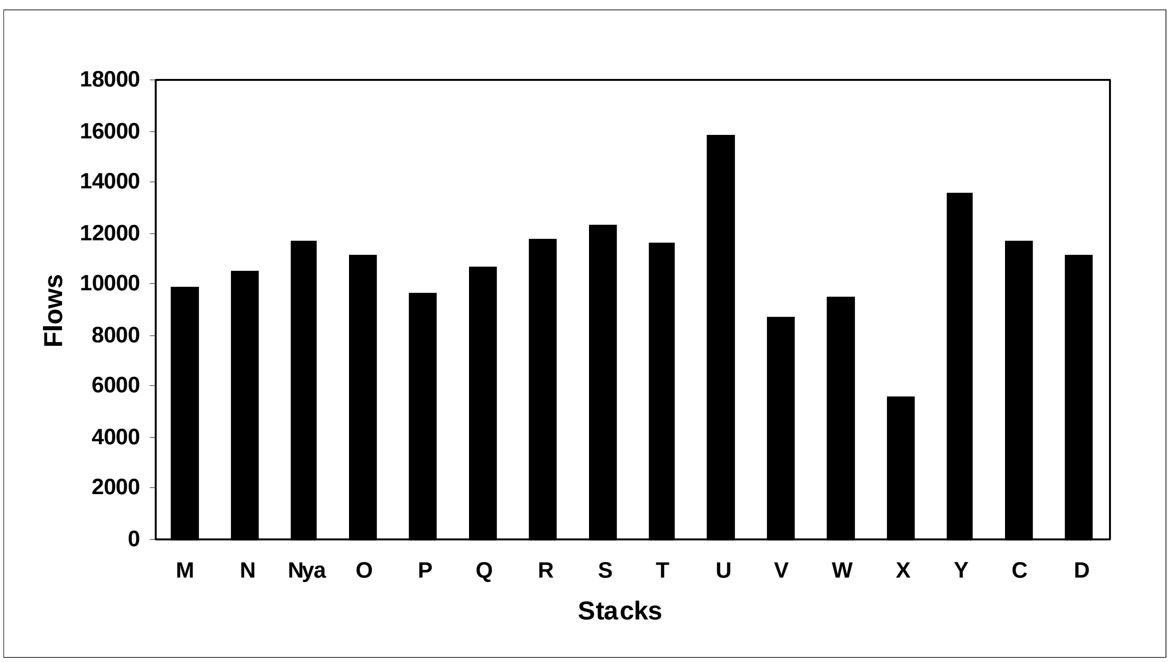


Figure C.2. Best Estimates for Flows for Mold Line 2

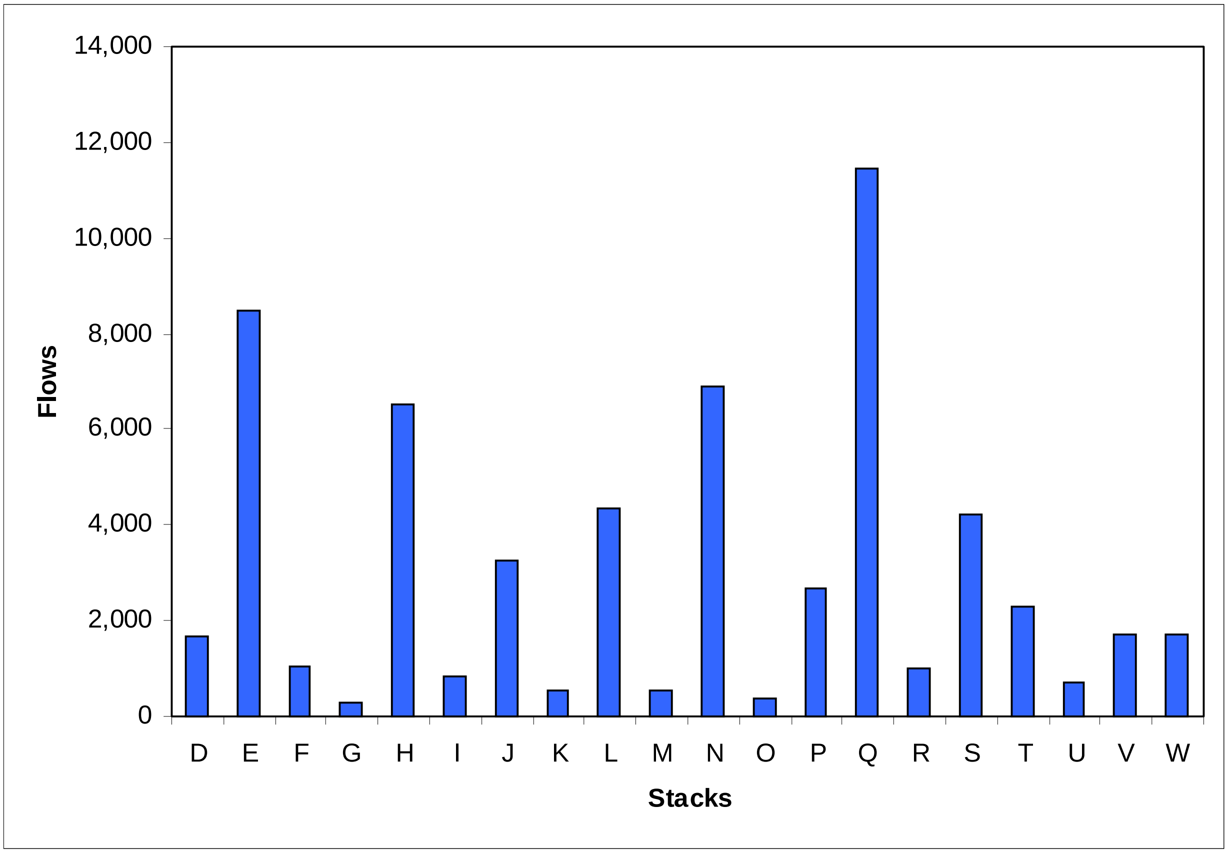


Figure C.3. Best Estimates for Flows for Mold Line 3

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix D. Emission Factors for Pouring, Cooling, and Shakeout

Table D.1 gives emission factors in units of lb species/ton mold sand; Table D.2 gives emission factors in units of lb species/ton core sand; Table D.3 gives emission factors in units of lb species/ton seacoal; and Table D.4 lists emission factors in units of lb species/lb of resin. Tables D.5 – D.8 give similar results to Tables D.1 – D.4, but just for the emission factors of HAPs.

Table D.1. Pouring, Cooling, and Shakeout Emission Factors for Blocks (1, 2, 3)
Average Lb / Ton Mold Sand

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	1.78E-05	7.18E-06	2.03E-05	2.37E-04	4.92E-05	3.43E-04	2.52E-05	4.36E-05	7.55E-05	2.79E-04	6.61E-05	4.39E-04
1,2,4-Trimethylbenzene	4.56E-05	2.42E-05	6.49E-05	6.21E-04	1.17E-04	8.53E-04	9.42E-05	3.58E-05	1.20E-04	7.61E-04	1.25E-04	1.04E-03
1,2-Diethylbenzene	1.42E-06	5.69E-06	5.69E-06	3.68E-05	1.47E-05	7.60E-05	2.28E-06	3.94E-06	6.83E-06	4.05E-05	1.63E-05	8.85E-05
1,3,5-Trimethylbenzene	2.17E-05	1.31E-05	3.12E-05	3.45E-04	5.77E-05	4.64E-04	4.39E-05	1.63E-05	5.71E-05	4.11E-04	6.14E-05	5.52E-04
1,3-Diethylbenzene	ND	ND	ND	3.11E-05	1.95E-05	7.86E-05	ND	ND	ND	3.11E-05	1.95E-05	7.86E-05
1,3-Diisopropylbenzene	1.35E-06	5.41E-06	5.41E-06	4.20E-05	1.98E-05	9.22E-05	7.63E-06	7.94E-06	1.58E-05	5.09E-05	2.20E-05	1.13E-04
1,3-Dimethylnaphthalene	7.75E-07	1.93E-06	2.36E-06	2.15E-05	1.05E-05	5.41E-05	ND	ND	ND	2.22E-05	1.07E-05	5.64E-05
1,4-Diethylbenzene	8.54E-06	1.21E-05	1.43E-05	1.53E-04	3.46E-05	2.49E-04	2.21E-05	2.35E-05	4.67E-05	1.84E-04	4.35E-05	3.10E-04
1,4-Dimethylnaphthalene	ND	ND	ND	4.90E-06	2.16E-06	1.15E-05	ND	ND	ND	4.90E-06	2.16E-06	1.15E-05
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	1.01E-06	9.52E-07	3.85E-06	ND	ND	ND	1.01E-06	9.52E-07	3.85E-06
1-Methylnaphthalene	1.38E-05	1.25E-05	2.14E-05	1.73E-04	6.87E-05	3.91E-04	6.54E-06	6.30E-06	1.26E-05	1.93E-04	7.01E-05	4.25E-04
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	1.19E-06	4.74E-06	4.74E-06	3.44E-05	1.92E-05	9.02E-05	2.79E-06	4.83E-06	8.37E-06	3.83E-05	2.04E-05	1.03E-04
2,3-Dimethylnaphthalene	ND	ND	ND	1.83E-05	8.71E-06	4.06E-05	1.91E-06	3.31E-06	5.74E-06	2.02E-05	9.32E-06	4.63E-05
2,3-Dimethylphenol	6.69E-06	1.56E-05	1.48E-05	1.94E-04	7.23E-05	3.57E-04	5.66E-05	2.72E-05	8.52E-05	2.58E-04	7.88E-05	4.57E-04
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	1.04E-04	1.28E-04	2.66E-04	ND	ND	ND	1.04E-04	1.28E-04	2.66E-04
2,6-Dimethylnaphthalene	ND	ND	ND	2.10E-06	1.82E-06	6.31E-06	ND	ND	ND	2.10E-06	1.82E-06	6.31E-06
2,6-Dimethylphenol	1.56E-06	6.25E-06	6.25E-06	5.25E-05	6.95E-05	1.89E-04	6.01E-06	1.04E-05	1.80E-05	6.00E-05	7.05E-05	2.13E-04
2,7-Dimethylnaphthalene	2.27E-07	9.08E-07	9.09E-07	4.98E-06	3.15E-06	1.54E-05	ND	ND	ND	5.20E-06	3.28E-06	1.63E-05
2-Ethyltoluene	8.31E-06	7.60E-06	1.34E-05	1.51E-04	2.78E-05	2.18E-04	2.32E-05	6.83E-06	2.95E-05	1.82E-04	2.96E-05	2.61E-04
2-Methylnaphthalene	1.63E-05	1.26E-05	2.44E-05	1.97E-04	7.48E-05	4.42E-04	8.33E-06	8.07E-06	1.61E-05	2.22E-04	7.63E-05	4.82E-04
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	8.51E-07	3.40E-06	3.40E-06	9.55E-06	1.11E-05	2.01E-05	1.67E-05	1.98E-05	3.85E-05	2.71E-05	2.29E-05	6.20E-05
3,5-Dimethylphenol	1.06E-05	2.50E-05	2.65E-05	1.28E-04	3.57E-05	2.21E-04	1.50E-05	1.55E-05	3.09E-05	1.53E-04	4.62E-05	2.78E-04
3-Ethyltoluene	2.46E-06	9.84E-06	9.84E-06	9.05E-05	7.47E-05	3.31E-04	1.72E-05	2.98E-05	5.16E-05	1.10E-04	8.10E-05	3.93E-04
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	7.29E-06	1.05E-05	1.23E-05	2.23E-04	8.56E-05	4.35E-04	4.31E-05	2.09E-05	5.68E-05	2.73E-04	8.87E-05	5.04E-04
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	2.70E-07	7.61E-07	5.39E-07	4.48E-06	1.85E-06	9.41E-06	ND	ND	ND	4.75E-06	2.00E-06	9.95E-06
Acetaldehyde	5.28E-05	4.14E-05	7.49E-05	6.28E-04	9.40E-05	8.69E-04	8.74E-05	2.76E-05	1.14E-04	7.68E-04	1.06E-04	1.06E-03
Acetone	7.57E-05	5.19E-05	1.05E-04	7.36E-04	9.76E-05	9.05E-04	1.63E-04	5.59E-05	2.13E-04	9.75E-04	1.24E-04	1.22E-03
Acetophenone	ND	ND	ND	4.13E-05	7.55E-05	1.65E-04	ND	ND	ND	4.13E-05	7.55E-05	1.65E-04
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	3.93E-04	3.20E-04	6.23E-04	6.65E-03	7.40E-04	8.53E-03	5.14E-04	2.46E-04	7.66E-04	7.56E-03	8.43E-04	9.92E-03
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	1.99E-06	1.34E-06	6.82E-06	ND	ND	ND	1.99E-06	1.34E-06	6.82E-06
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	9.53E-05	1.56E-05	1.16E-04	7.93E-06	1.37E-05	2.38E-05	1.03E-04	2.08E-05	1.39E-04
Butylbenzene	ND	ND	ND	6.83E-05	4.34E-05	1.72E-04	1.53E-05	2.66E-05	4.60E-05	8.36E-05	5.09E-05	2.18E-04
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	1.07E-06	1.97E-06	2.38E-06	2.31E-05	5.10E-06	3.74E-05	ND	ND	ND	2.42E-05	5.47E-06	3.98E-05
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	8.32E-05	6.25E-05	1.32E-04	4.37E-04	7.43E-05	6.29E-04	6.75E-05	4.59E-05	1.20E-04	5.87E-04	1.07E-04	8.81E-04
Dibenzofuran	ND	ND	ND	3.04E-06	2.05E-06	1.00E-05	ND	ND	ND	3.04E-06	2.05E-06	1.00E-05
Dodecane	1.12E-04	8.94E-05	1.82E-04	5.11E-04	1.12E-04	7.66E-04	5.76E-05	2.10E-05	7.74E-05	6.81E-04	1.45E-04	1.03E-03
Ethylbenzene	1.82E-05	8.80E-06	2.48E-05	3.60E-04	4.45E-05	4.52E-04	4.50E-05	1.98E-05	6.63E-05	4.23E-04	4.94E-05	5.43E-04
Formaldehyde	2.46E-05	3.84E-05	4.67E-05	3.35E-04	5.95E-05	5.22E-04	9.72E-05	9.69E-05	2.07E-04	4.57E-04	1.20E-04	7.76E-04
Heptane	5.08E-05	4.79E-05	8.19E-05	7.25E-04	7.51E-05	9.55E-04	2.76E-04	3.41E-04	6.65E-04	1.05E-03	3.52E-04	1.70E-03
Hexanal	ND	ND	ND	7.42E-06	9.24E-06	2.23E-05	ND	ND	ND	7.42E-06	9.24E-06	2.23E-05
Indan	2.63E-06	6.13E-06	5.78E-06	1.02E-04	1.84E-05	1.53E-04	2.07E-05	1.59E-05	3.87E-05	1.25E-04	2.51E-05	1.97E-04
Indene	5.85E-06	9.32E-06	1.14E-05	1.38E-04	6.46E-05	2.95E-04	2.92E-05	1.09E-05	4.18E-05	1.73E-04	6.61E-05	3.48E-04
Isobutylbenzene	2.93E-07	1.17E-06	1.17E-06	2.01E-05	1.04E-05	4.22E-05	ND	ND	ND	2.04E-05	1.05E-05	4.34E-05
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	7.62E-05	4.31E-05	1.09E-04	1.45E-03	1.67E-04	1.80E-03	1.76E-04	6.00E-05	2.36E-04	1.70E-03	1.82E-04	2.14E-03
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	2.45E-05	1.53E-05	3.70E-05	1.64E-05	2.84E-05	4.91E-05	4.08E-05	3.22E-05	8.61E-05
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	3.50E-05	6.06E-05	1.05E-04	3.50E-05	6.06E-05	1.05E-04
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	1.22E-06	2.02E-06	4.90E-06	7.98E-06	1.38E-05	2.39E-05	9.21E-06	1.40E-05	2.88E-05
Naphthalene	3.25E-05	2.37E-05	4.88E-05	4.65E-04	1.25E-04	7.44E-04	5.80E-05	2.63E-05	8.79E-05	5.55E-04	1.30E-04	8.81E-04
Nitrobenzene	ND	ND	ND	9.35E-07	1.87E-06	3.74E-06	ND	ND	ND	9.35E-07	1.87E-06	3.74E-06
Nonane	2.96E-05	2.79E-05	5.11E-05	4.58E-04	6.37E-05	6.17E-04	5.19E-05	3.01E-05	8.47E-05	5.39E-04	7.58E-05	7.53E-04
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	3.07E-07	1.23E-06	1.23E-06	1.73E-04	4.66E-05	2.82E-04	4.19E-05	4.05E-05	8.08E-05	2.16E-04	6.18E-05	3.64E-04
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	3.44E-05	1.84E-05	4.84E-05	7.29E-04	9.18E-05	9.35E-04	8.46E-05	3.54E-05	1.22E-04	8.48E-04	1.00E-04	1.10E-03
Octane	2.96E-05	2.65E-05	4.95E-05	5.59E-04	5.89E-05	6.99E-04	4.15E-05	1.88E-05	5.53E-05	6.30E-04	6.72E-05	8.03E-04
p-cymene	2.29E-05	2.99E-05	4.52E-05	1.04E-04	1.92E-05	1.64E-04	2.00E-05	1.89E-05	3.77E-05	1.47E-04	4.03E-05	2.46E-04
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	5.13E-05	4.70E-05	8.24E-05	1.04E-03	2.37E-04	1.63E-03	9.41E-04	1.21E-03	2.30E-03	2.04E-03	1.23E-03	4.01E-03
Propanal	ND	ND	ND	7.85E-06	6.80E-06	1.20E-05	ND	ND	ND	7.85E-06	6.80E-06	1.20E-05
Styrene	9.53E-06	7.86E-06	1.48E-05	8.52E-05	3.47E-05	1.63E-04	1.71E-05	1.23E-05	3.13E-05	1.12E-04	3.77E-05	2.09E-04
Tetradecane	1.07E-05	1.04E-05	1.71E-05	9.93E-05	2.26E-05	1.48E-04	9.42E-06	9.56E-06	1.91E-05	1.19E-04	2.67E-05	1.84E-04
Toluene	1.90E-04	1.06E-04	2.73E-04	3.60E-03	4.66E-04	4.61E-03	4.55E-04	1.70E-04	6.26E-04	4.24E-03	5.08E-04	5.51E-03
Tridecane	4.95E-05	3.44E-05	7.28E-05	2.78E-04	4.42E-05	3.62E-04	3.33E-05	8.59E-06	4.05E-05	3.61E-04	5.66E-05	4.75E-04
Undecane	1.74E-04	1.47E-04	2.89E-04	8.94E-04	1.92E-04	1.37E-03	1.23E-04	6.48E-05	1.86E-04	1.19E-03	2.51E-04	1.85E-03
Valeraldehyde	ND	ND	ND	2.68E-05	1.69E-05	4.39E-05	ND	ND	ND	2.68E-05	1.69E-05	4.39E-05
Total POMs	6.39E-05		9.84E-05	8.91E-04		1.72E-03	7.48E-05		1.22E-04	1.03E-03		1.94E-03

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

Table D.2. Pouring, Cooling, and Shakeout Emission Factors for Blocks (1, 2, 3)
Average Lb / Ton Core Sand

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	1.64E-04	6.63E-05	1.88E-04	2.81E-03	4.71E-04	3.85E-03	3.36E-04	5.82E-04	1.01E-03	3.31E-03	7.52E-04	5.05E-03
1,2,4-Trimethylbenzene	4.58E-04	1.85E-04	6.00E-04	7.42E-03	1.34E-03	1.04E-02	1.03E-03	5.53E-04	1.60E-03	8.92E-03	1.46E-03	1.26E-02
1,2-Diethylbenzene	1.90E-05	7.60E-05	7.60E-05	4.27E-04	1.55E-04	8.80E-04	2.10E-05	3.64E-05	6.31E-05	4.67E-04	1.77E-04	1.02E-03
1,3,5-Trimethylbenzene	2.17E-04	9.53E-05	2.88E-04	4.13E-03	6.31E-04	5.69E-03	4.84E-04	2.64E-04	7.63E-04	4.83E-03	6.91E-04	6.74E-03
1,3-Diethylbenzene	ND	ND	ND	3.88E-04	2.69E-04	1.05E-03	ND	ND	ND	3.88E-04	2.69E-04	1.05E-03
1,3-Diisopropylbenzene	1.81E-05	7.22E-05	7.22E-05	4.85E-04	2.09E-04	1.08E-03	7.06E-05	7.34E-05	1.46E-04	5.74E-04	2.33E-04	1.29E-03
1,3-Dimethylnaphthalene	7.17E-06	1.78E-05	2.18E-05	2.73E-04	1.36E-04	6.88E-04	ND	ND	ND	2.80E-04	1.37E-04	7.10E-04
1,4-Diethylbenzene	9.94E-05	1.32E-04	1.34E-04	1.94E-03	4.46E-04	3.27E-03	2.04E-04	2.17E-04	4.32E-04	2.24E-03	5.13E-04	3.84E-03
1,4-Dimethylnaphthalene	ND	ND	ND	5.50E-05	2.70E-05	1.46E-04	ND	ND	ND	5.50E-05	2.70E-05	1.46E-04
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	1.27E-05	1.23E-05	4.86E-05	ND	ND	ND	1.27E-05	1.23E-05	4.86E-05
1-Methylnaphthalene	1.31E-04	1.14E-04	1.98E-04	2.11E-03	8.37E-04	4.86E-03	6.05E-05	5.82E-05	1.16E-04	2.30E-03	8.46E-04	5.17E-03
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	1.58E-05	6.33E-05	6.33E-05	4.41E-04	2.53E-04	1.16E-03	2.58E-05	4.46E-05	7.73E-05	4.82E-04	2.65E-04	1.30E-03
2,3-Dimethylnaphthalene	ND	ND	ND	2.20E-04	1.12E-04	5.13E-04	1.77E-05	3.06E-05	5.30E-05	2.38E-04	1.16E-04	5.66E-04
2,3-Dimethylphenol	8.93E-05	2.09E-04	1.98E-04	2.32E-03	7.84E-04	4.19E-03	5.96E-04	2.70E-04	7.88E-04	3.01E-03	8.55E-04	5.17E-03
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	8.41E-04	1.04E-03	2.16E-03	ND	ND	ND	8.41E-04	1.04E-03	2.16E-03
2,6-Dimethylnaphthalene	ND	ND	ND	2.81E-05	2.44E-05	8.43E-05	ND	ND	ND	2.81E-05	2.44E-05	8.43E-05
2,6-Dimethylphenol	2.09E-05	8.34E-05	8.34E-05	5.15E-04	5.67E-04	1.79E-03	5.56E-05	9.63E-05	1.67E-04	5.92E-04	5.81E-04	2.04E-03
2,7-Dimethylnaphthalene	2.10E-06	8.40E-06	8.40E-06	5.16E-05	3.47E-05	1.65E-04	ND	ND	ND	5.37E-05	3.57E-05	1.74E-04
2-Ethyltoluene	7.99E-05	6.88E-05	1.24E-04	1.76E-03	2.74E-04	2.44E-03	2.55E-04	1.26E-04	3.94E-04	2.10E-03	3.09E-04	2.96E-03
2-Methylnaphthalene	1.55E-04	1.12E-04	2.26E-04	2.41E-03	9.05E-04	5.47E-03	7.70E-05	7.46E-05	1.49E-04	2.65E-03	9.15E-04	5.84E-03
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	1.14E-05	4.54E-05	4.54E-05	7.76E-05	8.98E-05	1.63E-04	1.54E-04	1.83E-04	3.56E-04	2.43E-04	2.09E-04	5.65E-04
3,5-Dimethylphenol	1.09E-04	2.52E-04	2.87E-04	1.55E-03	3.60E-04	2.61E-03	1.39E-04	1.43E-04	2.85E-04	1.79E-03	4.62E-04	3.19E-03
3-Ethyltoluene	3.28E-05	1.31E-04	1.31E-04	1.21E-03	9.97E-04	4.43E-03	2.30E-04	3.98E-04	6.89E-04	1.47E-03	1.08E-03	5.25E-03
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	8.48E-05	1.15E-04	1.24E-04	2.59E-03	8.91E-04	5.03E-03	4.72E-04	2.72E-04	7.13E-04	3.15E-03	9.38E-04	5.87E-03
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	2.49E-06	7.05E-06	4.98E-06	5.14E-05	2.21E-05	1.15E-04	ND	ND	ND	5.39E-05	2.32E-05	1.20E-04
Acetaldehyde	5.07E-04	3.27E-04	6.93E-04	6.97E-03	6.84E-04	8.90E-03	8.08E-04	2.55E-04	1.05E-03	8.29E-03	8.00E-04	1.06E-02
Acetone	7.37E-04	4.06E-04	9.72E-04	8.33E-03	8.87E-04	1.08E-02	1.51E-03	5.16E-04	1.97E-03	1.06E-02	1.10E-03	1.37E-02
Acetophenone	ND	ND	ND	3.55E-04	6.15E-04	1.42E-03	ND	ND	ND	3.55E-04	6.15E-04	1.42E-03
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	3.80E-03	2.63E-03	5.76E-03	8.21E-02	1.03E-02	1.10E-01	5.80E-03	3.98E-03	1.02E-02	9.17E-02	1.14E-02	1.26E-01
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	2.57E-05	1.76E-05	8.75E-05	ND	ND	ND	2.57E-05	1.76E-05	8.75E-05
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	1.10E-03	1.43E-04	1.35E-03	7.33E-05	1.27E-04	2.20E-04	1.17E-03	1.91E-04	1.57E-03
Butylbenzene	ND	ND	ND	7.35E-04	4.25E-04	1.93E-03	2.05E-04	3.55E-04	6.15E-04	9.40E-04	5.54E-04	2.55E-03
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	9.93E-06	1.82E-05	2.20E-05	2.79E-04	5.37E-05	4.34E-04	ND	ND	ND	2.89E-04	5.66E-05	4.56E-04
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	8.29E-04	4.92E-04	1.22E-03	5.12E-03	8.61E-04	7.41E-03	7.88E-04	7.06E-04	1.60E-03	6.74E-03	1.22E-03	1.02E-02
Dibenzofuran	ND	ND	ND	4.06E-05	2.73E-05	1.34E-04	ND	ND	ND	4.06E-05	2.73E-05	1.34E-04
Dodecane	1.09E-03	7.40E-04	1.68E-03	6.25E-03	1.35E-03	9.53E-03	6.38E-04	3.60E-04	1.03E-03	7.98E-03	1.58E-03	1.22E-02
Ethylbenzene	1.85E-04	6.05E-05	2.29E-04	4.33E-03	4.88E-04	5.46E-03	5.07E-04	3.35E-04	8.85E-04	5.03E-03	5.95E-04	6.58E-03
Formaldehyde	2.28E-04	3.55E-04	4.31E-04	3.94E-03	7.82E-04	6.36E-03	8.98E-04	8.96E-04	1.92E-03	5.07E-03	1.24E-03	8.70E-03
Heptane	5.21E-04	4.72E-04	8.02E-04	8.89E-03	1.15E-03	1.24E-02	2.74E-03	3.05E-03	6.15E-03	1.21E-02	3.29E-03	1.94E-02
Hexanal	ND	ND	ND	6.02E-05	7.50E-05	1.81E-04	ND	ND	ND	6.02E-05	7.50E-05	1.81E-04
Indan	2.92E-05	6.79E-05	6.33E-05	1.26E-03	2.30E-04	1.91E-03	2.44E-04	2.38E-04	5.17E-04	1.53E-03	3.38E-04	2.49E-03
Indene	6.08E-05	9.27E-05	1.05E-04	1.64E-03	5.85E-04	3.30E-03	3.03E-04	9.28E-05	3.86E-04	2.00E-03	5.99E-04	3.79E-03
Isobutylbenzene	3.91E-06	1.56E-05	1.56E-05	2.23E-04	1.04E-04	4.69E-04	ND	ND	ND	2.26E-04	1.06E-04	4.84E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	7.60E-04	3.05E-04	1.01E-03	1.80E-02	2.38E-03	2.31E-02	1.95E-03	1.07E-03	3.15E-03	2.07E-02	2.63E-03	2.72E-02
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	2.24E-04	1.43E-04	3.77E-04	1.51E-04	2.62E-04	4.54E-04	3.76E-04	2.99E-04	8.31E-04
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	4.67E-04	8.09E-04	1.40E-03	4.67E-04	8.09E-04	1.40E-03
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	1.64E-05	2.69E-05	6.54E-05	1.07E-04	1.85E-04	3.20E-04	1.23E-04	1.87E-04	3.85E-04
Naphthalene	3.17E-04	1.87E-04	4.51E-04	5.49E-03	1.23E-03	8.85E-03	5.89E-04	1.98E-04	8.13E-04	6.39E-03	1.26E-03	1.01E-02
Nitrobenzene	ND	ND	ND	1.25E-05	2.50E-05	4.99E-05	ND	ND	ND	1.25E-05	2.50E-05	4.99E-05
Nonane	3.11E-04	2.44E-04	4.72E-04	5.49E-03	7.70E-04	7.80E-03	5.96E-04	4.73E-04	1.13E-03	6.40E-03	9.36E-04	9.40E-03
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	4.10E-06	1.64E-05	1.64E-05	2.27E-03	6.22E-04	3.71E-03	3.87E-04	3.74E-04	7.47E-04	2.66E-03	7.26E-04	4.47E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	3.49E-04	1.38E-04	4.47E-04	8.93E-03	1.16E-03	1.17E-02	9.49E-04	6.01E-04	1.62E-03	1.02E-02	1.31E-03	1.38E-02
Octane	2.91E-04	2.12E-04	4.57E-04	6.73E-03	7.69E-04	8.83E-03	4.59E-04	2.76E-04	7.38E-04	7.49E-03	8.44E-04	1.00E-02
p-cymene	2.41E-04	2.36E-04	4.17E-04	1.26E-03	3.06E-04	2.18E-03	1.85E-04	1.75E-04	3.48E-04	1.69E-03	4.24E-04	2.95E-03
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	4.94E-04	4.25E-04	7.62E-04	1.29E-02	3.03E-03	2.10E-02	8.70E-03	1.12E-02	2.13E-02	2.21E-02	1.16E-02	4.30E-02
Propanal	ND	ND	ND	6.37E-05	5.52E-05	9.78E-05	ND	ND	ND	6.37E-05	5.52E-05	9.78E-05
Styrene	9.03E-05	7.03E-05	1.37E-04	9.51E-04	3.32E-04	1.84E-03	2.01E-04	1.88E-04	4.18E-04	1.24E-03	3.88E-04	2.40E-03
Tetradecane	1.03E-04	9.33E-05	1.58E-04	1.23E-03	2.75E-04	1.86E-03	8.71E-05	8.84E-05	1.77E-04	1.42E-03	3.03E-04	2.20E-03
Toluene	1.89E-03	7.70E-04	2.52E-03	4.47E-02	6.45E-03	5.87E-02	5.07E-03	2.96E-03	8.36E-03	5.16E-02	7.14E-03	6.96E-02
Tridecane	4.84E-04	2.67E-04	6.73E-04	3.57E-03	6.02E-04	4.78E-03	3.63E-04	1.63E-04	5.41E-04	4.42E-03	6.79E-04	6.00E-03
Undecane	1.71E-03	1.21E-03	2.67E-03	1.07E-02	2.14E-03	1.65E-02	1.39E-03	1.00E-03	2.48E-03	1.38E-02	2.66E-03	2.16E-02
Valeraldehyde	ND	ND	ND	2.45E-04	1.55E-04	4.22E-04	ND	ND	ND	2.45E-04	1.55E-04	4.22E-04
Total POMs	6.14E-04		9.10E-04	1.07E-02		2.09E-02	7.44E-04		1.13E-03	1.21E-02		2.30E-02

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

Table D.3. Pouring, Cooling, and Shakeout Emission Factors for Blocks (1, 2, 3)
Average Lb / Ton Seacoal

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	3.55E-04	1.43E-04	4.06E-04	4.73E-03	9.84E-04	6.86E-03	5.04E-04	8.72E-04	1.51E-03	5.59E-03	1.32E-03	8.78E-03
1,2,4-Trimethylbenzene	9.12E-04	4.84E-04	1.30E-03	1.24E-02	2.35E-03	1.71E-02	1.88E-03	7.16E-04	2.40E-03	1.52E-02	2.50E-03	2.08E-02
1,2-Diethylbenzene	2.85E-05	1.14E-04	1.14E-04	7.35E-04	2.94E-04	1.52E-03	4.55E-05	7.88E-05	1.37E-04	8.09E-04	3.25E-04	1.77E-03
1,3,5-Trimethylbenzene	4.34E-04	2.61E-04	6.23E-04	6.91E-03	1.15E-03	9.28E-03	8.77E-04	3.27E-04	1.14E-03	8.22E-03	1.23E-03	1.10E-02
1,3-Diethylbenzene	ND	ND	ND	6.23E-04	3.91E-04	1.57E-03	ND	ND	ND	6.23E-04	3.91E-04	1.57E-03
1,3-Diisopropylbenzene	2.71E-05	1.08E-04	1.08E-04	8.39E-04	3.97E-04	1.85E-03	1.53E-04	1.59E-04	3.17E-04	1.02E-03	4.41E-04	2.27E-03
1,3-Dimethylnaphthalene	1.55E-05	3.86E-05	4.72E-05	4.30E-04	2.10E-04	1.08E-03	ND	ND	ND	4.45E-04	2.13E-04	1.13E-03
1,4-Diethylbenzene	1.71E-04	2.42E-04	2.86E-04	3.07E-03	6.92E-04	4.97E-03	4.42E-04	4.69E-04	9.34E-04	3.68E-03	8.71E-04	6.19E-03
1,4-Dimethylnaphthalene	ND	ND	ND	9.81E-05	4.33E-05	2.31E-04	ND	ND	ND	9.81E-05	4.33E-05	2.31E-04
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	2.01E-05	1.90E-05	7.71E-05	ND	ND	ND	2.01E-05	1.90E-05	7.71E-05
1-Methylnaphthalene	2.76E-04	2.50E-04	4.28E-04	3.45E-03	1.37E-03	7.83E-03	1.31E-04	1.26E-04	2.51E-04	3.86E-03	1.40E-03	8.51E-03
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	2.37E-05	9.49E-05	9.49E-05	6.88E-04	3.84E-04	1.80E-03	5.57E-05	9.66E-05	1.67E-04	7.67E-04	4.08E-04	2.07E-03
2,3-Dimethylnaphthalene	ND	ND	ND	3.65E-04	1.74E-04	8.12E-04	3.82E-05	6.62E-05	1.15E-04	4.04E-04	1.86E-04	9.27E-04
2,3-Dimethylphenol	1.34E-04	3.13E-04	2.97E-04	3.89E-03	1.45E-03	7.14E-03	1.13E-03	5.44E-04	1.70E-03	5.15E-03	1.58E-03	9.14E-03
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	2.07E-03	2.56E-03	5.31E-03	ND	ND	ND	2.07E-03	2.56E-03	5.31E-03
2,6-Dimethylnaphthalene	ND	ND	ND	4.21E-05	3.65E-05	1.26E-04	ND	ND	ND	4.21E-05	3.65E-05	1.26E-04
2,6-Dimethylphenol	3.12E-05	1.25E-04	1.25E-04	1.05E-03	1.39E-03	3.78E-03	1.20E-04	2.08E-04	3.61E-04	1.20E-03	1.41E-03	4.27E-03
2,7-Dimethylnaphthalene	4.54E-06	1.82E-05	1.82E-05	9.95E-05	6.31E-05	3.08E-04	ND	ND	ND	1.04E-04	6.56E-05	3.26E-04
2-Ethyltoluene	1.66E-04	1.52E-04	2.68E-04	3.01E-03	5.55E-04	4.37E-03	4.65E-04	1.37E-04	5.90E-04	3.64E-03	5.92E-04	5.22E-03
2-Methylnaphthalene	3.26E-04	2.52E-04	4.89E-04	3.94E-03	1.50E-03	8.84E-03	1.67E-04	1.61E-04	3.22E-04	4.43E-03	1.53E-03	9.65E-03
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	1.70E-05	6.81E-05	6.81E-05	1.91E-04	2.21E-04	4.02E-04	3.33E-04	3.95E-04	7.70E-04	5.41E-04	4.58E-04	1.24E-03
3,5-Dimethylphenol	2.13E-04	5.00E-04	5.30E-04	2.55E-03	7.13E-04	4.41E-03	3.00E-04	3.09E-04	6.17E-04	3.07E-03	9.25E-04	5.56E-03
3-Ethyltoluene	4.92E-05	1.97E-04	1.97E-04	1.81E-03	1.49E-03	6.63E-03	3.44E-04	5.96E-04	1.03E-03	2.20E-03	1.62E-03	7.86E-03
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	1.46E-04	2.09E-04	2.45E-04	4.45E-03	1.71E-03	8.70E-03	8.62E-04	4.17E-04	1.14E-03	5.46E-03	1.77E-03	1.01E-02
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	5.39E-06	1.52E-05	1.08E-05	8.97E-05	3.70E-05	1.88E-04	ND	ND	ND	9.51E-05	4.01E-05	1.99E-04
Acetaldehyde	1.06E-03	8.28E-04	1.50E-03	1.26E-02	1.88E-03	1.74E-02	1.75E-03	5.52E-04	2.27E-03	1.54E-02	2.13E-03	2.12E-02
Acetone	1.51E-03	1.04E-03	2.10E-03	1.47E-02	1.95E-03	1.81E-02	3.26E-03	1.12E-03	4.27E-03	1.95E-02	2.48E-03	2.45E-02
Acetophenone	ND	ND	ND	8.26E-04	1.51E-03	3.31E-03	ND	ND	ND	8.26E-04	1.51E-03	3.31E-03
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	7.86E-03	6.40E-03	1.25E-02	1.33E-01	1.48E-02	1.71E-01	1.03E-02	4.92E-03	1.53E-02	1.51E-01	1.69E-02	1.98E-01
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	3.98E-05	2.68E-05	1.36E-04	ND	ND	ND	3.98E-05	2.68E-05	1.36E-04
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	1.91E-03	3.11E-04	2.31E-03	1.59E-04	2.75E-04	4.76E-04	2.07E-03	4.15E-04	2.79E-03
Butylbenzene	ND	ND	ND	1.37E-03	8.67E-04	3.44E-03	3.07E-04	5.32E-04	9.21E-04	1.67E-03	1.02E-03	4.36E-03
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	2.15E-05	3.93E-05	4.76E-05	4.63E-04	1.02E-04	7.48E-04	ND	ND	ND	4.84E-04	1.09E-04	7.95E-04
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	1.66E-03	1.25E-03	2.63E-03	8.73E-03	1.49E-03	1.26E-02	1.35E-03	9.20E-04	2.40E-03	1.17E-02	2.15E-03	1.76E-02
Dibenzofuran	ND	ND	ND	6.08E-05	4.09E-05	2.01E-04	ND	ND	ND	6.08E-05	4.09E-05	2.01E-04
Dodecane	2.25E-03	1.79E-03	3.64E-03	1.02E-02	2.25E-03	1.53E-02	1.15E-03	4.20E-04	1.55E-03	1.36E-02	2.90E-03	2.05E-02
Ethylbenzene	3.65E-04	1.76E-04	4.95E-04	7.19E-03	8.89E-04	9.05E-03	9.00E-04	3.96E-04	1.33E-03	8.46E-03	9.89E-04	1.09E-02
Formaldehyde	4.92E-04	7.67E-04	9.33E-04	6.70E-03	1.19E-03	1.04E-02	1.94E-03	1.94E-03	4.14E-03	9.13E-03	2.40E-03	1.55E-02
Heptane	1.02E-03	9.57E-04	1.64E-03	1.45E-02	1.50E-03	1.91E-02	5.53E-03	6.81E-03	1.33E-02	2.10E-02	7.04E-03	3.40E-02
Hexanal	ND	ND	ND	1.48E-04	1.85E-04	4.45E-04	ND	ND	ND	1.48E-04	1.85E-04	4.45E-04
Indan	5.26E-05	1.23E-04	1.15E-04	2.04E-03	3.68E-04	3.06E-03	4.14E-04	3.19E-04	7.74E-04	2.51E-03	5.02E-04	3.95E-03
Indene	1.17E-04	1.86E-04	2.27E-04	2.77E-03	1.29E-03	5.90E-03	5.85E-04	2.18E-04	8.35E-04	3.47E-03	1.32E-03	6.96E-03
Isobutylbenzene	5.86E-06	2.34E-05	2.34E-05	4.02E-04	2.08E-04	8.44E-04	ND	ND	ND	4.08E-04	2.09E-04	8.67E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	1.52E-03	8.61E-04	2.19E-03	2.89E-02	3.33E-03	3.60E-02	3.53E-03	1.20E-03	4.72E-03	3.40E-02	3.65E-03	4.29E-02
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	4.89E-04	3.06E-04	7.40E-04	3.27E-04	5.67E-04	9.82E-04	8.17E-04	6.44E-04	1.72E-03
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	7.00E-04	1.21E-03	2.10E-03	7.00E-04	1.21E-03	2.10E-03
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	2.45E-05	4.03E-05	9.80E-05	1.60E-04	2.77E-04	4.79E-04	1.84E-04	2.80E-04	5.77E-04
Naphthalene	6.50E-04	4.74E-04	9.75E-04	9.29E-03	2.50E-03	1.49E-02	1.16E-03	5.26E-04	1.76E-03	1.11E-02	2.60E-03	1.76E-02
Nitrobenzene	ND	ND	ND	1.87E-05	3.74E-05	7.48E-05	ND	ND	ND	1.87E-05	3.74E-05	7.48E-05
Nonane	5.92E-04	5.57E-04	1.02E-03	9.15E-03	1.27E-03	1.23E-02	1.04E-03	6.02E-04	1.70E-03	1.08E-02	1.52E-03	1.51E-02
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	6.14E-06	2.46E-05	2.46E-05	3.47E-03	9.33E-04	5.63E-03	8.37E-04	8.10E-04	1.62E-03	4.31E-03	1.24E-03	7.27E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	6.87E-04	3.68E-04	9.67E-04	1.46E-02	1.84E-03	1.87E-02	1.69E-03	7.09E-04	2.43E-03	1.70E-02	2.00E-03	2.21E-02
Octane	5.91E-04	5.29E-04	9.90E-04	1.12E-02	1.18E-03	1.40E-02	8.30E-04	3.76E-04	1.11E-03	1.26E-02	1.34E-03	1.61E-02
p-cymene	4.58E-04	5.98E-04	9.03E-04	2.08E-03	3.85E-04	3.27E-03	3.99E-04	3.79E-04	7.54E-04	2.94E-03	8.06E-04	4.93E-03
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.03E-03	9.40E-04	1.65E-03	2.09E-02	4.74E-03	3.26E-02	1.88E-02	2.41E-02	4.60E-02	4.07E-02	2.46E-02	8.03E-02
Propanal	ND	ND	ND	1.57E-04	1.36E-04	2.41E-04	ND	ND	ND	1.57E-04	1.36E-04	2.41E-04
Styrene	1.90E-04	1.57E-04	2.96E-04	1.70E-03	6.94E-04	3.25E-03	3.43E-04	2.46E-04	6.27E-04	2.24E-03	7.53E-04	4.18E-03
Tetradecane	2.15E-04	2.08E-04	3.41E-04	1.99E-03	4.52E-04	2.96E-03	1.88E-04	1.91E-04	3.82E-04	2.39E-03	5.33E-04	3.68E-03
Toluene	3.80E-03	2.12E-03	5.45E-03	7.20E-02	9.33E-03	9.22E-02	9.11E-03	3.41E-03	1.25E-02	8.49E-02	1.02E-02	1.10E-01
Tridecane	9.90E-04	6.87E-04	1.45E-03	5.57E-03	8.84E-04	7.24E-03	6.65E-04	1.72E-04	8.11E-04	7.22E-03	1.13E-03	9.51E-03
Undecane	3.48E-03	2.94E-03	5.78E-03	1.79E-02	3.84E-03	2.74E-02	2.45E-03	1.30E-03	3.72E-03	2.38E-02	5.01E-03	3.69E-02
Valeraldehyde	ND	ND	ND	5.36E-04	3.38E-04	8.78E-04	ND	ND	ND	5.36E-04	3.38E-04	8.78E-04
Total POMs	1.28E-03		1.97E-03	1.78E-02		3.44E-02	1.50E-03		2.45E-03	2.06E-02		3.88E-02

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

Table D.4. Pouring, Cooling, and Shakeout Emission Factors for Blocks (1, 2, 3)
Average Lb / Lb Resin

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trimethylbenzene	4.45E-06	1.80E-06	5.08E-06	7.56E-05	1.27E-05	1.04E-04	9.04E-06	1.57E-05	2.71E-05	8.91E-05	4.10E-10	1.36E-04
1,2,4-Trimethylbenzene	1.24E-05	5.03E-06	1.62E-05	2.00E-04	3.60E-05	2.80E-04	2.79E-05	1.48E-05	4.30E-05	2.40E-04	1.54E-09	3.39E-04
1,2-Diethylbenzene	5.11E-07	2.04E-06	2.04E-06	1.15E-05	4.20E-06	2.37E-05	5.70E-07	9.86E-07	1.71E-06	1.26E-05	2.28E-11	2.75E-05
1,3,5-Trimethylbenzene	5.88E-06	2.60E-06	7.81E-06	1.11E-04	1.70E-05	1.53E-04	1.31E-05	7.08E-06	2.05E-05	1.30E-04	3.47E-10	1.82E-04
1,3-Diethylbenzene	ND	ND	ND	1.04E-05	7.24E-06	2.82E-05	ND	ND	ND	1.04E-05	5.24E-11	2.82E-05
1,3-Diisopropylbenzene	4.86E-07	1.94E-06	1.94E-06	1.31E-05	5.66E-06	2.90E-05	1.91E-06	1.99E-06	3.97E-06	1.55E-05	3.97E-11	3.49E-05
1,3-Dimethylnaphthalene	1.94E-07	4.86E-07	5.92E-07	7.34E-06	3.65E-06	1.85E-05	ND	ND	ND	7.54E-06	1.36E-11	1.91E-05
1,4-Diethylbenzene	2.68E-06	3.57E-06	3.61E-06	5.23E-05	1.20E-05	8.80E-05	5.54E-06	5.87E-06	1.17E-05	6.05E-05	1.91E-10	1.03E-04
1,4-Dimethylnaphthalene	ND	ND	ND	1.49E-06	7.27E-07	3.93E-06	ND	ND	ND	1.49E-06	5.29E-13	3.93E-06
1,6-Dimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,8-Dimethylnaphthalene	ND	ND	ND	3.42E-07	3.31E-07	1.31E-06	ND	ND	ND	3.42E-07	1.10E-13	1.31E-06
1-Methylnaphthalene	3.54E-06	3.09E-06	5.36E-06	5.69E-05	2.25E-05	1.31E-04	1.64E-06	1.58E-06	3.15E-06	6.21E-05	5.20E-10	1.39E-04
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trimethylphenol	4.26E-07	1.70E-06	1.70E-06	1.19E-05	6.81E-06	3.13E-05	6.98E-07	1.21E-06	2.10E-06	1.30E-05	5.07E-11	3.51E-05
2,3-Dimethylnaphthalene	ND	ND	ND	5.94E-06	3.02E-06	1.38E-05	4.79E-07	8.28E-07	1.44E-06	6.42E-06	9.80E-12	1.53E-05
2,3-Dimethylphenol	2.40E-06	5.61E-06	5.33E-06	6.26E-05	2.12E-05	1.13E-04	1.61E-05	7.28E-06	2.13E-05	8.11E-05	5.32E-10	1.40E-04
2,4,6-Trimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Diaminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-Dimethylphenol	ND	ND	ND	2.29E-05	2.84E-05	5.88E-05	ND	ND	ND	2.29E-05	8.04E-10	5.88E-05
2,6-Dimethylnaphthalene	ND	ND	ND	7.56E-07	6.56E-07	2.27E-06	ND	ND	ND	7.56E-07	4.30E-13	2.27E-06
2,6-Dimethylphenol	5.61E-07	2.24E-06	2.24E-06	1.40E-05	1.55E-05	4.84E-05	1.51E-06	2.61E-06	4.52E-06	1.60E-05	2.51E-10	5.52E-05
2,7-Dimethylnaphthalene	5.69E-08	2.30E-07	2.28E-07	1.40E-06	9.39E-07	4.46E-06	ND	ND	ND	1.45E-06	9.34E-13	4.69E-06
2-Ethyltoluene	2.16E-06	1.87E-06	3.36E-06	4.75E-05	7.40E-06	6.59E-05	6.89E-06	3.37E-06	1.06E-05	5.65E-05	6.95E-11	7.98E-05
2-Methylnaphthalene	4.20E-06	3.05E-06	6.12E-06	6.50E-05	2.44E-05	1.47E-04	2.09E-06	2.02E-06	4.04E-06	7.13E-05	6.08E-10	1.57E-04
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dimethylphenol	3.05E-07	1.22E-06	1.22E-06	2.11E-06	2.45E-06	4.45E-06	4.18E-06	4.95E-06	9.64E-06	6.60E-06	3.20E-11	1.53E-05
3,5-Dimethylphenol	2.95E-06	6.81E-06	7.76E-06	4.17E-05	9.74E-06	7.05E-05	3.75E-06	3.87E-06	7.73E-06	4.84E-05	1.56E-10	8.60E-05
3-Ethyltoluene	8.83E-07	3.53E-06	3.53E-06	3.25E-05	2.68E-05	1.19E-04	6.17E-06	1.07E-05	1.85E-05	3.96E-05	8.46E-10	1.41E-04
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Aminobiphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	2.29E-06	3.09E-06	3.35E-06	6.99E-05	2.41E-05	1.36E-04	1.27E-05	7.32E-06	1.92E-05	8.50E-05	6.42E-10	1.58E-04
a-Methylstyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthalene/1,2-Dimethylnaphthalene	6.75E-08	1.83E-07	1.35E-07	1.39E-06	6.03E-07	3.11E-06	ND	ND	ND	1.45E-06	3.98E-13	3.25E-06
Acetaldehyde	1.37E-05	8.89E-06	1.88E-05	1.88E-04	1.86E-05	2.41E-04	2.19E-05	6.92E-06	2.84E-05	2.24E-04	4.73E-10	2.88E-04
Acetone	2.00E-05	1.10E-05	2.63E-05	2.25E-04	2.39E-05	2.91E-04	4.08E-05	1.40E-05	5.35E-05	2.86E-04	8.91E-10	3.71E-04
Acetophenone	ND	ND	ND	9.65E-06	1.68E-05	3.86E-05	ND	ND	ND	9.65E-06	2.81E-10	3.86E-05
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1.03E-04	7.14E-05	1.56E-04	2.21E-03	2.76E-04	2.97E-03	1.56E-04	1.07E-04	2.75E-04	2.47E-03	9.29E-08	3.40E-03
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bibenzyl	ND	ND	ND	6.92E-07	4.74E-07	2.36E-06	ND	ND	ND	6.92E-07	2.24E-13	2.36E-06
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanal/Benzaldehyde	ND	ND	ND	2.97E-05	3.85E-06	3.64E-05	1.99E-06	3.44E-06	5.96E-06	3.16E-05	2.67E-11	4.23E-05
Butylbenzene	ND	ND	ND	1.99E-05	1.15E-05	5.22E-05	5.51E-06	9.55E-06	1.65E-05	2.54E-05	2.24E-10	6.87E-05
Crotonaldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	2.69E-07	4.90E-07	5.97E-07	7.53E-06	1.45E-06	1.17E-05	ND	ND	ND	7.80E-06	2.35E-12	1.23E-05
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Decane	2.24E-05	1.34E-05	3.29E-05	1.38E-04	2.32E-05	2.00E-04	2.13E-05	1.89E-05	4.30E-05	1.82E-04	1.07E-09	2.76E-04
Dibenzofuran	ND	ND	ND	1.09E-06	7.35E-07	3.60E-06	ND	ND	ND	1.09E-06	5.40E-13	3.60E-06
Dodecane	2.96E-05	2.01E-05	4.56E-05	1.68E-04	3.64E-05	2.57E-04	1.72E-05	9.64E-06	2.78E-05	2.15E-04	1.82E-09	3.30E-04
Ethylbenzene	5.00E-06	1.65E-06	6.20E-06	1.17E-04	1.31E-05	1.47E-04	1.37E-05	8.97E-06	2.38E-05	1.35E-04	2.56E-10	1.77E-04
Formaldehyde	6.17E-06	9.61E-06	1.17E-05	1.06E-04	2.10E-05	1.71E-04	2.43E-05	2.43E-05	5.19E-05	1.37E-04	1.12E-09	2.35E-04
Heptane	1.41E-05	1.28E-05	2.16E-05	2.39E-04	3.08E-05	3.34E-04	7.41E-05	8.27E-05	1.67E-04	3.28E-04	7.95E-09	5.22E-04
Hexanal	ND	ND	ND	1.64E-06	2.04E-06	4.93E-06	ND	ND	ND	1.64E-06	4.18E-12	4.93E-06
Indan	7.87E-07	1.83E-06	1.70E-06	3.40E-05	6.19E-06	5.13E-05	6.58E-06	6.39E-06	1.39E-05	4.14E-05	8.25E-11	6.69E-05
Indene	1.64E-06	2.50E-06	2.85E-06	4.42E-05	1.59E-05	8.90E-05	8.19E-06	2.51E-06	1.05E-05	5.41E-05	2.64E-10	1.02E-04
Isobutylbenzene	1.05E-07	4.22E-07	4.21E-07	6.01E-06	2.83E-06	1.27E-05	ND	ND	ND	6.12E-06	8.17E-12	1.31E-05
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	2.06E-05	8.31E-06	2.74E-05	4.84E-04	6.39E-05	6.21E-04	5.27E-05	2.87E-05	8.47E-05	5.57E-04	4.98E-09	7.33E-04
m-Tolualdehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methacrolein	ND	ND	ND	6.09E-06	3.89E-06	1.02E-05	4.10E-06	7.10E-06	1.23E-05	1.02E-05	6.55E-11	2.25E-05
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	1.26E-05	2.18E-05	3.77E-05	1.26E-05	4.74E-10	3.77E-05
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	4.40E-07	7.23E-07	1.76E-06	2.87E-06	4.97E-06	8.60E-06	3.31E-06	2.52E-11	1.04E-05
Naphthalene	8.58E-06	5.09E-06	1.22E-05	1.48E-04	3.33E-05	2.39E-04	1.59E-05	5.38E-06	2.20E-05	1.73E-04	1.16E-09	2.73E-04
Nitrobenzene	ND	ND	ND	3.36E-07	6.71E-07	1.34E-06	ND	ND	ND	3.36E-07	4.50E-13	1.34E-06
Nonane	8.41E-06	6.61E-06	1.28E-05	1.48E-04	2.07E-05	2.10E-04	1.61E-05	1.27E-05	3.04E-05	1.72E-04	6.33E-10	2.53E-04
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	1.10E-07	4.42E-07	4.41E-07	6.11E-05	1.67E-05	9.98E-05	1.05E-05	1.01E-05	2.02E-05	7.17E-05	3.83E-10	1.21E-04
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	9.45E-06	3.74E-06	1.21E-05	2.41E-04	3.10E-05	3.15E-04	2.56E-05	1.61E-05	4.37E-05	2.76E-04	1.24E-09	3.71E-04
Octane	7.88E-06	5.76E-06	1.24E-05	1.82E-04	2.06E-05	2.38E-04	1.24E-05	7.40E-06	1.98E-05	2.02E-04	5.13E-10	2.70E-04
p-cymene	6.51E-06	6.42E-06	1.13E-05	3.40E-05	8.19E-06	5.87E-05	5.00E-06	4.74E-06	9.44E-06	4.55E-05	1.31E-10	7.95E-05
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.34E-05	1.15E-05	2.06E-05	3.48E-04	8.16E-05	5.65E-04	2.36E-04	3.02E-04	5.76E-04	5.97E-04	9.82E-08	1.16E-03
Propanal	ND	ND	ND	1.74E-06	1.51E-06	2.66E-06	ND	ND	ND	1.74E-06	2.27E-12	2.66E-06
Styrene	2.44E-06	1.91E-06	3.71E-06	2.57E-05	8.98E-06	4.97E-05	5.42E-06	5.05E-06	1.12E-05	3.36E-05	1.10E-10	6.46E-05
Tetradecane	2.80E-06	2.53E-06	4.28E-06	3.31E-05	7.40E-06	5.02E-05	2.36E-06	2.39E-06	4.79E-06	3.83E-05	6.69E-11	5.93E-05
Toluene	5.10E-05	2.10E-05	6.83E-05	1.20E-03	1.73E-04	1.58E-03	1.37E-04	7.92E-05	2.25E-04	1.39E-03	3.67E-08	1.87E-03
Tridecane	1.31E-05	7.28E-06	1.82E-05	9.61E-05	1.62E-05	1.29E-04	9.80E-06	4.37E-06	1.46E-05	1.19E-04	3.34E-10	1.61E-04
Undecane	4.62E-05	3.27E-05	7.23E-05	2.89E-04	5.78E-05	4.44E-04	3.75E-05	2.68E-05	6.68E-05	3.72E-04	5.13E-09	5.83E-04
Valeraldehyde	ND	ND	ND	6.66E-06	4.21E-06	1.14E-05	ND	ND	ND	6.66E-06	1.77E-11	1.14E-05
Total POMs	1.66E-05		2.47E-05	2.89E-04		5.64E-04	2.01E-05		3.06E-05	3.25E-04		6.19E-04

Notes:
ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

Table D.5. Pouring, Cooling, and Shakeout HAP Emission Factors from Blocks (1, 2, 3)
Average Lb / Ton Mold Sand

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetaldehyde	5.28E-05	4.14E-05	7.49E-05	6.28E-04	9.40E-05	8.69E-04	8.74E-05	2.76E-05	1.14E-04	7.68E-04	1.06E-04	1.06E-03
Acetophenone	ND	ND	ND	4.13E-05	7.55E-05	1.65E-04	ND	ND	ND	4.13E-05	7.55E-05	1.65E-04
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	3.93E-04	3.20E-04	6.23E-04	6.65E-03	7.40E-04	8.53E-03	5.14E-04	2.46E-04	7.66E-04	7.56E-03	8.43E-04	9.92E-03
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	7.26E-07	6.02E-07	1.46E-06	3.63E-06	1.33E-06	7.51E-06	1.68E-06	6.90E-07	2.61E-06	6.04E-06	1.62E-06	1.16E-05
Chromium	7.85E-06	4.19E-06	1.11E-05	4.11E-05	4.63E-06	5.33E-05	1.97E-05	1.26E-05	4.03E-05	6.86E-05	1.40E-05	1.05E-04
Copper	9.24E-06	6.18E-06	1.41E-05	3.32E-05	1.13E-05	7.28E-05	1.41E-05	6.28E-06	2.42E-05	5.65E-05	1.43E-05	1.11E-04
Cumene	1.07E-06	1.97E-06	2.38E-06	2.31E-05	5.10E-06	3.74E-05	ND	ND	ND	2.42E-05	5.47E-06	3.98E-05
Dibenzofuran	ND	ND	ND	3.04E-06	2.05E-06	1.00E-05	ND	ND	ND	3.04E-06	2.05E-06	1.00E-05
Ethylbenzene	1.82E-05	8.80E-06	2.48E-05	3.60E-04	4.45E-05	4.52E-04	4.50E-05	1.98E-05	6.63E-05	4.23E-04	4.94E-05	5.43E-04
Formaldehyde	2.46E-05	3.84E-05	4.67E-05	3.35E-04	5.95E-05	5.22E-04	9.72E-05	9.69E-05	2.07E-04	4.57E-04	1.20E-04	7.76E-04
Lead	3.02E-05	4.39E-05	6.88E-05	3.82E-05	9.70E-06	7.77E-05	8.39E-06	3.04E-06	1.11E-05	7.68E-05	4.51E-05	1.58E-04
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	7.62E-05	4.31E-05	1.09E-04	1.45E-03	1.67E-04	1.80E-03	1.76E-04	6.00E-05	2.36E-04	1.70E-03	1.82E-04	2.14E-03
Manganese	1.41E-04	1.88E-04	2.88E-04	9.36E-05	2.78E-05	1.91E-04	3.24E-05	1.74E-05	6.59E-05	2.67E-04	1.91E-04	5.44E-04
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	3.50E-05	6.06E-05	1.05E-04	3.50E-05	6.06E-05	1.05E-04
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	3.25E-05	2.37E-05	4.88E-05	4.65E-04	1.25E-04	7.44E-04	5.80E-05	2.63E-05	8.79E-05	5.55E-04	1.30E-04	8.81E-04
Nitrobenzene	ND	ND	ND	9.35E-07	1.87E-06	3.74E-06	ND	ND	ND	9.35E-07	1.87E-06	3.74E-06
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	3.07E-07	1.23E-06	1.23E-06	1.73E-04	4.66E-05	2.82E-04	4.19E-05	4.05E-05	8.08E-05	2.16E-04	6.18E-05	3.64E-04
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	3.44E-05	1.84E-05	4.84E-05	7.29E-04	9.18E-05	9.35E-04	8.46E-05	3.54E-05	1.22E-04	8.48E-04	1.00E-04	1.10E-03
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	5.13E-05	4.70E-05	8.24E-05	1.04E-03	2.37E-04	1.63E-03	9.41E-04	1.21E-03	2.30E-03	2.04E-03	1.23E-03	4.01E-03
Propanal	ND	ND	ND	7.85E-06	6.80E-06	1.20E-05	ND	ND	ND	7.85E-06	6.80E-06	1.20E-05
Selenium	ND	ND	ND	7.63E-07	9.34E-07	4.58E-06	ND	ND	ND	7.63E-07	9.34E-07	4.58E-06
Styrene	9.53E-06	7.86E-06	1.48E-05	8.52E-05	3.47E-05	1.63E-04	1.71E-05	1.23E-05	3.13E-05	1.12E-04	3.77E-05	2.09E-04
Toluene	1.90E-04	1.06E-04	2.73E-04	3.60E-03	4.66E-04	4.61E-03	4.55E-04	1.70E-04	6.26E-04	4.24E-03	5.08E-04	5.51E-03
Total POMs	6.39E-05		9.84E-05	8.91E-04		1.72E-03	7.48E-05		1.22E-04	1.03E-03		1.94E-03

Table D.6. Pouring, Cooling, and Shakeout HAP Emission Factors from Blocks (1, 2, 3)
Average Lb / Ton Core Sand

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetaldehyde	5.07E-04	3.27E-04	6.93E-04	6.97E-03	6.84E-04	8.90E-03	8.08E-04	2.55E-04	1.05E-03	8.29E-03	8.00E-04	1.06E-02
Acetophenone	ND	ND	ND	3.55E-04	6.15E-04	1.42E-03	ND	ND	ND	3.55E-04	6.15E-04	1.42E-03
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	3.80E-03	2.63E-03	5.76E-03	8.21E-02	1.03E-02	1.10E-01	5.80E-03	3.98E-03	1.02E-02	9.17E-02	1.14E-02	1.26E-01
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	8.70E-06	1.16E-05	1.57E-05	4.56E-05	1.77E-05	8.79E-05	1.27E-04	7.92E-05	2.65E-04	1.81E-04	8.20E-05	3.69E-04
Chromium	8.28E-05	3.78E-05	1.05E-04	4.49E-04	6.27E-05	6.09E-04	9.50E-04	5.43E-04	1.84E-03	1.48E-03	5.48E-04	2.55E-03
Copper	9.67E-05	6.73E-05	1.35E-04	3.27E-04	1.28E-04	6.61E-04	9.18E-04	5.30E-04	1.82E-03	1.34E-03	5.49E-04	2.61E-03
Cumene	9.93E-06	1.82E-05	2.20E-05	2.79E-04	5.37E-05	4.34E-04	ND	ND	ND	2.89E-04	5.66E-05	4.56E-04
Dibenzofuran	ND	ND	ND	4.06E-05	2.73E-05	1.34E-04	ND	ND	ND	4.06E-05	2.73E-05	1.34E-04
Ethylbenzene	1.85E-04	6.05E-05	2.29E-04	4.33E-03	4.88E-04	5.46E-03	5.07E-04	3.35E-04	8.85E-04	5.03E-03	5.95E-04	6.58E-03
Formaldehyde	2.28E-04	3.55E-04	4.31E-04	3.94E-03	7.82E-04	6.36E-03	8.98E-04	8.96E-04	1.92E-03	5.07E-03	1.24E-03	8.70E-03
Lead	3.91E-04	5.15E-04	7.16E-04	3.38E-04	1.09E-04	6.51E-04	3.96E-04	2.30E-04	7.89E-04	1.13E-03	5.75E-04	2.16E-03
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	7.60E-04	3.05E-04	1.01E-03	1.80E-02	2.38E-03	2.31E-02	1.95E-03	1.07E-03	3.15E-03	2.07E-02	2.63E-03	2.72E-02
Manganese	1.70E-03	1.93E-03	2.86E-03	1.06E-03	3.49E-04	1.92E-03	2.19E-03	1.53E-03	4.74E-03	4.96E-03	2.49E-03	9.52E-03
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	4.67E-04	8.09E-04	1.40E-03	4.67E-04	8.09E-04	1.40E-03
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	3.17E-04	1.87E-04	4.51E-04	5.49E-03	1.23E-03	8.85E-03	5.89E-04	1.98E-04	8.13E-04	6.39E-03	1.26E-03	1.01E-02
Nitrobenzene	ND	ND	ND	1.25E-05	2.50E-05	4.99E-05	ND	ND	ND	1.25E-05	2.50E-05	4.99E-05
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	4.10E-06	1.64E-05	1.64E-05	2.27E-03	6.22E-04	3.71E-03	3.87E-04	3.74E-04	7.47E-04	2.66E-03	7.26E-04	4.47E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	3.49E-04	1.38E-04	4.47E-04	8.93E-03	1.16E-03	1.17E-02	9.49E-04	6.01E-04	1.62E-03	1.02E-02	1.31E-03	1.38E-02
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	4.94E-04	4.25E-04	7.62E-04	1.29E-02	3.03E-03	2.10E-02	8.70E-03	1.12E-02	2.13E-02	2.21E-02	1.16E-02	4.30E-02
Propanal	ND	ND	ND	6.37E-05	5.52E-05	9.78E-05	ND	ND	ND	6.37E-05	5.52E-05	9.78E-05
Selenium	ND	ND	ND	2.04E-05	1.77E-05	6.11E-05	ND	ND	ND	2.04E-05	1.77E-05	6.11E-05
Styrene	9.03E-05	7.03E-05	1.37E-04	9.51E-04	3.32E-04	1.84E-03	2.01E-04	1.88E-04	4.18E-04	1.24E-03	3.88E-04	2.40E-03
Toluene	1.89E-03	7.70E-04	2.52E-03	4.47E-02	6.45E-03	5.87E-02	5.07E-03	2.96E-03	8.36E-03	5.16E-02	7.14E-03	6.96E-02
Total POMs	6.14E-04		9.10E-04	1.07E-02		2.09E-02	7.44E-04		1.13E-03	1.21E-02		2.30E-02

ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK

Table D.7. Pouring, Cooling, and Shakeout HAP Emission Factors from Blocks (1, 2, 3)
Average Lb / Ton Seacoal

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetaldehyde	1.06E-03	8.28E-04	1.50E-03	1.26E-02	1.88E-03	1.74E-02	1.75E-03	5.52E-04	2.27E-03	1.54E-02	2.13E-03	2.12E-02
Acetophenone	ND	ND	ND	8.26E-04	1.51E-03	3.31E-03	ND	ND	ND	8.26E-04	1.51E-03	3.31E-03
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	7.86E-03	6.40E-03	1.25E-02	1.33E-01	1.48E-02	1.71E-01	1.03E-02	4.92E-03	1.53E-02	1.51E-01	1.69E-02	1.98E-01
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	1.45E-05	1.20E-05	2.93E-05	7.25E-05	2.67E-05	1.50E-04	3.37E-05	1.38E-05	5.23E-05	1.21E-04	3.24E-05	2.32E-04
Chromium	1.57E-04	8.38E-05	2.21E-04	8.21E-04	9.26E-05	1.07E-03	3.94E-04	2.52E-04	8.07E-04	1.37E-03	2.81E-04	2.09E-03
Copper	1.85E-04	1.23E-04	2.83E-04	6.65E-04	2.26E-04	1.46E-03	2.81E-04	1.25E-04	4.83E-04	1.13E-03	2.86E-04	2.22E-03
Cumene	2.15E-05	3.93E-05	4.76E-05	4.63E-04	1.02E-04	7.48E-04	ND	ND	ND	4.84E-04	1.09E-04	7.95E-04
Dibenzofuran	ND	ND	ND	6.08E-05	4.09E-05	2.01E-04	ND	ND	ND	6.08E-05	4.09E-05	2.01E-04
Ethylbenzene	3.65E-04	1.76E-04	4.95E-04	7.19E-03	8.89E-04	9.05E-03	9.00E-04	3.96E-04	1.33E-03	8.46E-03	9.89E-04	1.09E-02
Formaldehyde	4.92E-04	7.67E-04	9.33E-04	6.70E-03	1.19E-03	1.04E-02	1.94E-03	1.94E-03	4.14E-03	9.13E-03	2.40E-03	1.55E-02
Lead	6.05E-04	8.78E-04	1.38E-03	7.64E-04	1.94E-04	1.55E-03	1.68E-04	6.09E-05	2.22E-04	1.54E-03	9.01E-04	3.15E-03
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	1.52E-03	8.61E-04	2.19E-03	2.89E-02	3.33E-03	3.60E-02	3.53E-03	1.20E-03	4.72E-03	3.40E-02	3.65E-03	4.29E-02
Manganese	2.82E-03	3.76E-03	5.76E-03	1.87E-03	5.56E-04	3.81E-03	6.48E-04	3.47E-04	1.32E-03	5.34E-03	3.82E-03	1.09E-02
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	7.00E-04	1.21E-03	2.10E-03	7.00E-04	1.21E-03	2.10E-03
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	6.50E-04	4.74E-04	9.75E-04	9.29E-03	2.50E-03	1.49E-02	1.16E-03	5.26E-04	1.76E-03	1.11E-02	2.60E-03	1.76E-02
Nitrobenzene	ND	ND	ND	1.87E-05	3.74E-05	7.48E-05	ND	ND	ND	1.87E-05	3.74E-05	7.48E-05
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	6.14E-06	2.46E-05	2.46E-05	3.47E-03	9.33E-04	5.63E-03	8.37E-04	8.10E-04	1.62E-03	4.31E-03	1.24E-03	7.27E-03
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	6.87E-04	3.68E-04	9.67E-04	1.46E-02	1.84E-03	1.87E-02	1.69E-03	7.09E-04	2.43E-03	1.70E-02	2.00E-03	2.21E-02
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.03E-03	9.40E-04	1.65E-03	2.09E-02	4.74E-03	3.26E-02	1.88E-02	2.41E-02	4.60E-02	4.07E-02	2.46E-02	8.03E-02
Propanal	ND	ND	ND	1.57E-04	1.36E-04	2.41E-04	ND	ND	ND	1.57E-04	1.36E-04	2.41E-04
Selenium	ND	ND	ND	1.53E-05	1.87E-05	9.16E-05	ND	ND	ND	1.53E-05	1.87E-05	9.16E-05
Styrene	1.90E-04	1.57E-04	2.96E-04	1.70E-03	6.94E-04	3.25E-03	3.43E-04	2.46E-04	6.27E-04	2.24E-03	7.53E-04	4.18E-03
Toluene	3.80E-03	2.12E-03	5.45E-03	7.20E-02	9.33E-03	9.22E-02	9.11E-03	3.41E-03	1.25E-02	8.49E-02	1.02E-02	1.10E-01
Total POMs	1.28E-03		1.97E-03	1.78E-02		3.44E-02	1.50E-03		2.45E-03	2.06E-02		3.88E-02

Table D.8. Pouring, Cooling, and Shakeout HAP Emission Factors from Blocks (1, 2, 3)
Average Lb / Lb Resin

	Pouring			Cooling			Shakeout			Totals		
Analyte Name	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**	**Avg**	**Std Dev**	**Max**
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylene Bis (2-Chloroaniline)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-Methylenedianiline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetaldehyde	1.37E-05	8.89E-06	1.88E-05	1.88E-04	1.86E-05	2.41E-04	2.19E-05	6.92E-06	2.84E-05	2.24E-04	4.73E-10	2.88E-04
Acetophenone	ND	ND	ND	9.65E-06	1.68E-05	3.86E-05	ND	ND	ND	9.65E-06	2.81E-10	3.86E-05
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1.03E-04	7.14E-05	1.56E-04	2.21E-03	2.76E-04	2.97E-03	1.56E-04	1.07E-04	2.75E-04	2.47E-03	9.29E-08	3.40E-03
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	2.31E-07	3.09E-07	4.22E-07	1.23E-06	4.84E-07	2.36E-06	3.21E-06	2.26E-06	7.18E-06	4.67E-06	5.43E-12	9.97E-06
Chromium	2.22E-06	1.10E-06	2.82E-06	1.21E-05	1.68E-06	1.64E-05	2.43E-05	1.54E-05	5.03E-05	3.86E-05	2.43E-10	6.96E-05
Copper	2.60E-06	1.88E-06	3.66E-06	8.82E-06	3.45E-06	1.78E-05	2.33E-05	1.51E-05	4.94E-05	3.47E-05	2.42E-10	7.09E-05
Cumene	2.69E-07	4.90E-07	5.97E-07	7.53E-06	1.45E-06	1.17E-05	ND	ND	ND	7.80E-06	2.35E-12	1.23E-05
Dibenzofuran	ND	ND	ND	1.09E-06	7.35E-07	3.60E-06	ND	ND	ND	1.09E-06	5.40E-13	3.60E-06
Ethylbenzene	5.00E-06	1.65E-06	6.20E-06	1.17E-04	1.31E-05	1.47E-04	1.37E-05	8.97E-06	2.38E-05	1.35E-04	2.56E-10	1.77E-04
Formaldehyde	6.17E-06	9.61E-06	1.17E-05	1.06E-04	2.10E-05	1.71E-04	2.43E-05	2.43E-05	5.19E-05	1.37E-04	1.12E-09	2.35E-04
Lead	1.06E-05	1.40E-05	1.94E-05	9.12E-06	2.91E-06	1.75E-05	1.02E-05	6.59E-06	2.17E-05	2.98E-05	2.48E-10	5.85E-05
m,p-Cresol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	2.06E-05	8.31E-06	2.74E-05	4.84E-04	6.39E-05	6.21E-04	5.27E-05	2.87E-05	8.47E-05	5.57E-04	4.98E-09	7.33E-04
Manganese	4.60E-05	5.21E-05	7.70E-05	2.84E-05	9.39E-06	5.16E-05	5.59E-05	4.32E-05	1.30E-04	1.30E-04	4.66E-09	2.58E-04
Methyl Ethyl Ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Methacrylate	ND	ND	ND	ND	ND	ND	1.26E-05	2.18E-05	3.77E-05	1.26E-05	4.74E-10	3.77E-05
N,N-Dimethylaniline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodimethylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	8.58E-06	5.09E-06	1.22E-05	1.48E-04	3.33E-05	2.39E-04	1.59E-05	5.38E-06	2.20E-05	1.73E-04	1.16E-09	2.73E-04
Nitrobenzene	ND	ND	ND	3.36E-07	6.71E-07	1.34E-06	ND	ND	ND	3.36E-07	4.50E-13	1.34E-06
o-Anisidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Cresol	1.10E-07	4.42E-07	4.41E-07	6.11E-05	1.67E-05	9.98E-05	1.05E-05	1.01E-05	2.02E-05	7.17E-05	3.83E-10	1.21E-04
o-Toluidine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	9.45E-06	3.74E-06	1.21E-05	2.41E-04	3.10E-05	3.15E-04	2.56E-05	1.61E-05	4.37E-05	2.76E-04	1.24E-09	3.71E-04
p-Phenylenediamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.34E-05	1.15E-05	2.06E-05	3.48E-04	8.16E-05	5.65E-04	2.36E-04	3.02E-04	5.76E-04	5.97E-04	9.82E-08	1.16E-03
Propanal	ND	ND	ND	1.74E-06	1.51E-06	2.66E-06	ND	ND	ND	1.74E-06	2.27E-12	2.66E-06
Selenium	ND	ND	ND	5.48E-07	4.71E-07	1.64E-06	ND	ND	ND	5.48E-07	2.22E-13	1.64E-06
Styrene	2.44E-06	1.91E-06	3.71E-06	2.57E-05	8.98E-06	4.97E-05	5.42E-06	5.05E-06	1.12E-05	3.36E-05	1.10E-10	6.46E-05
Toluene	5.10E-05	2.10E-05	6.83E-05	1.20E-03	1.73E-04	1.58E-03	1.37E-04	7.92E-05	2.25E-04	1.39E-03	3.67E-08	1.87E-03
Total POMs	1.66E-05		2.47E-05	2.89E-04		5.64E-04	2.01E-05		3.06E-05	3.25E-04		6.19E-04

ND = not detected
Blank Spaces = not sampled

THIS PAGE INTENTIONALLY LEFT BLANK