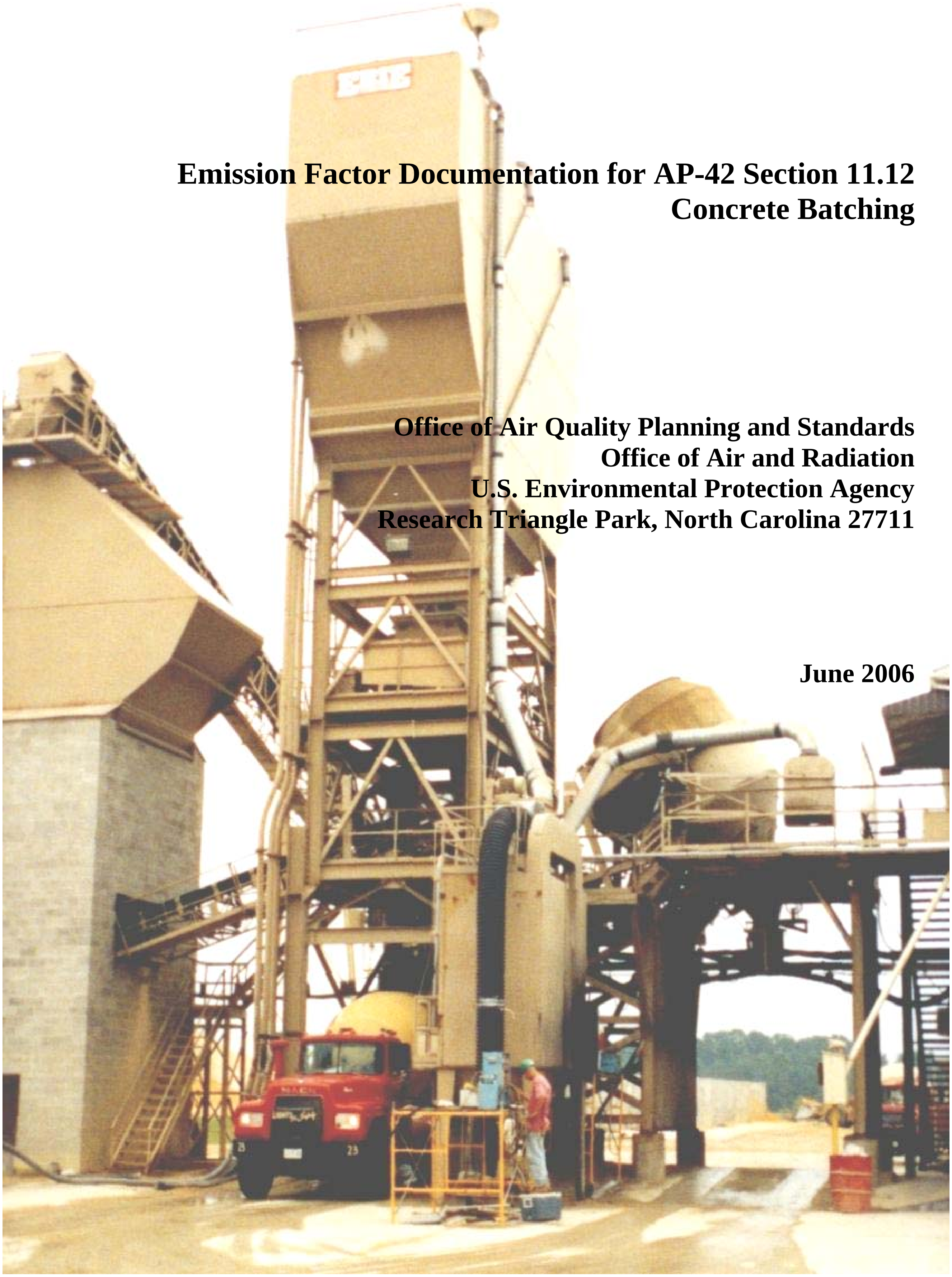

Emission Factor Documentation for AP-42 Section 11.12
Concrete Batching

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1. INTRODUCTION

The document “Compilation of Air Pollutant Emissions Factors” (AP-42) has been published by the U.S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by EPA to respond to new emission factor needs of EPA, state and local air pollution control programs and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. With differing levels of accuracy, the uses of the emission factors reported in AP-42 include:

- Estimates of area-wide emissions;
- Estimates of emissions from a specific facility; and
- Evaluation of emissions relative to ambient air quality.

The purpose of this report is to document the development of the emission factors presented in AP-42 Section 11.12 Concrete Batching.

2. AP-42 DESCRIPTION OF THE CONCRETE BATCHING INDUSTRY

AP-42 11.12-1 Process Description [1-5]

Concrete is composed essentially of water, cement, sand (fine aggregate) and coarse aggregate. Coarse aggregate may consist of gravel, crushed stone or iron blast furnace slag. Some specialty aggregate products could be either heavyweight aggregate (of barite, magnetite, limonite, ilmenite, iron or steel) or lightweight aggregate (with sintered clay, shale, slate, diatomaceous shale, perlite, vermiculite, slag pumice, cinders, or sintered fly ash). Supplementary cementitious materials, also called mineral admixtures or pozzolan minerals may be added to make the concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Typical examples are natural pozzolans, fly ash, ground granulated blast-furnace slag, and silica fume, which can be used individually with portland or blended cement or in different combinations. Chemical admixtures are usually liquid ingredients that are added to concrete to entrain air, reduce the water required to reach a required slump, retard or accelerate the setting rate, to make the concrete more flowable or other more specialized functions.

Approximately 75 percent of the U.S. concrete manufactured is produced at plants that store, convey, measure and discharge these constituents into trucks for transport to a job site. At most of these plants, sand, aggregate, cement and water are all gravity fed from the weight hopper into the mixer trucks. The concrete is mixed on the way to the site where the concrete is to be poured. At some of these plants, the concrete may also be manufactured in a central mix drum and transferred to a transport truck. Most of the remaining concrete manufactured are products cast in a factory setting. Precast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding. Concrete masonry, another type of manufactured concrete, may be best known for its conventional 8 x 8 x 16-inch block. In a few cases concrete is dry batched or prepared at a building construction site. Figure 11.12-1 is a generalized process diagram for concrete batching.

The raw materials can be delivered to a plant by rail, truck or barge. The cement is transferred to elevated storage silos pneumatically or by bucket elevator. The sand and coarse aggregate are transferred to elevated bins by front end loader, clam shell crane, belt conveyor, or bucket elevator. From these elevated bins, the constituents are fed by gravity or screw conveyor to weigh hoppers, which combine the proper amounts of each material.

11.12-2 Emissions and Controls [6-8]

Particulate matter, consisting primarily of cement and pozzolan dust but including some aggregate and sand dust emissions, is the primary pollutant of concern. In addition, there are emissions of metals that are associated with this particulate matter. All but one of the emission points are fugitive in nature. The only point sources are the transfer of cement and pozzolan material to silos, and these are usually vented to a fabric filter or “sock”. Fugitive sources include the transfer of sand and aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion from sand and aggregate storage piles. The amount of fugitive emissions generated during the transfer of sand and aggregate depends primarily on the surface moisture content of these materials. The extent of fugitive emission control varies widely from plant to plant. Particulate emission factors for concrete batching are give in Tables 11.12-1 and 11.12-2.

Types of controls used may include water sprays, enclosures, hoods, curtains, shrouds, movable and telescoping chutes, central duct collection systems, and the like. A major source of potential emissions, the movement of heavy trucks over unpaved or dusty surfaces in and around the plant, can be controlled by good maintenance and wetting of the road surface.

Predictive equations that allow for emission factor adjustment based on plant specific conditions are given in the Background Document for Chapter 11.12 and Chapter 13. Whenever plant specific data are available, they should be used with these predictive equations (e.g. Equations 11.12-1 through 11.12-3) in lieu of the general fugitive emission factors presented in Table 11.12-1, 11.12-2, and 11.12-5 through11.12-8 in order to adjust to site specific conditions, such as moisture levels and localized wind speeds.

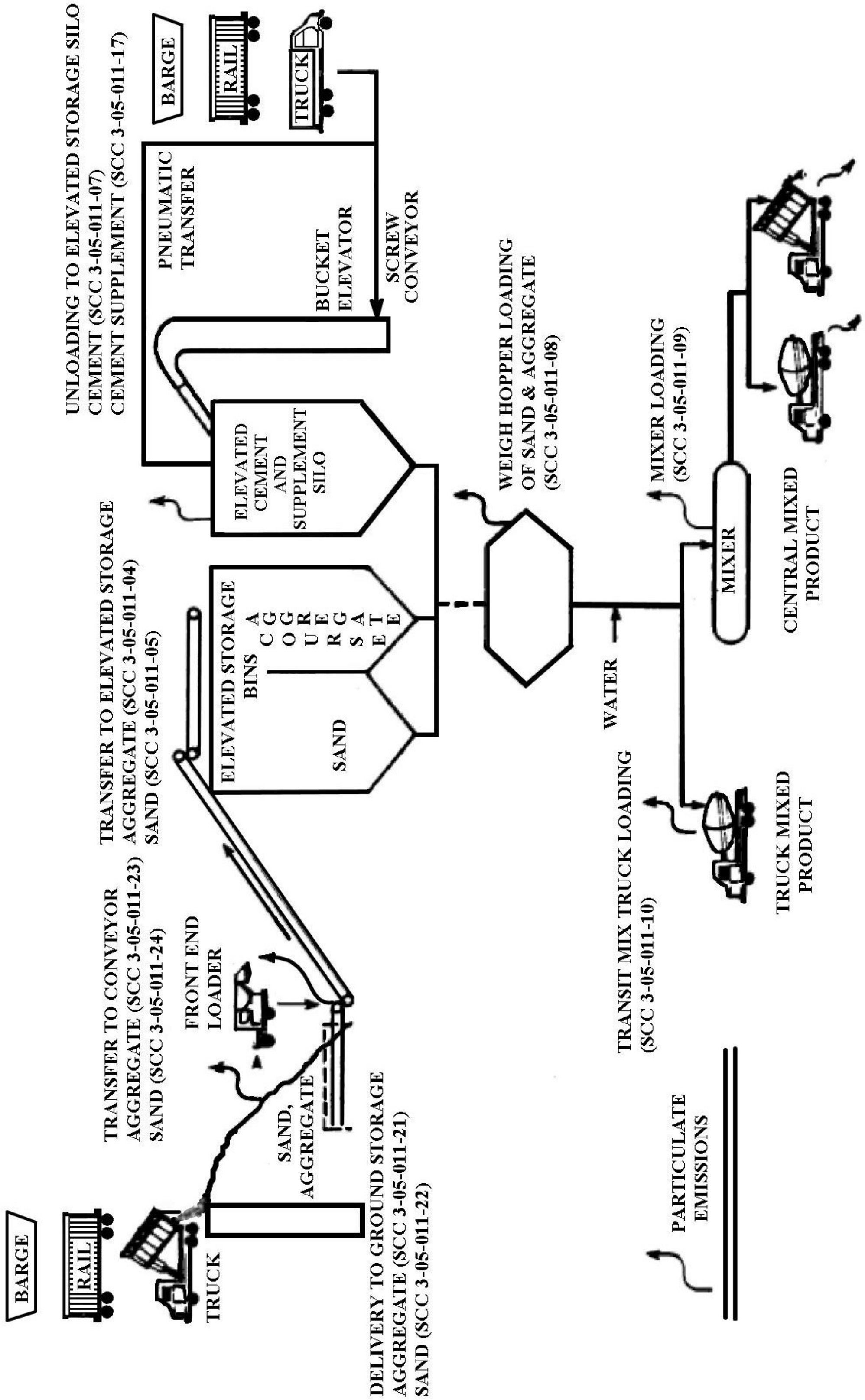

Figure 11.12-1. Typical Concrete Batching Process.

References for Section 11.12

1. *Air Pollutant Emission Factors*, APTD-0923, U.S. Environmental Protection Agency, Research Triangle Park, NC, April 1970

2. *Air Pollution Engineering Manual*, 2nd Edition, AP-40, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1974. Out of Print.

3. Telephone and written communication between Edwin A. Pfetzing, PEDCo Environmental., Inc., Cincinnati, OH, and Richards Morris and Richard Meininger, National Ready Mix Concrete Association, Silver Spring, MD, May 1984.

4. *Development Document for Effluent Limitations Guidelines and Standards of Performance, The Concrete Products Industries, Draft*, U.S. Environmental Protection Agency, Washington, DC, August 1975.

5. Portland Cement Association. (2001). Concrete Basics. Retrieved August 27, 2001 from the World Wide Web: http://www.portcement.org/cb/

6. *Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions*, EPA-450/3-77-010, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1977

7. *Fugitive Dust Assessment at Rock and Sand Facilities in the South Coast Air Basin*, Southern California Rock Products Association and Southern California Ready Mix Concrete Association, Santa Monica, CA, November 1979.

8. Telephone communication between T.R. Blackwood, Monsanto Research Corp., Dayton, OH, and John Zoller, PEDCo Environmental, Inc., Cincinnati, OH, October 18, 1976.

9. *Final Test Report for USEPA* [sic] *Test Program Conducted at Chaney Enterprises Cement Plant*, ETS, Inc., Roanoke, VA April 1994

10. *Final Test Report for USEPA* [sic] *Test Program Conducted at Concrete Ready Mixed Corporation*, ETS, Inc., Roanoke, VA April 1994

11. *Emission Test for Tiberi Engineering Company*, Alar Engineering Corporation, Burbank, IL, October, 1972.

12. *Stack Test "Confidential"* (Test obtained from State of Tennessee), Environmental Consultants, Oklahoma City, OK, February 1976.

13. Source Sampling Report, Particulate Emissions from Cement Silo Loading, Specialty Alloys Corporation, Gallaway, Tennessee, Reference number 24-00051-02, State of Tennessee, Department of Health and Environment, Division of Air Pollution Control, June 12, 1984.

14. Richards, J. and T. Brozell. "*Ready Mixed Concrete Emission Factors, Final Report*" Report to the Ready Mixed Concrete Research Foundation, Silver Spring, Maryland. August 2004.

3. QUALITY RATING SYSTEMS

3.1 Emission Data Quality System

The rating system specified by the Emission Factor and Inventory Group (EFIG) for preparing AP-42 sections was used as a general guide in rating the emission data used in this report. The rating system is as follows:

A Multiple tests that were preformed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in EPA reference test methods, although these methods were used as a guide for the methodology actually used.

B Tests that were preformed by a generally sound methodology but lack enough detail for adequate validation.

C Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.
2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted method, the deviations are well documented. When this occurred, an evaluation was made of the extent to which such alternative procedures could influence the test results
3. Sampling and process data. Adequate sampling and process data are documented in the report, and any variations in the sampling and process operations are noted. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and were given a lower rating.
4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculation was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the report.

3.2 Emission Factor Quality Rating System

The quality rating of each of the final emission factors was guided by the following general criteria:

A Excellent: Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized

B Above Average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. The source category is specific enough so that variability within the source category population may be minimized.

C Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D Below Average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

References for Section 3

1. *Procedures for Preparing Emission Factor Documents*, EPA-454/R-95-015, Office of Air Quality Planning Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1997.

4. EMISSION FACTOR DEVELOPMENT

Six emission test reports were used to develop emission factors for AP-42 Section 11.12, Concrete Batching. Two of the tests (References 1 and 2) were sponsored by EPA in order to add PM_{10} emission factors and to improve the quality of the other concrete batching emission factors. The third test report (Reference 3) was produced by a company that sold a control device for silo filling operations. The fourth test report (Reference 4) was produced by a consulting firm to determine whether a facility was in compliance with Oklahoma regulations. The fifth test report (Reference 5) was produced by a State agency to evaluate the performance of a non commercial silo filling emissions control device. Information from AP-42 Section 13.2.4, *Aggregate Handling And Storage Piles* was used to provide the basis for material transfer operations that occur at but were not measured at concrete batch plants. The sixth set of test reports (Reference 6) were sponsored by The Ready Mixed Concrete Research Foundation (RMC Research Foundation) at six ready mixed concrete facilities located in North Carolina, Virginia, and South Carolina. The purpose of the RMC Research Foundation project was to improve concrete batching plant emissions factors for total particulate matter, PM_{10}, $PM_{10-2.5}$, $PM_{2.5}$, and arsenic from truck mix and central mix process operations at ready mixed concrete plants.

4.1 Reference 1

This report (Reference 1 presents the results of emission testing on a typical concrete batching operation performed at Chaney Enterprises in Waldorf, Maryland. This reference includes measurements of the amounts of PM, PM_{10} and then select metals that were released during truck mix loadings, central mix loadings, and silo fillings. In addition, tests were conducted on process material samples and road surface samples.

Several kinds of tests and test methods were used:

- EPA Reference Test Method 201A was used to collect emissions released during the truck loadings and the silo fillings. In addition to the usual recovering and weighing of collected PM_{10}, larger particulate (greater than ten micrometers) collected in the probe and the cyclone was also recovered and weighed.
- Sieve and moisture analyses were conducted on the process materials (aggregates) and the road materials.
- Laboratory tests were conducted on the emissions collected during the tests as well as the material collected for the sieve analysis to determine the amount of each of the ten metals that were contained in these materials.

Emissions resulting from the truck mix and central mix loadings were controlled with a shroud connected to a centrally located pulse-jet type baghouse (C & W Model No. RA 140-S). In order to develop both controlled and uncontrolled emission factors, tests were conducted at both the inlet and outlet of the dust collector. Also, visual estimates of the capture efficiency of the control device were made during the individual truck mix loadings and central mix operations. This information made it possible to estimate the emission not captured during the test.

Emissions due to the loading of silos were also controlled by the central dust collector. As a consequence of the frequency of the truck loadings, only one test run captured emissions due solely to silo fillings. In the other silo emission tests, an attempt was made to subtract out the emissions from the truck loadings. Unfortunately, the resulting values are significantly different from the silo only emission test and therefore are not used for emission factor development.

Most of the emission data that were used to develop the controlled and the uncontrolled PM and PM_{10} emission factors for truck mix loading and central mix loading warrant an A rating. However, the methodology used to estimate the capture efficiencies of the control device is qualitative rather than quantitative. This issue is significant since the uncontrolled and controlled emission factors for truck loading depend significantly on the capture efficiency estimates. Due to the subjective nature of the capture efficiency estimates, the emission data set for the truck loading emission factors is **rated B**.

The emission data from run number 7 that were used to develop the usable controlled and uncontrolled, PM, PM_{10} and metal emission factors for cement silo fillings are generally of the same quality as the aforementioned test data. However, since only one test run was used to develop each of these emission factor types, this test data set is **rated C**

The data sets used to develop the emission factors for batching by central mixing are **rated A**, since the methodology used to collect the data was sound and the dependence on capture efficiency estimates are minimal.

The following tables present the data that were used to develop the emission factors for Reference 1 as well as the emission factors themselves (with the exception of the data and emission factors associated with traversing paved and unpaved roads and for loading aggregate and sand to elevated bins). The layouts of the tables make the methods used to develop these emission factors largely self-evident (see the technical notes in Appendix A for more information).

Note that “fines” stands for cement, cement supplement, and the silt from sand and course aggregate.

Reference 1
Emission Factor Tables

Tables	Emission Factor Types
1.1 - 1.3	PM_{10} Emission Factors
2.1 - 2.3	Controlled PM_{10} Emission Factors
3.1 - 3.3	PM Emission Factors
4.1 - 4.3	Controlled PM Emission Factors
5.1 - 5.5	Metal Emission Factors
6.1 - 6.5	Controlled Metal Emission Factors

Table 1.1

PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM-10 per hour IN INLET (lb)	TIME (min)	PM-10 IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM-10 (lb)	CONCRETE MADE (yd^3)	PM-10 per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lb Solid Raw Material (lb)	PM-10 per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING																	
RUN 2	4.013	30.2	2.020	72	2.805	41.5	0.06760	16,950	0.16551	12,250	0.09607	59,950	1,343.94	130,020	320.69	0.01280	0.09089
RUN 4	2.970	30.0	1.485	79	1.880	54.0	0.03481	27,840	0.06752	0	0.06752	73,600	1,649.94	173,150	427.07	0.00685	0.06283
RUN 9	1.588	30.1	0.797	78	1.021	69.0	0.01480	39,110	0.02611	0	0.02611	104,910	2,351.84	218,940	540.02	0.00281	0.02432
RUN 14	4.971	22.1	1.831	56	3.270	41.0	0.07975	19,180	0.17047	10,220	0.11121	54,120	1,213.24	127,300	313.99	0.01551	0.10572
RUN 15	4.477	30.0	2.239	64	3.498	59.5	0.05878	32,650	0.10713	3,100	0.09784	80,240	1,798.79	187,330	462.05	0.01153	0.09202
RUN 16	3.470	30.0	1.735	58	2.991	41.5	0.07208	22,010	0.13591	0	0.13591	57,510	1,289.24	133,660	329.67	0.01403	0.12660
AVG.				**68**			**0.05464**		0.11211		**0.08911**					0.01059	0.08373
STD. DEV.				**10**			**0.02490**		0.05698		**0.03805**					0.00482	0.03580
CENTRAL MIX LOADING																	
RUN 10	1.529	30.1	0.767	90	0.850	45.0	0.01890	16,280	0.05224	13,900	0.02818	68,130	1,527.32	143,470	353.87	0.00352	0.02652
RUN 11	1.622	30.2	0.816	84	0.972	49.8	0.01952	22,340	0.04351	8,870	0.03114	70,770	1,586.50	158,600	391.19	0.00373	0.02929
RUN 12	0.309	30.2	0.156	99	0.157	45.0	0.00349	22,130	0.00710	9,300	0.00500	59,080	1,324.44	141,640	349.36	0.00068	0.00475
RUN 13	3.422	29.9	1.705	99	1.723	44.0	0.03915	19,240	0.08953	8,770	0.06150	66,750	1,496.38	138,830	342.42	0.00737	0.05771
RUN 17	6.708	27.2	3.041	99	3.072	72.0	0.04266	30,950	0.09925	13,900	0.06849	104,850	2,350.49	228,760	564.24	0.00812	0.06431
AVG.				**94**			**0.02474**		0.05832		**0.03886**					0.00468	0.03651
STD. DEV.				**7**			**0.01614**		0.03718		**0.02603**					0.00306	0.02441

* AVG. % SILT CONTENT OF SAND :	**2.2418**	** AVG. % SILT CONTENT OF AGGREGATE :	**0.2467**

Table 1.2

PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM-10 per hour IN INLET (lb)	TIME (min)	PM-10 IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM-10 (lb)	CONCRETE MADE (yd³)	PM-10 per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	SILT FROM AGGR. (lb)	PM-10 per 1000 lb Solid Raw Material (lb)	PM-10 per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING & CEMENT SILO FILLING																	
RUN 1	8.655	56.8	8.193	71	11.548	95.0	0.12156	48,620	0.23752	11,240	0.19292	135,290	3,032.89	281,640	694.67	0.02422	0.18161
RUN 3	16.990	30.0	8.495	70	12.136	50.0	0.24271	27,880	0.43528	0	0.43528	67,530	1,513.87	157,500	388.47	0.04798	0.40748
RUN 8	17.574	27.8	8.143	72	11.309	27.0	0.41886	14,170	0.79811	0	0.79811	36,030	807.71	86,430	213.18	0.08277	0.74447
AVG.				**71**			0.26104		0.49030		0.47544					0.05166	**0.44452**
STD. DEV.				**1**			0.14950		0.28432		0.30459					0.02945	**0.28325**
CEMENT SILO FILLING																	
RUN 7	14.608	30.2	7.353	100	7.353			37,775	0.19465								
RUN 1 EST.					6.224			40,299	0.15444								
RUN 3 EST.					9.642			34,268	0.28138								
RUN 8 EST.					10.037			31,722	0.31641								
AVG.									**0.23672**								
STD. DEV.									**0.07502**								
TRUCK MIX LOADING & NEWCEM SILO FILLING																	
RUN 5	41.768	30.1	20.954	79	26.524	51.0	0.52007	11,340	2.33894	0	2.33894	26,550	595.19	158,280	390.40	0.13521	2.15191
RUN 18	23.287	29.9	11.605	65	17.853	5.0	3.57067	1,800	9.91854	2,380	4.27114	7,260	162.75	16,570	40.87	0.63739	4.07274
AVG.				**72**			2.04537		6.12874		3.30504					0.38630	**3.11233**
STD. DEV.				**10**			2.15710		5.35959		1.36627					0.35510	**1.35823**
NEWCEM SILO FILLING																	
RUN 5 EST.					25.492					30,096	0.84701						
RUN 18 EST.					17.486					39,276	0.44522						
AVG.											**0.64611**						
STD. DEV.											**0.28411**						

* AVG. % SILT CONTENT OF SAND : **2.2418**

** AVG. % SILT CONTENT OF AGGREGATE : **0.2467**

Table 1.3

PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM-10 per hour IN INLET (lb)	TIME (min)	PM-10 IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM-10 (lb)	CONCRETE MADE (yd^3)	PM-10 per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lb Solid Raw Material (lb)	PM-10 per 1000 lb ``FINES" (lb)
GENERAL SILO FILLING																	
RUN 7	14.608	30.2	7.353	100	7.353			37,775		0	0.19465						
RUN 1 EST.					6.224			40,299		0	0.15444						
RUN 3 EST.					9.642			34,268		0	0.28138						
RUN 5 EST.					25.492			0		30,096	0.84701						
RUN 8 EST.					10.037			31,722		0	0.31641						
RUN 18 EST.					17.486			0		39,276	0.44522						
AVG.											**0.37318**						
STD. DEV.											**0.25341**						

Table 2.1

CONTROLLED PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM-10 per hour IN INLET (lb)	PM-10 per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM-10 ESCAPED INLET (lb)	PM-10 OUT OUTLET (lb)	TOTAL PM-10 RELEASED (lb)	CONCRETE MADE (yd³)	PM-10 per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lbs Solid Raw Material (lb)	PM-10 per 1000 lbs ``FINES" (lb)
TRUCK MIX LOADING																			
RUN 2	4.013	0.00450	30.2	72	0.78551	0.00227	0.78777	41.5	0.01898	16,950	0.04648	12,250	0.02698	59,950	1,344	130,020	321	0.00359	0.02552
RUN 4	2.970	0.00450	30.0	79	0.39475	0.00225	0.39700	54.0	0.00735	27,840	0.01426	0	0.01426	73,600	1,650	173,150	427	0.00145	0.01327
RUN 9	1.588	0.00450	30.1	78	0.22470	0.00226	0.22695	69.0	0.00329	39,110	0.00580	0	0.00580	104,910	2,352	218,940	540	0.00063	0.00540
RUN 14	4.971	0.00450	22.1	56	1.43863	0.00166	1.44029	41.0	0.03513	19,180	0.07509	10,220	0.04899	54,120	1,213	127,300	314	0.00683	0.04657
RUN 15	4.477	0.00450	30.0	64	1.25916	0.00225	1.26141	59.5	0.02120	32,650	0.03863	3,100	0.03528	80,240	1,799	187,330	462	0.00416	0.03319
RUN 16	3.470	0.00450	30.0	58	1.25638	0.00225	1.25863	41.5	0.03033	22,010	0.05718	0	0.05718	57,510	1,289	133,660	330	0.00590	0.05327
AVG.				**68**					**0.01938**		0.03958		**0.03142**					0.00376	0.02954
STD. DEV.				**10**					**0.01245**		0.02608		**0.01979**					0.00242	0.01860
CENTRAL MIX LOADING																			
RUN 10	1.529	0.00450	30.1	90	0.08334	0.00226	0.08560	45.0	0.00190	16,280	0.00526	13,900	0.00284	68,130	1,527	143,470	354	0.00035	0.00267
RUN 11	1.622	0.00450	30.2	84	0.15551	0.00227	0.15777	49.8	0.00317	22,340	0.00706	8,870	0.00506	70,770	1,586	158,600	391	0.00061	0.00475
RUN 12	0.309	0.00450	30.2	99	0.00157	0.00227	0.00384	45.0	0.00009	22,130	0.00017	9,300	0.00012	59,080	1,324	141,640	349	0.00002	0.00012
RUN 13	3.422	0.00450	29.9	99	0.01723	0.00224	0.01947	44.0	0.00044	19,240	0.00101	8,770	0.00070	66,750	1,496	138,830	342	0.00008	0.00065
RUN 17	6.708	0.00450	27.2	99	0.03072	0.00204	0.03276	72.0	0.00045	30,950	0.00106	13,900	0.00073	104,850	2,350	228,760	564	0.00009	0.00069
AVG.				**94**					**0.00121**		0.00291		**0.00189**					0.00023	0.00178
STD. DEV.				**7**					**0.00130**		0.00305		**0.00205**					0.00025	0.00193

* AVG. % SILT CONTENT OF SAND **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE : **0.24665**

Table 2.2

CONTROLLED PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

	PM-10 per hour IN INLET (lb)	PM-10 per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM-10 ESCAPED INLET (lb)	PM-10 OUT OUTLET (lb)	TOTAL PM-10 RELEASED (lb)	CONCRETE MADE (yd^3)	PM-10 per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lbs Solid Raw Material (lb)	PM-10 per 1000 lbs ``FINES" (lb)
TRUCK MIX LOADING & CEMENT SILO FILLING																			
RUN 1	8.655	0.00450	56.8	71	3.35473	0.00426	3.35899	95.0	0.03536	48,620	0.06909	11,240	0.05611	135,290	3,033	281,640	695	0.00705	0.05282
RUN 3	16.990	0.00450	30.0	70	3.64071	0.00225	3.64296	50.0	0.07286	27,880	0.13067	0	0.13067	67,530	1,514	157,500	388	0.01440	0.12232
RUN 8	17.574	0.00450	27.8	72	3.16657	0.00209	3.16866	27.0	0.11736	14,170	0.22362	0	0.22362	36,030	808	86,430	213	0.02319	0.20859
AVG.				**71**					**0.07519**		**0.14112**		**0.13680**					**0.01488**	**0.12791**
STD. DEV.				**1**					**0.04105**		**0.07779**		**0.08392**					**0.00808**	**0.07803**
CEMENT SILO FILLING																			
RUN 7	14.608	0.00450	30.2	100	0.00000	0.00227	0.00227			37,775	0.00006								
RUN 1 EST.							1.48084			40,299	0.03675								
RUN 3 EST.							2.76330			34,268	0.08064								
RUN 8 EST.							2.71997			31,722	0.08574								
AVG.											**0.05080**								
STD. DEV.											**0.04035**								
TRUCK MIX LOADING & NEWCEM SILO FILLING																			
RUN 5	41.768	0.00450	30.1	79	5.56995	0.00226	5.57221	51.0	0.10926	11,340	0.49138	0	0.49138	26,550	595	158,280	390	0.02840	0.45208
RUN 18	23.287	0.00450	29.9	65	6.24868	0.00224	6.25092	5.0	1.25018	1,800	3.47273	2,380	1.49544	7,260	163	16,570	41	0.22317	1.42597
AVG.				**72**					**0.67972**		**1.98205**		**0.99341**					**0.12579**	**0.93903**
STD. DEV.				**10**					**0.80676**		**2.10814**		**0.70998**					**0.13772**	**0.68864**
NEWCEM SILO FILLING																			
RUN 5 EST.							5.20815					30,096	0.17305						
RUN 18 EST.							6.12144					39,276	0.15586						
AVG.													**0.16445**						
STD. DEV.													**0.01216**						

* AVG. % SILT CONTENT OF SAND **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE : **0.24665**

Table 2.3

CONTROLLED PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM-10 per hour IN INLET (lb)	PM-10 per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM-10 ESCAPED INLET (lb)	PM-10 OUT OUTLET (lb)	TOTAL PM-10 RELEASED (lb)	CONCRETE MADE (yd^3)	PM-10 per yard^3 CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM-10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lbs Solid Raw Material (lb)	PM-10 per 1000 lbs ``FINES" (lb)
GENERAL SILO FILLING																			
RUN 7	14.608	0.00450	30.2	100	0.00000	0.00227	0.00227			37,775		0	0.00006						
RUN 1 EST.							1.48084			40,299		0	0.03675						
RUN 3 EST.							2.76330			34,268		0	0.08064						
RUN 5 EST.							5.20815			0		30,096	0.17305						
RUN 8 EST.							2.71997			31,722		0	0.08574						
RUN 18 EST.							6.12144			0		39,276	0.15586						
AVG.													**0.08868**						
STD. DEV.													**0.06672**						

Table 3.1

PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM per hour IN INLET (lb)	TIME (min)	PM IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING																	
RUN 2	5.358	30.2	2.697	72	3.746	41.5	0.09026	16,950	0.22098	12,250	0.12828	59,950	1,343.94	130,020	320.69	0.01709	0.12136
RUN 4	4.112	30.0	2.056	79	2.603	54.0	0.04820	27,840	0.09348	0	0.09348	73,600	1,649.94	173,150	427.07	0.00948	0.08699
RUN 9	3.583	30.1	1.797	78	2.304	69.0	0.03340	39,110	0.05892	0	0.05892	104,910	2,351.84	218,940	540.02	0.00635	0.05487
! RUN 14	144.524	22.1	53.233	56	95.059	41.0	2.31851	19,180	4.95615	10,220	3.23330	54,120	1,213.24	127,300	313.99	0.45090	3.07363
RUN 15	40.027	30.0	20.014	64	31.271	59.5	0.52556	32,650	0.95777	3,100	0.87472	80,240	1,798.79	187,330	462.05	0.10310	0.82269
RUN 16	15.351	30.0	7.676	58	13.234	41.5	0.31888	22,010	0.60125	0	0.60125	57,510	1,289.24	133,660	329.67	0.06208	0.56006
AVG.				**70**			**0.20326**		0.38648		**0.35133**					0.03962	0.32919
STD. DEV.				**9**			**0.21384**		0.38504		**0.36679**					0.04200	0.34422
CENTRAL MIX LOADING																	
RUN 10	2.154	30.1	1.081	90	1.198	45.0	0.02662	16,280	0.07359	13,900	0.03969	68,130	1,527.32	143,470	353.87	0.00495	0.03737
RUN 11	6.320	30.2	3.181	84	3.787	49.8	0.07604	22,340	0.16952	8,870	0.12134	70,770	1,586.50	158,600	391.19	0.01453	0.11411
RUN 12	14.119	30.2	7.107	99	7.178	45.0	0.15952	22,130	0.32437	9,300	0.22839	59,080	1,324.44	141,640	349.36	0.03092	0.21684
RUN 13	4.600	29.9	2.292	99	2.315	44.0	0.05262	19,240	0.12035	8,770	0.08267	66,750	1,496.38	138,830	342.42	0.00991	0.07757
RUN 17	8.274	27.2	3.751	99	3.789	72.0	0.05262	30,950	0.12242	13,900	0.08448	104,850	2,350.49	228,760	564.24	0.01001	0.07932
AVG.				**94**			**0.07349**		0.16205		**0.11131**					0.01407	0.10504
STD. DEV.				**7**			**0.05117**		0.09688		**0.07155**					0.01001	0.06815

***** AVG. % SILT CONTENT OF SAND : **2.2418**

****** AVG. % SILT CONTENT OF AGGREGATE : **0.2467**

! Test Run 14 is not used to calculate the means or standard deviations because it is a statistical outlier (see Appendix A).

Table 3.2

PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM per hour IN INLET (lb)	TIME (min)	PM IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING & CEMENT SILO FILLING																	
RUN 1	10.020	56.8	9.486	71	13.369	95.0	0.14073	48,620	0.27498	11,240	0.22334	135,290	3,032.89	281,640	694.67	0.02804	0.21025
RUN 3	19.456	30.0	9.728	70	13.897	50.0	0.27794	27,880	0.49846	0	0.49846	67,530	1,513.87	157,500	388.47	0.05495	0.46662
RUN 8	31.730	27.8	14.702	72	20.419	27.0	0.75625	14,170	1.44099	0	1.44099	36,030	807.71	86,430	213.18	0.14945	1.34415
AVG.				**71**			**0.39164**		**0.73814**		**0.72093**					**0.07748**	**0.67368**
STD. DEV.				**1**			**0.32313**		**0.61886**		**0.63858**					**0.06376**	**0.59463**
CEMENT SILO FILLING																	
RUN 7	18.004	30.2	9.062	100	9.062			37,775	0.23990								
RUN 1 EST.					--			40,299	--								
RUN 3 EST.					--			34,268	--								
RUN 8 EST.					15.418			31,722	0.48604								
AVG.									**0.36297**								
STD. DEV.									**0.17405**								
TRUCK MIX LOADING & NEWCEM SILO FILLING																	
RUN 5	72.339	30.1	36.290	79	45.937	51.0	0.90072	11,340	4.05086	0	4.05086	26,550	595.19	158,280	390.40	0.23417	3.72695
RUN 18	91.223	29.9	45.459	65	69.938	5.0	13.98753	1,800	38.85424	2,380	16.73149	7,260	162.75	16,570	40.87	2.49688	15.95430
AVG.				**72**			**7.44412**		**21.45255**		**10.39118**					**1.36552**	**9.84062**
STD. DEV.				**10**			**9.25377**		**24.60970**		**8.96656**					**1.59998**	**8.64605**
NEWCEM SILO FILLING																	
RUN 5 EST.					41.879					30,096	1.39152						
RUN 18 EST.					68.495					39,276	1.74394						
AVG.											**1.56773**						
STD. DEV.											**0.24920**						

* AVG. % SILT CONTENT OF SAND : **2.2418**

** AVG. % SILT CONTENT OF AGGREGATE : **0.2467**

Table 3.3

PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM per hour IN INLET (lb)	TIME (min)	PM IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM (lb)	CONCRETE MADE (yd^3)	PM per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
GENERAL SILO FILLING																	
RUN 7	18.004	30.2	9.062	100	9.062			37,775		0	0.23990						
RUN 1 EST.					--			40,299		0	--						
RUN 3 EST.					--			34,268		0	--						
RUN 5 EST.					41.879			0		30,096	1.39152						
RUN 8 EST.					15.418			31,722		0	0.48604						
RUN 18 EST.					68.495			0		39,276	1.74394						
AVG.											**0.96535**						
STD. DEV.											**0.71737**						

Table 4.1

CONTROLLED PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM per hour IN INLET (lb)	PM per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM ESCAPED INLET (lb)	PM OUT OUTLET (lb)	TOTAL PM RELEASED (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING																			
RUN 2	5.358	0.00850	30.2	72	1.04878	0.00428	1.05306	41.5	0.02537	16,950	0.06213	12,250	0.03606	59,950	1,343.94	130,020	320.69	0.00480	0.03412
RUN 4	4.112	0.00850	30.0	79	0.54653	0.00425	0.55078	54.0	0.01020	27,840	0.01978	0	0.01978	73,600	1,649.94	173,150	427.07	0.00201	0.01841
RUN 9	3.583	0.00850	30.1	78	0.50698	0.00426	0.51124	69.0	0.00741	39,110	0.01307	0	0.01307	104,910	2,351.84	218,940	540.02	0.00141	0.01217
! RUN 14	144.524	0.00850	22.1	56	41.82593	0.00313	41.82906	41.0	1.02022	19,180	2.18087	10,220	1.42276	54,120	1,213.24	127,300	313.99	0.19841	1.35250
RUN 15	40.027	0.00850	30.0	64	11.25759	0.00425	11.26184	59.5	0.18927	32,650	0.34493	3,100	0.31502	80,240	1,798.79	187,330	462.05	0.03713	0.29628
RUN 16	15.351	0.00850	30.0	58	5.55812	0.00425	5.56237	41.5	0.13403	22,010	0.25272	0	0.25272	57,510	1,289.24	133,660	329.67	0.02609	0.23541
AVG.				**70**					**0.07326**		0.13853		**0.12733**					0.01429	0.11928
STD. DEV.				**9**					**0.08330**		0.15109		**0.14483**					0.01634	0.13575
CENTRAL MIX LOADING																			
RUN 10	2.154	0.00850	30.1	90	0.11740	0.00426	0.12167	45.0	0.00270	16,280	0.00747	13,900	0.00403	68,130	1,527.32	143,470	353.87	0.00050	0.00379
RUN 11	6.320	0.00850	30.2	84	0.60592	0.00428	0.61020	49.8	0.01225	22,340	0.02731	8,870	0.01955	70,770	1,586.50	158,600	391.19	0.00234	0.01839
RUN 12	14.119	0.00850	30.2	99	0.07178	0.00428	0.07606	45.0	0.00169	22,130	0.00344	9,300	0.00242	59,080	1,324.44	141,640	349.36	0.00033	0.00230
RUN 13	4.600	0.00850	29.9	99	0.02315	0.00424	0.02739	44.0	0.00062	19,240	0.00142	8,770	0.00098	66,750	1,496.38	138,830	342.42	0.00012	0.00092
RUN 17	8.274	0.00850	27.2	99	0.03789	0.00385	0.04174	72.0	0.00058	30,950	0.00135	13,900	0.00093	104,850	2,350.49	228,760	564.24	0.00011	0.00087
AVG.				**94**					**0.00357**		0.00820		**0.00558**					0.00068	0.00525
STD. DEV.				**7**					**0.00493**		0.01097		**0.00791**					0.00094	0.00744

* AVG. % SILT CONTENT OF SAND : **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE : **0.24665**

! Test Run 14 is not used to calculate the means or standard deviations because it is a statistical outlier (see Appendix A).

Table 4.2

CONTROLLED PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	PM per hour IN INLET (lb)	PM per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM ESCAPED INLET (lb)	PM OUT OUTLET (lb)	TOTAL PM RELEASED (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING & CEMENT SILO FILLING																			
RUN 1	10.020	0.00850	56.8	71	3.88382	0.00805	3.89186	95.0	0.04097	48,620	0.08005	11,240	0.06502	135,290	3,032.89	281,640	694.67	0.00816	0.06120
RUN 3	19.456	0.00850	30.0	70	4.16914	0.00425	4.17339	50.0	0.08347	27,880	0.14969	0	0.14969	67,530	1,513.87	157,500	388.47	0.01650	0.14013
RUN 8	31.730	0.00850	27.8	72	5.71728	0.00394	5.72121	27.0	0.21190	14,170	0.40376	0	0.40376	36,030	807.71	86,430	213.18	0.04187	0.37662
AVG.				**71**					0.11211		0.21116		0.20615					0.02218	0.19265
STD. DEV.				**1**					0.08899		0.17039		0.17629					0.01756	0.16414
CEMENT SILO FILLING																			
RUN 7	18.004	0.00850	30.2	100	--	0.00428	0.00428			37,775	0.00011								
RUN 1 EST.							--			40,299	--								
RUN 3 EST.							--			34,268	--								
RUN 8 EST.							3.90929			31,722	0.12324								
AVG.											**0.06167**								
STD. DEV.											**0.07544**								
TRUCK MIX LOADING & NEWCEM SILO FILLING																			
RUN 5	72.339	0.00850	30.1	79	9.64673	0.00426	9.65099	51.0	0.18924	11,340	0.85106	0	0.85106	26,550	595.19	158,280	390.40	0.04920	0.78300
RUN 18	91.223	0.00850	29.9	65	24.47817	0.00424	24.48241	5.0	4.89648	1,800	13.60134	2,380	5.85704	7,260	162.75	16,570	40.87	0.87406	5.58497
AVG.				**72**					2.54286		7.22620		3.35405					0.46163	3.18399
STD. DEV.				**10**					3.32853		9.01581		3.53976					0.58327	3.39550
NEWCEM SILO FILLING																			
RUN 5 EST.							8.18083					30,096	0.27182						
RUN 18 EST.							23.95954					39,276	0.61004						
AVG.													**0.44093**						
STD. DEV.													**0.23915**						

* AVG. % SILT CONTENT OF SAND : **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE : **0.24665**

Table 4.3

CONTROLLED PM EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

	PM per hour IN INLET (lb)	PM per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM ESCAPED INLET (lb)	PM OUT OUTLET (lb)	TOTAL PM RELEASED (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	PM10 per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Solid Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
GENERAL SILO FILLING																			
RUN 7	18.004	0.00850	30.2	100	--	0.00428	0.00428			37,775		0	0.00011						
RUN 1 EST.							--			40,299		0	--						
RUN 3 EST.							--			34,268		0	--						
RUN 5 EST.							8.18083			0		30,096	0.27182						
RUN 8 EST.							3.90929			31,722		0	0.12324						
RUN 18 EST.							23.95954			0		39,276	0.61004						
AVG.													**0.25130**						
STD. DEV.													**0.26370**						

Table 5.1

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd³)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUNS 2, 4, 9, 14, 15 & 16 TRUCK MIX LOADING																	
ARSENIC	1.71E-005	172.4	4.91E-005	68	7.23E-005	306.5	**2.36E-007**	157,740	4.58E-007	25,570	**3.94E-007**	430,330	9,646.99	970,400	2393.49	4.56E-008	3.70E-007
BERYLLIUM	1.56E-006	172.4	4.48E-006	68	6.59E-006	306.5	**2.15E-008**	157,740	4.18E-008	25,570	**3.60E-008**	430,330	9,646.99	970,400	2393.49	4.16E-009	3.37E-008
CADMIUM	8.62E-007	172.4	2.48E-006	68	3.64E-006	306.5	**1.19E-008**	157,740	2.31E-008	25,570	**1.99E-008**	430,330	9,646.99	970,400	2393.49	2.30E-009	1.86E-008
CHROMIUM	3.05E-004	172.4	8.76E-004	68	1.29E-003	306.5	**4.20E-006**	157,740	8.17E-006	25,570	**7.03E-006**	430,330	9,646.99	970,400	2393.49	8.14E-007	6.60E-006
LEAD	2.39E-005	172.4	6.87E-005	68	1.01E-004	306.5	**3.29E-007**	157,740	6.40E-007	25,570	**5.51E-007**	430,330	9,646.99	970,400	2393.49	6.38E-008	5.17E-007
MANGANESE	2.00E-003	172.4	5.75E-003	68	8.45E-003	306.5	**2.76E-005**	157,740	5.36E-005	25,570	**4.61E-005**	430,330	9,646.99	970,400	2393.49	5.34E-006	4.33E-005
MERCURY	--	172.4	--	68	--	306.5	--	157,740	--	25,570	--	430,330	9,646.99	970,400	2393.49		--
NICKEL	2.38E-004	172.4	6.84E-004	68	1.01E-003	306.5	**3.28E-006**	157,740	6.38E-006	25,570	**5.49E-006**	430,330	9,646.99	970,400	2393.49	6.35E-007	5.15E-006
PHOSPHORUS	8.35E-004	172.4	2.40E-003	68	3.53E-003	306.5	**1.15E-005**	157,740	2.24E-005	25,570	**1.92E-005**	430,330	9,646.99	970,400	2393.49	2.23E-006	1.81E-005
SELENIUM	--	172.4	--	68	--	306.5	--	157,740	--	25,570	--	430,330	9,646.99	970,400	2393.49		--
RUNS 10, 11, 12, 13 & 17 CENTRAL MIX LOADING																	
ARSENIC	7.37E-006	147.6	1.81E-005	94	1.93E-005	255.8	**7.54E-008**	110,940	1.74E-007	54,740	**1.16E-007**	369,580	8,285.12	811,300	2001.07	1.43E-008	1.10E-007
BERYLLIUM	--	147.6	--	94	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2001.07		--
CADMIUM	3.75E-007	147.6	9.23E-007	94	9.81E-007	255.8	**3.84E-009**	110,940	8.85E-009	54,740	**5.92E-009**	369,580	8,285.12	811,300	2001.07	7.29E-010	5.58E-009
CHROMIUM	4.50E-005	147.6	1.11E-004	94	1.18E-004	255.8	**4.60E-007**	110,940	1.06E-006	54,740	**7.11E-007**	369,580	8,285.12	811,300	2001.07	8.75E-008	6.69E-007
LEAD	1.21E-005	147.6	2.98E-005	94	3.17E-005	255.8	**1.24E-007**	110,940	2.85E-007	54,740	**1.91E-007**	369,580	8,285.12	811,300	2001.07	2.35E-008	1.80E-007
MANGANESE	1.94E-003	147.6	4.77E-003	94	5.08E-003	255.8	**1.98E-005**	110,940	4.58E-005	54,740	**3.06E-005**	369,580	8,285.12	811,300	2001.07	3.77E-006	2.89E-005
MERCURY	--	147.6	--	94	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2001.07		--
NICKEL	1.04E-004	147.6	2.56E-004	94	2.72E-004	255.8	**1.06E-006**	110,940	2.45E-006	54,740	**1.64E-006**	369,580	8,285.12	811,300	2001.07	2.02E-007	1.55E-006
PHOSPHORUS	6.37E-004	147.6	1.57E-003	94	1.67E-003	255.8	**6.52E-006**	110,940	1.50E-005	54,740	**1.01E-005**	369,580	8,285.12	811,300	2001.07	1.24E-006	9.47E-006
SELENIUM	--	147.6	--	94	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2001.07		--

* AVG. % SILT CONTENT OF SAND : **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE : **0.24665**

Table 5.2

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	SILT FROM AGGR. (lb)	METAL per 1000 lb Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUN 7 CEMENT SILO FILLING																	
ARSENIC	6.29E-005	30.2	3.17E-005	100	3.17E-005			37,775	**8.38E-007**								
BERYLLIUM	6.73E-007	30.2	3.39E-007	100	3.39E-007			37,775	**8.97E-009**								
CADMIUM	8.75E-006	30.2	4.40E-006	100	4.40E-006			37,775	**1.17E-007**								
CHROMIUM	9.42E-006	30.2	4.74E-006	100	4.74E-006			37,775	**1.26E-007**								
LEAD	2.76E-005	30.2	1.39E-005	100	1.39E-005			37,775	**3.68E-007**								
MANGANESE	7.61E-003	30.2	3.83E-003	100	3.83E-003			37,775	**1.01E-004**								
MERCURY	--	30.2	--	100	--			37,775	--								
NICKEL	6.63E-004	30.2	3.34E-004	100	3.34E-004			37,775	**8.83E-006**								
PHOSPHORUS	4.41E-003	30.2	2.22E-003	100	2.22E-003			37,775	**5.88E-005**								
SELENIUM	--	30.2	--	100	--			37,775	--								

Table 5.3

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd³)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUN 5 TRUCK MIX LOADING & NEWCEM SILO FILLING																	
ARSENIC	1.46E-005	30.1	7.32E-006	79	9.27E-006	51.0	1.82E-007	11,340	**8.18E-007**	0	**8.18E-007**	26,550	595.19	158,280	390.40	4.73E-008	**7.52E-007**
BERYLLIUM	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--
CADMIUM	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--
CHROMIUM	3.91E-005	30.1	1.96E-005	79	2.48E-005	51.0	4.87E-007	11,340	**2.19E-006**	0	**2.19E-006**	26,550	595.19	158,280	390.40	1.27E-007	**2.01E-006**
LEAD	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--
MANGANESE	7.67E-002	30.1	3.85E-002	79	4.87E-002	51.0	9.55E-004	11,340	**4.30E-003**	0	**4.30E-003**	26,550	595.19	158,280	390.40	2.48E-004	**3.95E-003**
MERCURY	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--
NICKEL	1.30E-004	30.1	6.52E-005	79	8.26E-005	51.0	1.62E-006	11,340	**7.28E-006**	0	**7.28E-006**	26,550	595.19	158,280	390.40	4.21E-007	**6.70E-006**
PHOSPHORUS	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--
SELENIUM	--	30.1	--	79	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40		--

RUN 5 ESTIMATED NEWCEM SILO FILLING	TOTAL METAL (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)
ARSENIC	4.71E-006	30,096	**1.57E-007**
BERYLLIUM	--	30,096	--
CADMIUM	--	30,096	--
CHROMIUM	--	30,096	--
LEAD	--	30,096	--
MANGANESE	4.82E-002	30,096	**1.60E-003**
MERCURY	--	30,096	--
NICKEL	1.91E-005	30,096	**6.35E-007**
PHOSPHORUS	--	30,096	--
SELENIUM	--	30,096	--

* AVG. % SILT CONTENT OF SAND : 2.24177

** AVG. % SILT CONTENT OF AGGREGATE 0.24665

Table 5.4

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT
WALDORF, MD

RUN 18
TRUCK MIX LOADING & NEWCEM SILO FILLING

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per yard^3 CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
ARSENIC	8.31E-006	29.9	4.14E-006	65	6.37E-006	5.0	**1.27E-006**	1,800	**3.54E-006**	2,380	**1.52E-006**	7,260	162.75	16,570	40.87	2.27E-007	**1.45E-006**
BERYLLIUM	1.33E-006	29.9	6.63E-007	65	1.02E-006	5.0	**2.04E-007**	1,800	**5.66E-007**	2,380	**2.44E-007**	7,260	162.75	16,570	40.87	3.64E-008	**2.33E-007**
CADMIUM	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--
CHROMIUM	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--
LEAD	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--
MANGANESE	3.48E-002	29.9	1.73E-002	65	2.67E-002	5.0	**5.34E-003**	1,800	**1.48E-002**	2,380	**6.38E-003**	7,260	162.75	16,570	40.87	9.53E-004	**6.09E-003**
MERCURY	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--
NICKEL	1.14E-004	29.9	5.68E-005	65	8.74E-005	5.0	**1.75E-005**	1,800	**4.86E-005**	2,380	**2.09E-005**	7,260	162.75	16,570	40.87	3.12E-006	**1.99E-005**
PHOSPHORUS	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--
SELENIUM	--	29.9	--	65	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87		--

RUN 18
ESTIMATED NEWCEM SILO FILLING

	TOTAL METAL (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)
ARSENIC	4.75E-006	39,276	**1.21E-007**
BERYLLIUM	8.72E-007	39,276	**2.22E-008**
CADMIUM	--	39,276	--
CHROMIUM	--	39,276	--
LEAD	--	39,276	--
MANGANESE	2.65E-002	39,276	**6.74E-004**
MERCURY	--	39,276	--
NICKEL	6.48E-005	39,276	**1.65E-006**
PHOSPHORUS	--	39,276	--
SELENIUM	--	39,276	--

* AVG. % SILT CONTENT OF SAND : 2.24177

** AVG. % SILT CONTENT OF AGGREGATE 0.24665

Table 5.5 METAL EMISSION FACTORS FOR CONCRETE BATCHING
CHANEY ENTERPRISES CEMENT PLANT, WALDORF, MD

	AVG. METAL per 1000 lb CEMENT & NEWCEM (lb)	STD. DEVIATION (lb)
AVG. RUN 5 & 18		
ESTIMATED NEWCEM SILO FILLING		
ARSENIC	**1.39E-07**	2.52E-08
BERYLLIUM	**2.22E-08**	--
CADMIUM	--	--
CHROMIUM	--	--
LEAD	--	--
MANGANESE	**1.14E-03**	6.55E-04
MERCURY	--	--
NICKEL	**1.14E-06**	7.18E-07
PHOSPHORUS	--	--
SELENIUM	--	--
AVG. RUN 5, 7, 18		
ESTIMATED GENERAL SILO FILLING		
ARSENIC	**3.72E-07**	4.04E-07
BERYLLIUM	**1.56E-08**	9.35E-09
CADMIUM	**1.17E-07**	--
CHROMIUM	**1.26E-07**	--
LEAD	**3.68E-07**	--
MANGANESE	**7.92E-04**	7.57E-04
MERCURY	--	--
NICKEL	**3.71E-06**	4.47E-06
PHOSPHORUS	**5.88E-05**	--
SELENIUM	--	--

Table 6.1

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL (lb)	CONCRETE MADE (yd³)	METAL per yard ³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUNS 2, 4, 9, 14 15 & 16 TRUCK MIX LOADING																			
ARSENIC	1.71E-005	1.59E-007	172.4	68	2.31E-005	4.57E-007	2.36E-005	306.5	**7.69E-008**	157,740	1.49E-007	25,570	**1.29E-007**	430,330	9,646.99	970,400	2,393.49	1.49E-008	1.21E-007
BERYLLIUM	1.56E-006	--	172.4	68	2.11E-006	--	2.11E-006	306.5	**6.88E-009**	157,740	1.34E-008	25,570	**1.15E-008**	430,330	9,646.99	970,400	2,393.49	1.33E-009	1.08E-008
CADMIUM	8.62E-007	--	172.4	68	1.17E-006	--	1.17E-006	306.5	**3.80E-009**	157,740	7.39E-009	25,570	**6.36E-009**	430,330	9,646.99	970,400	2,393.49	7.36E-010	5.97E-009
CHROMIUM	3.05E-004	1.40E-006	172.4	68	4.12E-004	4.02E-006	4.16E-004	306.5	**1.36E-006**	157,740	2.64E-006	25,570	**2.27E-006**	430,330	9,646.99	970,400	2,393.49	2.63E-007	2.13E-006
LEAD	2.39E-005	4.62E-007	172.4	68	3.23E-005	1.33E-006	3.36E-005	306.5	**1.10E-007**	157,740	2.13E-007	25,570	**1.84E-007**	430,330	9,646.99	970,400	2,393.49	2.12E-008	1.72E-007
MANGANESE	2.00E-003	3.72E-006	172.4	68	2.70E-003	1.07E-005	2.72E-003	306.5	**8.86E-006**	157,740	1.72E-005	25,570	**1.48E-005**	430,330	9,646.99	970,400	2,393.49	1.71E-006	1.39E-005
MERCURY	--	--	172.4	68	--	--	--	306.5	--	157,740	--	25,570	--	430,330	9,646.99	970,400	2,393.49	--	--
NICKEL	2.38E-004	1.69E-006	172.4	68	3.22E-004	4.85E-006	3.27E-004	306.5	**1.07E-006**	157,740	2.07E-006	25,570	**1.78E-006**	430,330	9,646.99	970,400	2,393.49	2.06E-007	1.67E-006
PHOSPHORUS	8.35E-004	--	172.4	68	1.13E-003	--	1.13E-003	306.5	**3.68E-006**	157,740	7.16E-006	25,570	**6.16E-006**	430,330	9,646.99	970,400	2,393.49	7.13E-007	5.78E-006
SELENIUM	--	--	172.4	68	--	--	--	306.5	--	157,740	--	25,570	--	430,330	9,646.99	970,400	2,393.49		--
RUNS 10, 11, 12 13 & 17 CENTRAL MIX LOADING																			
ARSENIC	7.37E-006	1.59E-007	147.6	94	1.16E-006	3.91E-007	1.55E-006	255.8	**6.05E-009**	110,940	1.40E-008	54,740	**9.35E-009**	369,580	8,285.12	811,300	2,001.07	1.15E-009	8.80E-009
BERYLLIUM	--	--	147.6	94	--	--	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2,001.07	--	--
CADMIUM	3.75E-007	--	147.6	94	5.89E-008	--	5.89E-008	255.8	**2.30E-010**	110,940	5.31E-010	54,740	**3.55E-010**	369,580	8,285.12	811,300	2,001.07	4.37E-011	3.35E-010
CHROMIUM	4.50E-005	1.40E-006	147.6	94	7.07E-006	3.44E-006	1.05E-005	255.8	**4.11E-008**	110,940	9.47E-008	54,740	**6.34E-008**	369,580	8,285.12	811,300	2,001.07	7.81E-009	5.97E-008
LEAD	1.21E-005	4.62E-007	147.6	94	1.90E-006	1.14E-006	3.04E-006	255.8	**1.19E-008**	110,940	2.74E-008	54,740	**1.83E-008**	369,580	8,285.12	811,300	2,001.07	2.25E-009	1.73E-008
MANGANESE	1.94E-003	3.72E-006	147.6	94	3.05E-004	9.15E-006	3.14E-004	255.8	**1.23E-006**	110,940	2.83E-006	54,740	**1.89E-006**	369,580	8,285.12	811,300	2,001.07	2.33E-007	1.78E-006
MERCURY	--	--	147.6	94	--	--	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2,001.07	--	--
NICKEL	1.04E-004	1.69E-006	147.6	94	1.63E-005	4.15E-006	2.05E-005	255.8	**8.01E-008**	110,940	1.85E-007	54,740	**1.24E-007**	369,580	8,285.12	811,300	2,001.07	1.52E-008	1.16E-007
PHOSPHORUS	6.37E-004	--	147.6	94	1.00E-004	--	1.00E-004	255.8	**3.91E-007**	110,940	9.02E-007	54,740	**6.04E-007**	369,580	8,285.12	811,300	2,001.07	7.43E-008	5.68E-007
SELENIUM	--	--	147.6	94	--	--	--	255.8	--	110,940	--	54,740	--	369,580	8,285.12	811,300	2,001.07	--	--

* AVG. % SILT CONTENT OF SAND : **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE **0.24665**

Table 6.2

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUN 7 CEMENT SILO FILLING																			
ARSENIC	6.29E-005	1.59E-007	30.2	100	--	8.00E-008	8.00E-008			37,775	**2.12E-009**								
BERYLLIUM	6.73E-007	--	30.2	100	--	--	--			37,775	--								
CADMIUM	8.75E-006	--	30.2	100	--	--	--			37,775	--								
CHROMIUM	9.42E-006	1.40E-006	30.2	100	--	7.05E-007	7.05E-007			37,775	**1.87E-008**								
LEAD	2.76E-005	4.62E-007	30.2	100	--	2.33E-007	2.33E-007			37,775	**6.16E-009**								
MANGANESE	7.61E-003	3.72E-006	30.2	100	--	1.87E-006	1.87E-006			37,775	**4.96E-008**								
MERCURY	--	--	30.2	100	--	--	--			37,775	--								
NICKEL	6.63E-004	1.69E-006	30.2	100	--	8.50E-007	8.50E-007			37,775	**2.25E-008**								
PHOSPHORUS	4.41E-003	--	30.2	100	--	--	--			37,775	--								
SELENIUM	--	--	30.2	100	--	--	--			37,775	--								

Table 6.3

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

RUN 5 TRUCK MIX LOADING & NEWCEM SILO FILLING

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
ARSENIC	1.46E-005	1.59E-007	30.1	79	1.95E-006	7.98E-008	2.03E-006	51.0	**3.97E-008**	11,340	**1.79E-007**	0	**1.79E-007**	26,550	595.19	158,280	390.40	**1.03E-008**	**1.64E-007**
BERYLLIUM	--	--	30.1	79	--	--	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40	--	--
CADMIUM	--	--	30.1	79	--	--	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40	--	--
CHROMIUM	3.91E-005	1.40E-006	30.1	79	5.21E-006	7.02E-007	5.92E-006	51.0	**1.16E-007**	11,340	**5.22E-007**	0	**5.22E-007**	26,550	595.19	158,280	390.40	**3.02E-008**	**4.80E-007**
LEAD	--	4.62E-007	30.1	79	--	2.32E-007	2.32E-007	51.0	**4.54E-009**	11,340	**2.04E-008**	0	**2.04E-008**	26,550	595.19	158,280	390.40	**1.18E-009**	**1.88E-008**
MANGANESE	7.67E-002	3.72E-006	30.1	79	1.02E-002	1.87E-006	1.02E-002	51.0	**2.01E-004**	11,340	**9.02E-004**	0	**9.02E-004**	26,550	595.19	158,280	390.40	**5.21E-005**	**8.30E-004**
MERCURY	--	--	30.1	79	--	--	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40	--	--
NICKEL	1.30E-004	1.69E-006	30.1	79	1.73E-005	8.47E-007	1.82E-005	51.0	**3.57E-007**	11,340	**1.60E-006**	0	**1.60E-006**	26,550	595.19	158,280	390.40	**9.27E-008**	**1.48E-006**
PHOSPHORUS	--	--	30.1	79	--	--	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40	--	--
SELENIUM	--	--	30.1	79	--	--	--	51.0	--	11,340	--	0	--	26,550	595.19	158,280	390.40	--	--

RUN 5 ESTIMATED NEWCEM SILO FILLING

	TOTAL METAL (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)
ARSENIC	5.39E-007	30,096	**1.79E-008**
BERYLLIUM	--	30,096	--
CADMIUM	--	30,096	--
CHROMIUM	--	30,096	--
LEAD	--	30,096	--
MANGANESE	1.01E-002	30,096	**3.34E-004**
MERCURY	--	30,096	--
NICKEL	--	30,096	--
PHOSPHORUS	--	30,096	--
SELENIUM	--	30,096	--

* AVG. % SILT CONTENT OF SAND : **2.24177**

** AVG. % SILT CONTENT OF AGGREGATE 0.24665

Table 6.4

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CHANEY ENTERPRISES CEMENT PLANT

WALDORF, MD

RUN 18
TRUCK MIX LOADING & NEWCEM SILO FILLING

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL (lb)	CONCRETE MADE (yd³)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
ARSENIC	8.31E-006	1.59E-007	29.9	65	2.23E-006	7.92E-008	2.31E-006	5.0	4.62E-007	1,800	1.28E-006	2,380	5.52E-007	7,260	162.75	16,570	40.87	8.24E-008	5.27E-007
BERYLLIUM	1.33E-006	--	29.9	65	3.57E-007	--	3.57E-007	5.0	7.14E-008	1,800	1.98E-007	2,380	8.54E-008	7,260	162.75	16,570	40.87	1.27E-008	8.14E-008
CADMIUM	--	--	29.9	65	--	--	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87	--	--
CHROMIUM	--	1.40E-006	29.9	65	--	6.98E-007	6.98E-007	5.0	1.40E-007	1,800	3.88E-007	2,380	1.67E-007	7,260	162.75	16,570	40.87	2.49E-008	1.59E-007
LEAD	--	4.62E-007	29.9	65	--	2.30E-007	2.30E-007	5.0	4.60E-008	1,800	1.28E-007	2,380	5.51E-008	7,260	162.75	16,570	40.87	8.22E-009	5.25E-008
MANGANESE	3.48E-002	3.72E-006	29.9	65	9.34E-003	1.85E-006	9.34E-003	5.0	1.87E-003	1,800	5.19E-003	2,380	2.23E-003	7,260	162.75	16,570	40.87	3.33E-004	2.13E-003
MERCURY	--	--	29.9	65	--	--	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87	--	--
NICKEL	1.14E-004	1.69E-006	29.9	65	3.06E-005	8.41E-007	3.14E-005	5.0	6.29E-006	1,800	1.75E-005	2,380	7.52E-006	7,260	162.75	16,570	40.87	1.12E-006	7.17E-006
PHOSPHORUS	--	--	29.9	65	--	--	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87	--	--
SELENIUM	--	--	29.9	65	--	--	--	5.0	--	1,800	--	2,380	--	7,260	162.75	16,570	40.87	--	--

RUN 18
ESTIMATED NEWCEM SILO FILLING

	TOTAL METAL (lb)	NEWCEM LOADED (lb)	METAL per 1000 lb CEMENT & NEWCEM (lb)
ARSENIC	1.78E-006	39,276	**4.53E-008**
BERYLLIUM	3.10E-007	39,276	**7.88E-009**
CADMIUM	--	39,276	--
CHROMIUM	--	39,276	--
LEAD	--	39,276	--
MANGANESE	9.28E-003	39,276	**2.36E-004**
MERCURY	--	39,276	--
NICKEL	2.41E-005	39,276	**6.14E-007**
PHOSPHORUS	--	39,276	--
SELENIUM	--	39,276	--

* AVG. % SILT CONTENT OF SAND : 2.24177

** AVG. % SILT CONTENT OF AGGREGATE 0.24665

Table 6.5 CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING
CHANEY ENTERPRISES CEMENT PLANT, WALDORF, MD

	AVG. METAL per 1000 lbs CEMENT & NEWCEM (lbs)	STD. DEVIATION (lbs)
AVG. RUN 5 & 18		
ESTIMATED NEWCEM SILO FILLING		
ARSENIC	**3.16E-08**	1.94E-08
BERYLLIUM	**7.88E-009**	--
CADMIUM	--	--
CHROMIUM	--	--
LEAD	--	--
MANGANESE	**2.85E-04**	6.93E-05
MERCURY	--	--
NICKEL	**6.14E-07**	0.00E+00
PHOSPHORUS	--	--
SELENIUM	--	--
AVG. RUN 5, 7, 18		
ESTIMATED GENERAL SILO FILLING		
ARSENIC	**2.18E-008**	
BERYLLIUM	**3.94E-009**	
CADMIUM	--	--
CHROMIUM	**1.87E-008**	--
LEAD	**6.16E-009**	--
MANGANESE	**1.90E-004**	
MERCURY	--	--
NICKEL	**2.12E-007**	
PHOSPHORUS	--	--
SELENIUM	--	--

4.2 Reference 2

This report (Reference 2) presents the results of emission testing on a typical concrete batching operation performed at Concrete Ready Mixed Corporation in Roanoke, VA. This test report includes measurements of the amounts of PM, PM_{10}, and ten select metals that were released during truck mix loadings and silo fillings. In addition, tests were conducted on process material samples and road surface samples.

Several kinds of test and test methods were used:

- EPA Reference Test Method 201A was used to collect emission released during the truck loadings and the silo fillings. In addition to recovering and weighing collected PM_{10}, larger particulate (greater than ten micrometers) collected in the probe and the cyclone was also recovered and weighed.
- Ambient air monitors were set up at upwind and downwind locations to measure background concentrations of suspended particulate matter resulting form both the traversal of paved and unpaved roads in and around the plant and the release of fugitive emissions from concrete batching operations.
- Sieve and moisture analyses were conducted on the process materials (aggregates) and the road materials.
- Laboratory tests were conducted on the emissions collected during the tests as well as the material collected for the sieve analyses to determine the amount of each of the ten metals that were contained in these materials.

Emissions resulting from the truck mix loadings were controlled with a hood system located above the truck delivery chute. This hood was connected to a central dust collector (Griffin Environmental Model JA-360DA). In order to develop both controlled and uncontrolled emission factors, tests were conducted at both the inlet and outlet of the dust collector. Also, visual estimates of the capture efficiency of the control device were made during each of the truck loadings. This information made it possible to estimate the amount of emissions that were not captured during the tests.

Emissions due to the pneumatic loading of silos were controlled with dust collectors located on the top of each of the silos. The dust collectors used fabric filters to clean air being displaced during the loading of cement or fly ash. Since emission tests were only conducted at the outlet of the dust collectors, no uncontrolled silo filling emission factors were developed.

Most of the emission data that were used to develop emission factors for truck mix loading warrants an A rating. However, the methodology used to estimate the capture efficiencies of the control device is qualitative rather than quantitative. This issue is significant since the uncontrolled and controlled emission factors from truck loading depend significantly on the capture efficiency estimates. Due to the subjective nature of the capture efficiency estimates, the emission data set for the truck loading emission factors is rated B.

The emission data set used to develop the controlled PM and controlled PM_{10} emission factors for cement and cement supplement silo filling is **rated A**, since it is sound and does not involve the subjective control efficiency estimations.

The emission data for the controlled metal emission factors for cement and cement supplement silo filling are generally of the same caliber as the controlled PM and controlled PM_{10} emission factors for cement and cement supplement silo filling. However, only one emission rate was obtained for each of the ten metal types. Consequently, this emission data set is **rated B**.

The following tables present the data that were used to develop the emission factors for Reference 2. The layouts of the table make the method used to develop these emission factors largely self-evident (see the technical notes in Appendix B for more information).

Note that “fines” stands for cement, cement supplement, and the silt from sand and course aggregate.

Reference 2
Emission Factor Tables

Tables	Emission Factor Types
7	PM_{10} Emission Factors
8	Controlled PM_{10} Emission Factors
9	PM Emission Factors
10	Controlled PM Emission Factors
11	Controlled Cement Silo Filling Emission Factors
12	Controlled Fly Ash Silo Filling Emission Factors
13.1 - 13.3	Metal Emission Factors
14.1 - 14.3	Controlled Metal Emission Factors

Table 7

PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

TRUCK MIX LOADING	PM-10 per hour IN INLET (lb)	TIME (min)	PM-10 IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM-10 RELEASED (lb)	CONCRETE MADE (yd³)	PM-10 per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	PM-10 per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGRE-GATE (lb)	PM-10 per 1000 lb RAW MATERIAL (lb)	PM-10 per 1000 lb ``FINES" (lb)
RUN 1	0.878	120	1.756	83	2.11566	60.5	0.03497	28,786	0.07350	4,932	0.06275	87,240	1,764.87	97,920	89.11	0.00967	0.05948
RUN 2	1.440	120	2.880	85	3.38824	71.5	0.04739	32,424	0.10450	8,124	0.08356	97,457	1,971.56	99,930	90.94	0.01424	0.07952
RUN 3	1.146	119	2.273	84	2.70583	70.5	0.03838	29,574	0.09149	7,644	0.07270	95,720	1,936.42	113,100	102.92	0.01100	0.06893
RUN 4	0.628	120	1.256	83	1.51325	61.5	0.02461	27,598	0.05483	6,248	0.04471	77,418	1,566.17	69,412	63.16	0.00838	0.04266
RUN 5	0.604	120	1.208	84	1.43810	47.5	0.03028	17,742	0.08106	5,922	0.06077	61,680	1,247.79	75,270	68.50	0.00895	0.05757
RUN 6	1.275	120	2.550	54	4.72222	44.5	0.10612	13,572	0.34794	7,890	0.22003	52,440	1,060.86	45,990	41.85	0.03939	0.20927
RUN 7	1.002	120	2.004	72	2.78333	100.2	0.02778	53,790	0.05174	4,200	0.04800	143790	2,908.87	167,940	152.83	0.00753	0.04559
RUN 8	0.052	120	0.104	56	0.18571	84.5	0.00220	46,116	0.00403	6,474	0.00353	67800	1,371.59	145,680	132.57	0.00070	0.00343
RUN 9	0.050	122	0.102	61	0.16667	67.25	0.00248	30,618	0.00544	6,600	0.00448	90750	1,835.87	123,930	112.78	0.00066	0.00426
RUN 10	0.050	120	0.100	80	0.12500	50.0	0.00250	28,554	0.00438	4,554	0.00378	53,460	1,081.50	57,690	52.50	0.00087	0.00365
AVG.				**74**			**0.03167**		0.08189		**0.06043**					0.01014	0.05743
STD. DEV.				**13**			**0.03070**		0.10056		**0.06337**					0.01130	0.06025

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE : **0.0910**

Table 8

CONTROLLED PM-10 EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	PM-10 per hour IN INLET (lb)	PM-10 per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM-10 ESCAPED INLET (lb)	PM-10 OUT OUTLET (lb)	TOTAL PM-10 RELEASED (lb)	CONCRETE MADE (yd^3)	PM-10 per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	PM-10 per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM-10 per 1000 lb Raw Material (lb)	PM-10 per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING																			
RUN 1	0.878	0.07947	120	83	0.360	0.15893	0.51859	60.5	0.00857	28,786	0.01802	4,932	0.01538	87,240	1,764.87	97,920	89.11	0.00237	0.01458
RUN 2	1.440	0.08302	120	85	0.508	0.16603	0.67427	71.5	0.00943	32,424	0.02080	8,124	0.01663	97,457	1,971.56	99,930	90.94	0.00283	0.01582
RUN 3	1.146	0.03952	119	84	0.433	0.07838	0.51131	70.5	0.00725	29,574	0.01729	7,644	0.01374	95,720	1,936.42	113,100	102.92	0.00208	0.01302
RUN 4	0.628	0.02351	120	83	0.257	0.04703	0.30428	61.5	0.00495	27,598	0.01103	6,248	0.00899	77,418	1,566.17	69,412	63.16	0.00168	0.00858
RUN 5	0.604	0.02289	120	84	0.230	0.04577	0.27587	47.5	0.00581	17,742	0.01555	5,922	0.01166	61,680	1,247.79	75,270	68.50	0.00172	0.01104
RUN 6	1.275	0.02331	120	54	2.172	0.04662	2.21884	44.5	0.04986	13,572	0.16349	7,890	0.10338	52,440	1,060.86	45,990	41.85	0.01851	0.09833
RUN 7	1.002	0.02902	120	72	0.779	0.05805	0.83738	100.2	0.00836	53,790	0.01557	4,200	0.01444	143790	2,908.87	167,940	152.83	0.00226	0.01372
RUN 8	0.052	0.03163	120	56	0.082	0.06327	0.14498	84.5	0.00172	46,116	0.00314	6,474	0.00276	67800	1,371.59	145,680	132.57	0.00054	0.00268
RUN 9	0.050	0.03175	122	61	0.065	0.06455	0.12955	67.25	0.00193	30,618	0.00423	6,600	0.00348	90750	1,835.87	123,930	112.78	0.00051	0.00331
RUN 10	0.050	0.03115	120	80	0.025	0.06231	0.08731	50.0	0.00175	28,554	0.00306	4,554	0.00264	53,460	1,081.50	57,690	52.50	0.00061	0.00255
AVG.				**74**					**0.00996**		0.02722		**0.01931**					0.00331	0.01836
STD. DEV.				**13**					**0.01432**		0.04833		**0.03003**					0.00540	0.02855

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE : **0.0910**

Table 9

PM EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

TRUCK MIX LOADING	PM per hour IN INLET (lb)	TIME (min)	PM IN INLET (lb)	ESTIMATED CAPTURE EFFICIENCY (%)	TOTAL PM RELEASED (lb)	CONCRETE MADE (yd³)	PM per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	PM per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGRE-GATE (lb)	PM per 1000 lb Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
RUN 1	3.500	120	7.000	83	8.43373	60.5	0.13940	28,786	0.29298	4,932	0.25013	87,240	1,764.87	97,920	89.11	0.03853	0.23709
RUN 2	7.079	120	14.158	85	16.65647	71.5	0.23296	32,424	0.51371	8,124	0.41078	97,457	1,971.56	99,930	90.94	0.07000	0.39090
RUN 3	5.124	119	10.163	84	12.09833	70.5	0.17161	29,574	0.40909	7,644	0.32507	95,720	1,936.42	113,100	102.92	0.04917	0.30818
RUN 4	3.322	120	6.644	83	8.00482	61.5	0.13016	27,598	0.29005	6,248	0.23651	77,418	1,566.17	69,412	63.16	0.04430	0.22564
RUN 5	2.468	120	4.936	84	5.87619	47.5	0.12371	17,742	0.33120	5,922	0.24832	61,680	1,247.79	75,270	68.50	0.03659	0.23523
RUN 6	6.163	120	12.326	54	22.82593	44.5	0.51294	13,572	1.68184	7,890	1.06355	52,440	1,060.86	45,990	41.85	0.19039	1.01158
RUN 7	1.029	120	2.058	72	2.85833	100.2	0.02853	53,790	0.05314	4,200	0.04929	143,790	2,908.87	167,940	152.83	0.00773	0.04682
RUN 8	0.063	120	0.126	56	0.22500	84.5	0.00266	46,116	0.00488	6,474	0.00428	67,800	1,371.59	145,680	132.57	0.00085	0.00416
RUN 9	0.101	122	0.205	61	0.33667	67.25	0.00501	30,618	0.01100	6,600	0.00905	90,750	1,835.87	123,930	112.78	0.00134	0.00860
RUN 10	0.099	120	0.198	80	0.24750	50.0	0.00495	28,554	0.00867	4,554	0.00748	53,460	1,081.50	57,690	52.50	0.00172	0.00723
AVG.				**74**			**0.13519**		0.35965		**0.26044**					0.04406	0.24754
STD. DEV.				**13**			**0.15514**		0.49989		**0.31798**					0.05677	0.30241

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE **0.0910**

Table 10

CONTROLLED PM EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

TRUCK MIX LOADING	PM per hour IN INLET (lb)	PM per hour OUT OUTLET (lb)	TIME (min)	ESTIMATED CAPTURE EFFICIENCY (%)	PM ESCAPED INLET (lbs)	PM OUT OUTLET (lb)	TOTAL PM RELEASED (lb)	CONCRETE MADE (yd^3)	PM per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	PM per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	PM per 1000 lb Raw Material (lb)	PM per 1000 lb ``FINES" (lb)
RUN 1	3.500	0.11321	120	83	1.434	0.22642	1.66016	60.5	0.02744	28,786	0.05767	4,932	0.04924	87,240	1,764.87	97,920	89.11	0.00758	0.04667
RUN 2	7.079	0.11827	120	85	2.498	0.23654	2.73501	71.5	0.03825	32,424	0.08435	8,124	0.06745	97,457	1,971.56	99,930	90.94	0.01149	0.06419
RUN 3	5.124	0.05200	119	84	1.936	0.10313	2.03886	70.5	0.02892	29,574	0.06894	7,644	0.05478	95,720	1,936.42	113,100	102.92	0.00829	0.05194
RUN 4	3.322	0.03755	120	83	1.361	0.07511	1.43593	61.5	0.02335	27,598	0.05203	6,248	0.04243	77,418	1,566.17	69,412	63.16	0.00795	0.04048
RUN 5	2.468	0.03655	120	84	0.940	0.07310	1.01329	47.5	0.02133	17,742	0.05711	5,922	0.04282	61,680	1,247.79	75,270	68.50	0.00631	0.04056
RUN 6	6.163	0.03722	120	54	10.500	0.07445	10.57437	44.5	0.23763	13,572	0.77913	7,890	0.49270	52,440	1,060.86	45,990	41.85	0.08820	0.46862
RUN 7	1.029	0.04160	120	72	0.800	0.08320	0.88353	100.2	0.00882	53,790	0.01643	4,200	0.01524	143,790	2,908.87	167,940	152.83	0.00239	0.01447
RUN 8	0.063	0.04534	120	56	0.099	0.09068	0.18968	84.5	0.00224	46,116	0.00411	6,474	0.00361	67,800	1,371.59	145,680	132.57	0.00071	0.00351
RUN 9	0.101	0.04550	122	61	0.131	0.09252	0.22382	67.25	0.00333	30,618	0.00731	6,600	0.00601	90,750	1,835.87	123,930	112.78	0.00089	0.00571
RUN 10	0.099	0.04465	120	80	0.050	0.08930	0.13880	50.0	0.00278	28,554	0.00486	4,554	0.00419	53,460	1,081.50	57,690	52.50	0.00096	0.00405
AVG.				**74**					**0.03941**		0.11319		**0.07785**					0.01348	0.07402
STD. DEV.				**13**					**0.07078**		0.23581		**0.14760**					0.02652	0.14038

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE : **0.0910**

Table 11

CONTROLLED CEMENT SILO FILLING EMISSION FACTORS
CONCRETE READY MIXED CORPORATION
ROANOKE, VA

PM-10

	PM-10 per hour OUT OUTLET (lb)	TIME (min)	PM-10 OUT OUTLET (lb)	CEMENT LOADED (lb)	PM-10 per 1000 lb CEMENT (lb)
CEMENT SILO FILLING					
RUN 1	0.016	123	0.033	147,920	2.22E-004
RUN 2	0.016	125	0.033	97,660	3.41E-004
RUN 3	0.013	185	0.040	146,310	2.74E-004
AVG.					**2.79E-004**
STD. DEV.					**5.99E-005**

PM

	PM per hour OUT OUTLET (lb)	TIME (min)	PM OUT OUTLET (lb)	CEMENT LOADED (lb)	PM per 1000 lb CEMENT (lb)
CEMENT SILO FILLING					
RUN 1	0.023	123	0.047	147,920	3.19E-004
RUN 2	0.021	125	0.044	97,660	4.48E-004
RUN 3	0.016	185	0.049	146,310	3.37E-004
AVG.					**3.68E-004**
STD. DEV.					**6.99E-005**

METALS

	METAL per hour OUT OUTLET (lb)	TIME (min)	METAL OUT OUTLET (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)
RUNS 1, 2 & 3 CEMENT SILO FILLING					
ARSENIC	--	433	--	391,890	--
BERYLLIUM	1.32E-008	433	9.53E-008	391,890	**2.43E-010**
CADMIUM	--	433	--	391,890	--
CHROMIUM	5.53E-007	433	3.99E-006	391,890	**1.02E-008**
LEAD	2.58E-007	433	1.86E-006	391,890	**4.75E-009**
MANGANESE	3.68E-006	433	2.66E-005	391,890	**6.78E-008**
MERCURY	--	433	--	391,890	--
NICKEL	1.05E-006	433	7.58E-006	391,890	**1.93E-008**
PHOSPHORUS	--	433	--	391,890	--
SELENIUM	--	433	--	391,890	--

Table 12

CONTROLLED EMISSION FACTORS FOR FLY ASH SILO FILLING
CONCRETE READY MIXED CORPORATION
ROANOKE, VA

PM-10

	PM-10 per hour OUT OUTLET (lb)	TIME (min)	PM-10 OUT OUTLET (lb)	FLY ASH LOADED (lb)	PM-10 per 1000 lb FLY ASH (lb)
FLY ASH SILO FILLING					
RUN 1	0.204	62	0.211	50,820	4.15E-003
RUN 2	0.078	60	0.078	50,820	1.53E-003
RUN 3	0.081	61	0.082	50,820	1.62E-003
AVG.					**2.43E-003**
STD. DEV.					**1.48E-003**

PM

	PM per hour OUT OUTLET (lb)	TIME (min)	PM OUT OUTLET (lb)	FLY ASH LOADED (lb)	PM per 1000 lb FLY ASH (lb)
FLY ASH SILO FILLING					
RUN 1	0.221	62	0.228	50,820	4.49E-003
RUN 2	0.887	60	0.887	50,820	1.75E-002
RUN 3	0.091	61	0.093	50,820	1.82E-003
AVG.					**7.92E-003**
STD. DEV.					**8.36E-003**

METALS

	METAL per hour OUT OUTLET (lb)	TIME (min)	METAL OUT OUTLET (lb)	FLY ASH LOADED (lb)	METAL per 1000 lb FLY ASH (lb)
RUNS 1, 2 & 3 FLY ASH SILO FILLING					
ARSENIC	2.51E-005	183	7.66E-005	152,460	**5.02E-007**
BERYLLIUM	2.26E-006	183	6.89E-006	152,460	**4.52E-008**
CADMIUM	4.96E-007	183	1.51E-006	152,460	**9.92E-009**
CHROMIUM	3.05E-005	183	9.30E-005	152,460	**6.10E-007**
LEAD	1.30E-005	183	3.97E-005	152,460	**2.60E-007**
MANGANESE	6.40E-006	183	1.95E-005	152,460	**1.28E-007**
MERCURY	--	183	--	152,460	--
NICKEL	5.70E-005	183	1.74E-004	152,460	**1.14E-006**
PHOSPHORUS	8.85E-005	183	2.70E-004	152,460	**1.77E-006**
SELENIUM	1.81E-006	183	5.52E-006	152,460	**3.62E-008**

Table 13.1

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	EST. CAPTURE EFFI-CIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per $yard^3$ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	METAL per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
PRELIMINARY RUN TRUCK MIX LOADING																	
ARSENIC	1.96E-005	120.1	3.92E-005	53	7.40E-005	24	**3.08E-006**	9,486	7.80E-006	2,694	**6.08E-006**	33,810	683.98	44,400	40.40	8.19E-007	5.74E-006
BERYLLIUM	2.12E-006	120.1	4.24E-006	53	8.01E-006	24	**3.34E-007**	9,486	8.44E-007	2,694	**6.57E-007**	33,810	683.98	44,400	40.40	8.86E-008	6.20E-007
CADMIUM	--	120.1	--	53	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40		--
CHROMIUM	3.92E-005	120.1	7.85E-005	53	1.48E-004	24	**6.17E-006**	9,486	1.56E-005	2,694	**1.22E-005**	33,810	683.98	44,400	40.40	1.64E-006	1.15E-005
LEAD	2.74E-005	120.1	5.48E-005	53	1.03E-004	24	**4.31E-006**	9,486	1.09E-005	2,694	**8.50E-006**	33,810	683.98	44,400	40.40	1.14E-006	8.02E-006
MANGANESE	1.16E-004	120.1	2.32E-004	53	4.38E-004	24	**1.83E-005**	9,486	4.62E-005	2,694	**3.60E-005**	33,810	683.98	44,400	40.40	4.85E-006	3.39E-005
MERCURY	--	120.1	--	53	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40		--
NICKEL	5.71E-005	120.1	1.14E-004	53	2.16E-004	24	**8.99E-006**	9,486	2.27E-005	2,694	**1.77E-005**	33,810	683.98	44,400	40.40	2.39E-006	1.67E-005
PHOSPHORUS	--	120.1	--	53	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40		--
SELENIUM	--	120.1	--	53	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40		--
RUNS 1, 2 & 3 TRUCK MIX LOADING																	
ARSENIC	2.70E-005	359	1.62E-004	84	1.92E-004	202.5	**9.50E-007**	90,784	2.12E-006	20,700	**1.73E-006**	280,417	5,672.84	310,950	282.96	2.74E-007	1.64E-006
BERYLLIUM	6.58E-007	359	3.94E-006	84	4.69E-006	202.5	**2.31E-008**	90,784	5.16E-008	20,700	**4.20E-008**	280,417	5,672.84	310,950	282.96	6.67E-009	3.99E-008
CADMIUM	4.93E-007	359	2.95E-006	84	3.51E-006	202.5	**1.73E-008**	90,784	3.87E-008	20,700	**3.15E-008**	280,417	5,672.84	310,950	282.96	5.00E-009	2.99E-008
CHROMIUM	3.45E-005	359	2.06E-004	84	2.46E-004	202.5	**1.21E-006**	90,784	2.71E-006	20,700	**2.20E-006**	280,417	5,672.84	310,950	282.96	3.50E-007	2.09E-006
LEAD	2.04E-005	359	1.22E-004	84	1.45E-004	202.5	**7.18E-007**	90,784	1.60E-006	20,700	**1.30E-006**	280,417	5,672.84	310,950	282.96	2.07E-007	1.24E-006
MANGANESE	2.13E-004	359	1.27E-003	84	1.52E-003	202.5	**7.49E-006**	90,784	1.67E-005	20,700	**1.36E-005**	280,417	5,672.84	310,950	282.96	2.16E-006	1.29E-005
MERCURY	--	359	--	84	--	202.5	--	90,784	--	20,700	--	280,417	5,672.84	310,950	282.96		--
NICKEL	5.48E-005	359	3.28E-004	84	3.90E-004	202.5	**1.93E-006**	90,784	4.30E-006	20,700	**3.50E-006**	280,417	5,672.84	310,950	282.96	5.55E-007	3.32E-006
PHOSPHORUS	--	359	--	84	--	202.5	--	90,784	--	20,700	--	280,417	5,672.84	310,950	282.96		--
SELENIUM	1.64E-006	359	9.81E-006	84	1.17E-005	202.5	**5.77E-008**	90,784	1.29E-007	20,700	**1.05E-007**	280,417	5,672.84	310,950	282.96	1.66E-008	9.95E-008

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE **0.0910**

Table 13.2

METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	METAL per hour IN INLET (lb)	TIME (min)	METAL IN INLET (lb)	EST. CAPTURE EFFI-CIENCY (%)	TOTAL METAL (lb)	CONCRETE MADE (yd^3)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	METAL per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUNS 4, 5 & 6 TRUCK MIX LOADING																	
ARSENIC	2.53E-005	360	1.52E-004	74	2.06E-004	153.5	**1.34E-006**	58,912	3.50E-006	20,060	**2.61E-006**	191,538	3,874.81	190,672	173.51	4.47E-007	2.48E-006
BERYLLIUM	1.21E-006	360	7.26E-006	74	9.86E-006	153.5	**6.42E-008**	58,912	1.67E-007	20,060	**1.25E-007**	191,538	3,874.81	190,672	173.51	2.14E-008	1.19E-007
CADMIUM	1.05E-007	360	6.30E-007	74	8.55E-007	153.5	**5.57E-009**	58,912	1.45E-008	20,060	**1.08E-008**	191,538	3,874.81	190,672	173.51	1.85E-009	1.03E-008
CHROMIUM	2.37E-005	360	1.42E-004	74	1.93E-004	153.5	**1.26E-006**	58,912	3.28E-006	20,060	**2.44E-006**	191,538	3,874.81	190,672	173.51	4.19E-007	2.33E-006
LEAD	2.00E-005	360	1.20E-004	74	1.63E-004	153.5	**1.06E-006**	58,912	2.77E-006	20,060	**2.06E-006**	191,538	3,874.81	190,672	173.51	3.53E-007	1.96E-006
MANGANESE	6.79E-005	360	4.07E-004	74	5.53E-004	153.5	**3.60E-006**	58,912	9.39E-006	20,060	**7.00E-006**	191,538	3,874.81	190,672	173.51	1.20E-006	6.66E-006
MERCURY	--	360	--	74	--	153.5	--	58,912	--	20,060	--	191,538	3,874.81	190,672	173.51		--
NICKEL	4.05E-005	360	2.43E-004	74	3.30E-004	153.5	**2.15E-006**	58,912	5.60E-006	20,060	**4.18E-006**	191,538	3,874.81	190,672	173.51	7.15E-007	3.97E-006
PHOSPHORUS	--	360	--	74	--	153.5	--	58,912	--	20,060	--	191,538	3,874.81	190,672	173.51		--
SELENIUM	3.68E-005	360	2.21E-004	74	3.00E-004	153.5	**1.95E-006**	58,912	5.09E-006	20,060	**3.80E-006**	191,538	3,874.81	190,672	173.51	6.50E-007	3.61E-006
RUNS 7, 8, 9 & 10 TRUCK MIX LOADING																	
ARSENIC	1.17E-005	120	2.34E-005	67	3.48E-005	301.95	**1.15E-007**	159,078	2.19E-007	21,828	**1.92E-007**	355,800	7,197.83	495,240	450.67	3.37E-008	1.85E-007
BERYLLIUM	3.15E-007	120	6.30E-007	67	9.37E-007	301.95	**3.10E-009**	159,078	5.89E-009	21,828	**5.18E-009**	355,800	7,197.83	495,240	450.67	9.08E-010	4.97E-009
CADMIUM	3.94E-008	122	8.01E-008	67	1.19E-007	301.95	**3.95E-010**	159,078	7.49E-010	21,828	**6.59E-010**	355,800	7,197.83	495,240	450.67	1.15E-010	6.32E-010
CHROMIUM	4.49E-005	120	8.98E-005	67	1.34E-004	301.95	**4.42E-007**	159,078	8.39E-007	21,828	**7.38E-007**	355,800	7,197.83	495,240	450.67	1.29E-007	7.08E-007
LEAD	2.56E-005	120	5.12E-005	67	7.61E-005	301.95	**2.52E-007**	159,078	4.79E-007	21,828	**4.21E-007**	355,800	7,197.83	495,240	450.67	7.38E-008	4.04E-007
MANGANESE	1.97E-004	120	3.94E-004	67	5.86E-004	301.95	**1.94E-006**	159,078	3.68E-006	21,828	**3.24E-006**	355,800	7,197.83	495,240	450.67	5.68E-007	3.11E-006
MERCURY	--	120	--	67	--	301.95	--	159,078	--	21,828	--	355,800	7,197.83	495,240	450.67		--
NICKEL	3.31E-005	120	6.62E-005	67	9.84E-005	301.95	**3.26E-007**	159,078	6.19E-007	21,828	**5.44E-007**	355,800	7,197.83	495,240	450.67	9.54E-008	5.22E-007
PHOSPHORUS	--	120	--	67	--	301.95	--	159,078	--	21,828	--	355,800	7,197.83	495,240	450.67		--
SELENIUM	1.58E-006	120	3.16E-006	67	4.70E-006	301.95	**1.56E-008**	159,078	2.95E-008	21,828	**2.60E-008**	355,800	7,197.83	495,240	450.67	4.55E-009	2.49E-008

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE **0.0910**

Table 13.3

AVERAGE OF METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	AVG. METAL per yard³ CONCRETE (lb)	STD. DEV. METAL per yard³ CONCRETE (lb)	AVG. METAL per 1000 lb CEMENT (lb)	STD. DEV. METAL per 1000 lb CEMENT (lb)	AVG. METAL per 1000 lb CEMENT & FLY ASH (lb)	STD. DEV. METAL per 1000 lb CEMENT & FLY ASH (lb)	AVG. METAL per 1000 lb Solid Raw Material (lb)	STD. DEV. METAL per 1000 lb Solid Raw Material (lb)	AVG. METAL per 1000 lb ``FINES" (lb)	STD. DEV. METAL per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING										
ARSENIC	**1.37E-006**	**1.25E-006**	3.41E-006	3.22E-006	**2.65E-006**	2.49E-006	3.93E-007	3.30E-007	2.51E-006	2.35E-006
BERYLLIUM	**1.06E-007**	**1.54E-007**	2.67E-007	3.91E-007	**2.07E-007**	3.04E-007	2.94E-008	4.04E-008	1.96E-007	2.87E-007
CADMIUM	**7.77E-009**	**8.68E-009**	1.80E-008	1.92E-008	**1.43E-008**	1.57E-008	2.32E-009	2.47E-009	1.36E-008	1.49E-008
CHROMIUM	**2.27E-006**	**2.63E-006**	5.61E-006	6.75E-006	**4.39E-006**	5.23E-006	6.34E-007	6.81E-007	4.15E-006	4.93E-006
LEAD	**1.59E-006**	**1.85E-006**	3.94E-006	4.74E-006	**3.07E-006**	3.68E-006	4.45E-007	4.81E-007	2.91E-006	3.47E-006
MANGANESE	**7.82E-006**	**7.33E-006**	1.90E-005	1.89E-005	**1.50E-005**	1.47E-005	2.19E-006	1.89E-006	1.42E-005	1.38E-005
MERCURY	--	--	--	--	--	--	--	--	--	--
NICKEL	**3.35E-006**	**3.85E-006**	8.31E-006	9.84E-006	**6.48E-006**	7.65E-006	9.38E-007	1.00E-006	6.13E-006	7.21E-006
PHOSPHORUS	--	--	--	--	--	--	--	--	--	--
SELENIUM	**6.75E-007**	**1.11E-006**	1.75E-006	2.89E-006	**1.31E-006**	2.15E-006	2.24E-007	3.69E-007	1.24E-006	2.05E-006

Table 14.1

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	EST. CAPTURE EFFI-CIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL RELEASED (lb)	CONCRETE MADE (yd^3)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	METAL per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
PRELIMINARY RUN TRUCK MIX LOADING																			
ARSENIC	1.96E-005	6.62E-007	120.1	53	3.48E-005	1.32E-006	3.61E-005	24	**1.50E-006**	9,486	3.81E-006	2,694	**2.97E-006**	33,810	683.98	44,400	40.40	4.00E-007	2.80E-006
BERYLLIUM	2.12E-006	4.40E-008	120.1	53	3.76E-006	8.81E-008	3.85E-006	24	**1.60E-007**	9,486	4.06E-007	2,694	**3.16E-007**	33,810	683.98	44,400	40.40	4.26E-008	2.98E-007
CADMIUM	--	--	120.1	53	--	--	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40	--	--
CHROMIUM	3.92E-005	1.10E-006	120.1	53	6.96E-005	2.21E-006	7.18E-005	24	**2.99E-006**	9,486	7.57E-006	2,694	**5.89E-006**	33,810	683.98	44,400	40.40	7.94E-007	5.56E-006
LEAD	2.74E-005	1.71E-006	120.1	53	4.86E-005	3.42E-006	5.21E-005	24	**2.17E-006**	9,486	5.49E-006	2,694	**4.27E-006**	33,810	683.98	44,400	40.40	5.76E-007	4.03E-006
MANGANESE	1.16E-004	6.94E-006	120.1	53	2.06E-004	1.39E-005	2.20E-004	24	**9.16E-006**	9,486	2.32E-005	2,694	**1.80E-005**	33,810	683.98	44,400	40.40	2.43E-006	1.70E-005
MERCURY	--	--	120.1	53	--	--	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40	--	--
NICKEL	5.71E-005	4.40E-006	120.1	53	1.01E-004	8.81E-006	1.10E-004	24	**4.59E-006**	9,486	1.16E-005	2,694	**9.04E-006**	33,810	683.98	44,400	40.40	1.22E-006	8.54E-006
PHOSPHORUS	--	--	120.1	53	--	--	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40	--	--
SELENIUM	--	--	120.1	53	--	--	--	24	--	9,486	--	2,694	--	33,810	683.98	44,400	40.40	--	--
RUNS 1, 2 & 3 TRUCK MIX LOADING																			
ARSENIC	2.81E-005	6.62E-007	359	84	3.20E-005	3.96E-006	3.60E-005	202.5	**1.78E-007**	90,784	3.96E-007	20,700	**3.23E-007**	280,417	5,672.84	310,950	282.96	5.12E-008	3.06E-007
BERYLLIUM	7.68E-007	4.40E-008	359	84	8.75E-007	2.63E-007	1.14E-006	202.5	**5.62E-009**	90,784	1.25E-008	20,700	**1.02E-008**	280,417	5,672.84	310,950	282.96	1.62E-009	9.69E-009
CADMIUM	4.93E-007	--	359	84	5.62E-007	--	5.62E-007	202.5	**2.77E-009**	90,784	6.19E-009	20,700	**5.04E-009**	280,417	5,672.84	310,950	282.96	7.99E-010	4.78E-009
CHROMIUM	3.45E-005	1.10E-006	359	84	3.93E-005	6.59E-006	4.59E-005	202.5	**2.27E-007**	90,784	5.06E-007	20,700	**4.12E-007**	280,417	5,672.84	310,950	282.96	6.53E-008	3.91E-007
LEAD	2.04E-005	1.71E-006	359	84	2.32E-005	1.02E-005	3.35E-005	202.5	**1.65E-007**	90,784	3.69E-007	20,700	**3.00E-007**	280,417	5,672.84	310,950	282.96	4.76E-008	2.85E-007
MANGANESE	2.13E-004	6.94E-006	359	84	2.43E-004	4.15E-005	2.84E-004	202.5	**1.40E-006**	90,784	3.13E-006	20,700	**2.55E-006**	280,417	5,672.84	310,950	282.96	4.04E-007	2.42E-006
MERCURY	--	--	359	84	--	--	--	202.5	--	90,784	--	20,700	--	280,417	5,672.84	310,950	282.96	--	--
NICKEL	6.58E-005	4.40E-006	359	84	7.50E-005	2.63E-005	1.01E-004	202.5	**5.00E-007**	90,784	1.12E-006	20,700	**9.09E-007**	280,417	5,672.84	310,950	282.96	1.44E-007	8.63E-007
PHOSPHORUS	--	--	359	84	--	--	--	202.5	--	90,784	--	20,700	--	280,417	5,672.84	310,950	282.96	--	--
SELENIUM	2.74E-006	--	359	84	3.12E-006	--	3.12E-006	202.5	**1.54E-008**	90,784	3.44E-008	20,700	**2.80E-008**	280,417	5,672.84	310,950	282.96	4.44E-009	2.66E-008

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE : **0.0910**

Table 14.2

CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	METAL per hour IN INLET (lb)	METAL per hour OUT OUTLET (lb)	TIME (min)	EST. CAPTURE EFFI-CIENCY (%)	METAL ESCAPED INLET (lb)	METAL OUT OUTLET (lb)	TOTAL METAL RELEASED (lb)	CONCRETE MADE (yd^3)	METAL per yard³ CONCRETE (lb)	CEMENT LOADED (lb)	METAL per 1000 lb CEMENT (lb)	FLY ASH LOADED (lb)	METAL per 1000 lb CEMENT & FLY ASH (lb)	SAND LOADED (lb)	* SILT FROM SAND (lb)	COURSE AGGRE-GATE LOADED (lb)	** SILT FROM AGGR. (lb)	METAL per 1000 lb Solid Raw Material (lb)	METAL per 1000 lb ``FINES" (lb)
RUNS 4, 5 & 6 TRUCK MIX LOADING																			
ARSENIC	2.63E-005	6.62E-007	360	74	5.64E-005	3.97E-006	6.04E-005	153.5	**3.93E-007**	58,912	1.02E-006	20,060	**7.65E-007**	191,538	3,874.81	190,672	173.51	1.31E-007	7.27E-007
BERYLLIUM	1.32E-006	4.40E-008	360	74	2.83E-006	2.64E-007	3.10E-006	153.5	**2.02E-008**	58,912	5.25E-008	20,060	**3.92E-008**	191,538	3,874.81	190,672	173.51	6.71E-009	3.73E-008
CADMIUM	1.05E-007	--	360	74	2.25E-007	--	2.25E-007	153.5	**1.47E-009**	58,912	3.82E-009	20,060	**2.85E-009**	191,538	3,874.81	190,672	173.51	4.88E-010	2.71E-009
CHROMIUM	2.37E-005	1.10E-006	360	74	5.08E-005	6.61E-006	5.74E-005	153.5	**3.74E-007**	58,912	9.75E-007	20,060	**7.27E-007**	191,538	3,874.81	190,672	173.51	1.25E-007	6.92E-007
LEAD	2.00E-005	1.71E-006	360	74	4.29E-005	1.02E-005	5.31E-005	153.5	**3.46E-007**	58,912	9.02E-007	20,060	**6.73E-007**	191,538	3,874.81	190,672	173.51	1.15E-007	6.40E-007
MANGANESE	6.79E-005	6.94E-006	360	74	1.46E-004	4.16E-005	1.87E-004	153.5	**1.22E-006**	58,912	3.18E-006	20,060	**2.37E-006**	191,538	3,874.81	190,672	173.51	4.06E-007	2.26E-006
MERCURY	--	--	360	74	--	--	--	153.5	--	58,912	--	20,060	--	191,538	3,874.81	190,672	173.51	--	--
NICKEL	5.10E-005	4.40E-006	360	74	1.09E-004	2.64E-005	1.36E-004	153.5	**8.85E-007**	58,912	2.30E-006	20,060	**1.72E-006**	191,538	3,874.81	190,672	173.51	2.94E-007	1.64E-006
PHOSPHORUS	--	--	360	74	--	--	--	153.5	--	58,912	--	20,060	--	191,538	3,874.81	190,672	173.51	--	--
SELENIUM	4.73E-006	--	360	74	1.01E-005	--	1.01E-005	153.5	**6.61E-008**	58,912	1.72E-007	20,060	**1.28E-007**	191,538	3,874.81	190,672	173.51	2.20E-008	1.22E-007
RUNS 7, 8, 9 & 10 TRUCK MIX LOADING																			
ARSENIC	1.25E-005	6.62E-007	120	67	1.22E-005	1.32E-006	1.35E-005	301.95	**4.47E-008**	159,078	8.49E-008	21,828	**7.46E-008**	355,800	7,197.83	495,240	450.67	1.31E-008	7.16E-008
BERYLLIUM	3.94E-007	4.40E-008	120	67	3.84E-007	8.80E-008	4.72E-007	301.95	**1.56E-009**	159,078	2.97E-009	21,828	**2.61E-009**	355,800	7,197.83	495,240	450.67	4.57E-010	2.50E-009
CADMIUM	3.94E-008	--	122	67	3.90E-008	--	3.90E-008	301.95	**1.29E-010**	159,078	2.45E-010	21,828	**2.16E-010**	355,800	7,197.83	495,240	450.67	3.78E-011	2.07E-010
CHROMIUM	4.49E-005	1.10E-006	120	67	4.37E-005	2.20E-006	4.59E-005	301.95	**1.52E-007**	159,078	2.89E-007	21,828	**2.54E-007**	355,800	7,197.83	495,240	450.67	4.45E-008	2.44E-007
LEAD	2.56E-005	1.71E-006	120	67	2.49E-005	3.41E-006	2.83E-005	301.95	**9.39E-008**	159,078	1.78E-007	21,828	**1.57E-007**	355,800	7,197.83	495,240	450.67	2.75E-008	1.50E-007
MANGANESE	1.97E-004	6.94E-006	120	67	1.92E-004	1.39E-005	2.06E-004	301.95	**6.81E-007**	159,078	1.29E-006	21,828	**1.14E-006**	355,800	7,197.83	495,240	450.67	1.99E-007	1.09E-006
MERCURY	--	--	120	67	--	--	--	301.95	--	159,078	--	21,828	--	355,800	7,197.83	495,240	450.67	--	--
NICKEL	4.10E-005	4.40E-006	120	67	3.99E-005	8.80E-006	4.87E-005	301.95	**1.61E-007**	159,078	3.06E-007	21,828	**2.69E-007**	355,800	7,197.83	495,240	450.67	4.72E-008	2.58E-007
PHOSPHORUS	--	--	120	67	--	--	--	301.95	--	159,078	--	21,828	--	355,800	7,197.83	495,240	450.67	--	--
SELENIUM	2.37E-006	--	120	67	2.31E-006	--	2.31E-006	301.95	**7.64E-009**	159,078	1.45E-008	21,828	**1.28E-008**	355,800	7,197.83	495,240	450.67	2.24E-009	1.22E-008

* AVG. % SILT CONTENT OF SAND : **2.0230**

** AVG. % SILT CONTENT OF AGGREGATE : **0.0910**

Table 14.3

AVERAGE OF CONTROLLED METAL EMISSION FACTORS FOR CONCRETE BATCHING

CONCRETE READY MIXED CORPORATION

ROANOKE, VA

	AVG. METAL per yard³ CONCRETE (lb)	STD. DEV. METAL per yard³ CONCRETE (lb)	AVG. METAL per 1000 lb CEMENT (lb)	STD. DEV. METAL per 1000 lb CEMENT (lb)	AVG. METAL per 1000 lb CEMENT & FLY ASH (lb)	STD. DEV. METAL per 1000 lb CEMENT & FLY ASH (lb)	AVG. METAL per 1000 lb Solid Raw Material (lb)	STD. DEV. METAL per 1000 lb Solid Raw Material (lb)	AVG. METAL per 1000 lb ``FINES" (lb)	STD. DEV. METAL per 1000 lb ``FINES" (lb)
TRUCK MIX LOADING										
ARSENIC	**5.30E-007**	**6.65E-007**	1.33E-006	1.70E-006	**1.03E-006**	**1.32E-006**	1.49E-007	1.74E-007	9.76E-007	1.25E-006
BERYLLIUM	**4.70E-008**	**7.61E-008**	1.19E-007	1.93E-007	**9.21E-008**	**1.50E-007**	1.28E-008	2.00E-008	8.70E-008	1.42E-007
CADMIUM	**1.46E-009**	**1.32E-009**	3.42E-009	2.99E-009	**2.70E-009**	**2.42E-009**	3.31E-010	3.83E-010	2.57E-009	2.29E-009
CHROMIUM	**9.36E-007**	**1.37E-006**	2.33E-006	3.50E-006	**1.82E-006**	**2.72E-006**	2.57E-007	3.60E-007	1.72E-006	2.57E-006
LEAD	**6.94E-007**	**9.89E-007**	1.73E-006	2.52E-006	**1.35E-006**	**1.96E-006**	1.92E-007	2.59E-007	1.28E-006	1.85E-006
MANGANESE	**3.12E-006**	**4.04E-006**	7.69E-006	1.04E-005	**6.03E-006**	**8.04E-006**	8.60E-007	1.05E-006	5.70E-006	7.58E-006
MERCURY	--	--	--	--	--	--			--	--
NICKEL	**1.53E-006**	**2.06E-006**	3.84E-006	5.25E-006	**2.99E-006**	**4.08E-006**	4.26E-007	5.38E-007	2.82E-006	3.85E-006
PHOSPHORUS	--	--	--	--	--	--			--	--
SELENIUM	**2.97E-008**	**3.17E-008**	7.37E-008	8.59E-008	**5.64E-008**	**6.29E-008**	7.17E-009	1.01E-008	5.37E-008	5.98E-008

4.3 Reference 3

This test report (Reference 3) presents the results of emission testing on the pneumatic transfer of cement to a silo at Allied Concrete Supply, Chicago Illinois on October 17, 1972. The emissions resulting from the silo filling were controlled with two baghouses (Tiberi Engineering Company dust collectors) located on the top of the silo. Because of the low flow rates from the dust collectors, a temporary six inch diameter stack of four feet length was added to one of the collectors. As a result, the emission testing quantified only particulate emissions from one of the two dust collectors. Consequently, the actual amount of total controlled emissions was assumed to be twice the measured amount.

The test method used to collect the emissions appears to be similar to EPA's Test Method Number 5. Explicit isokinetic calculations are not present in the test report. However based upon the 3/8 inch nozzle diameter and 13.67 cubic foot sample volume present in the report, a 99% isokinetic sampling rate can be calculated. Also, while two test runs were performed, meter volumes, nozzle diameters, and filter weights for only one test run are available. The test contains no QA data on meter volumes, nozzle geometry, and size or pitot geometries. Lastly, no details are included in the test report on whether changes were made in the arrangement of the S type pitot and the nozzle because of the small duct diameter. As a consequence of the deficiencies, the test data set from this report is **rated C**.

The following presents results from the report and demonstrates how these results were used to develop a controlled particulate matter (PM) emission factor for cement silo filling.

- **Results from the emission testing:**

Exhaust Loading	0.0139 grains per ft3
Exhaust Rate	115.4 ft3 per min
Test Duration	30 minutes
Cement Loaded	44,340 lb

- Calculations for the PM emission factor for cement silo filling:

$$\text{Lb of PM in inlet per dust collector} = \left(0.0139\,\frac{\text{grains}}{\text{ft}^3}\right)\left(115.4\,\frac{\text{ft}^3}{\text{min}}\right)(30\text{min})\left(\frac{1\,\text{lb}}{7{,}000\text{ grains}}\right)$$

= 0.00687 lb of PM

Total for both collectors = 2 x 0.00687 lb of PM
= 0.0137 lb of PM

$$\text{Lb of PM per 1,000 lb of cement loaded} = \left(\frac{0.0137\text{ lb PM}}{44.34\quad 1{,}000\text{ lb cement loaded}}\right)$$

$$3.10 \times 10^{-4}\,\frac{\text{lb PM}}{1{,}000\text{ lb cement loaded}}$$

4.4 Reference 4

The bulk of this test report (Reference 4) is classified as confidential and was not available for review. Apparently, this test report presents the results of emission testing on the uncontrolled and controlled pneumatic transfer of cement and Pozmix™ (a cement supplement) to a silo for an unknown company in Oklahoma City, Oklahoma in February of 1976. The emissions resulting from the silo filling were controlled with a baghouse (type unknown).

Only one page of information is available. This page includes process weights, permissible emissions, measured emissions, calculated baghouse control efficiencies and isokinetic variations for each of the twelve runs. This limited information is insufficient for determining whether the test method was in accordance with EPA standards. Consequently, the test data set from this report is **rated D**.

The following presents results from the report and demonstrates how these results were used to develop a controlled particulate matter (PM) emission factor for both cement silo filling and cement supplement silo filling.

- Results from the cement emission testing

Test 1 Cement Emission Rate	=	0.085 lb/hr	Baghouse efficiency	=	97.6%
Test 2 Cement Emission Rate	=	0.044 lb/hr	Baghouse efficiency	=	99.2%
Test 3 Cement Emission Rate	=	0.039 lb/hr	Baghouse efficiency	=	99.3%
Average	**=**	**0.056 lb/hr**			

- **Calculations for the PM emission factor for cement silo filling:**

Since the rate for all three transfers was 47,000 $\frac{\text{lb cement loaded}}{\text{hour}}$, the average emission factor was:

$$\text{Average Emission Factor} = \frac{0.056\,\frac{\text{lb PM}}{\text{hour}}}{47\,\frac{1000\text{ lb cement loaded}}{\text{hour}}}$$

$$= 1.2 \text{ x } 10^{-3}\,\frac{\text{lb PM}}{1000\text{ lb cement loaded}}$$

- **Results from the Pozmix™ emission testing:**

Test 1 Pozmix™ Emission Rate	=	0.1328 lb/hr	Baghouse efficiency	=	99.2%
Test 2 Pozmix™ Emission Rate	=	0.0940 lb/hr	Baghouse efficiency	=	98.5%
Test 3 Pozmix™Emission Rate	=	0.0541 lb/hr	Baghouse efficiency	=	99.0%
Average	**=**	**0.0936 lb/hr**			

- **Calculations for the PM emission factor for Pozmix™ silo filling:**

Since the rate for all three transfers was 92,500 $\frac{\text{lb cement loaded}}{\text{hour}}$, the average emission factor was:

$$\text{Average Emission Factor} = \frac{0.0936 \frac{\text{lb PM}}{\text{hour}}}{92.5 \frac{\text{1000 lb cement loaded}}{\text{hour}}}$$

$$= 1.01\text{x}10^{-3} \frac{\text{lb PM}}{\text{1000 lb cement loaded}}$$

4.5 Reference 5

This report (Reference 5) documents particulate emissions testing conducted by the State of Tennessee, Division of Air Pollution Control of a silo filling operation at Specialty Alloys Corporation in Gallaway, Tennessee. The silo filling operation was controlled by a water impingement scrubber made from a 55 gallon drum with a burlap cover. Emission testing was accomplished with a high volume air sampler held at a single point approximately two feet above the rim of the barrel. Two sets of emissions tests were conducted. The first series were three runs during a lowered loading rate while one layer of burlap covered the drum. Opacities averaged 30% and ranged from 5% to 80% during these test runs. The second series were two runs during a normal loading rate while two layers of burlap covered the drum. Opacities averaged less than 20% and ranged from 5% to 15% during the second run. The test report presents average emissions rates of 0.11 lb/hr during the first test series and 0.04 lb/hr during the second test series. Approximately 26.5 tons of cement was unloaded during each test series. The data documented in this reference are not suitable for developing emission factors. The control device is unique and atypical of those typically used for controlling silo filling emissions. The emission testing methodology used is unlikely to provide a reasonable quantification of the emissions which are fugitive in nature. The test report is not rated.

4.6. Information Useful for Estimating Emission Factors for Traversing Paved and Unpaved Roads and for Loading Aggregate and Sand to Elevated Bins (data are from Reference 1 and Reference 2)

Tables 15.1 and 16.1 present information presented in references 1 and 2 that are parameters needed to estimate emissions using methodologies contained in other AP-42 sections. Table 16.2 presents summary statistical information of the batch formulations that were produced during the emissions testing documents in references 1 and 2. Table 16.3 presents the application of the methodology presented in AP-42 Section 13.2.4, *Aggregate Handling and Storage Piles***,** and used to develop the final emissions factors for loading aggregate and sand to storage piles, and to elevated bins.

Table	**Table Name**
15.1	Percent Silt and Silt Loading of Road Surfaces
16.1	Silt & Moisture Content of Aggregate and Sand
16.2	Batch Formulation Summary Statistics
16.3	Emission Factors for Aggregates & Sand Transfer to Elevated Bins

Table 15.1

PERCENT SILT & SILT LOADING OF ROAD SURFACES

		Sample Number	Avg. % Silt Content (%)
Unpaved	Chaney Enterprises	2	6.131
		3	9.172
	Average	--	**7.652**

			Sample Number	Avg. % Silt Content (%)	Sample Mass (g)	Silt Mass (g)	Sample Area (m²)	Silt Loading (g/m²)
Paved (uncontrolled)		Chaney Enterprises	1	16.908	5,614	949.2	37.16	25.54
			4	11.375	6,124	696.6	10.41	66.94
			Average	**14.1415**	**5,869**	**822.9**	**23.7838**	**46.2437**
	*	AP-42	**Average**	--	--	--	--	**12.00**
		Average of Averages	--	--	--	--	--	**29.1218**
Paved (controlled)		Concrete Ready Mixed	1	10.727	8,732	936.7	31.39	29.85
			2	12.540	2,722	341.3	48.45	7.04
			Average	**11.63355**	**5,727**	**639.0**	**39.9179**	**18.4452**

* The value from AP-42 is taken from Table 13.2.1-3 in Chapter 13.2.1 (10/97).

Table 16.1

SILT & MOISTURE CONTENT OF AGGREGATE & SAND

		Sample Description	Avg. % Silt Content (%)	Avg. % Moisture (%)
Aggregate	Chaney Enterprises	Course Chaney Stone	0.1398	3.28
		Course Black Aggregate	0.3535	0.61
		Average	**0.2467**	**1.95**
	Concrete Ready Mixed	Aggregate Gravel	**0.0910**	**1.59**
	Average of Facilities	**--**	**0.1688**	**1.77**
Sand	Chaney Enterprises	Sand 1	1.8216	4.88
		Sand 2	2.4295	4.87
		Sand 3	2.4742	5.26
		Average	**2.2418**	**5.00**
	Concrete Ready Mixed	Sand from West Pit (Right)	2.0230	3.29
		Sand from West Pit (Left)		3.39
		Average	**2.0230**	**3.34**
	Average of Facilities	**--**	**2.1324**	**4.17**

Table 16.2

BATCH FORMULATION SUMMARY STATISTICS

	Concrete Ready Mixed Corp., Roanoke, VA												
	Course Aggregate		Sand		Cement		Fly Ash		Cement + Fly Ash		Water		Total weight
	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(gal/yard)	(weight %)	(lbs/yard)
Average	1864.8	45.1%	1454.2	35.4%	467.6	11.4%	97.1	2.5%	565	13.9%	27.3	5.7%	4111
Standard Deviation	593.5	10.8%	484.9	8.6%	167.6	3.8%	67.2	2.1%	150	3.8%	5.8	1.9%	746
Median	1839.9	46.4%	1440.0	34.9%	470.4	11.3%	116.8	2.7%	563	12.7%	27.1	5.7%	3976
5th Percentile	853.2	37.4%	1183.0	28.5%	284.6	7.2%	0.0	0.0%	414	10.5%	22.5	4.1%	3277
10th Percentile	1677.5	42.6%	1221.8	29.6%	289.8	7.3%	0.0	0.0%	422	10.7%	25.6	4.1%	3846
25th Percentile	1788.8	45.1%	1249.7	31.3%	371.2	9.3%	72.0	1.8%	478	11.7%	26.2	5.5%	3953
50th Percentile	1839.9	46.4%	1440.0	34.9%	470.4	11.3%	116.8	2.7%	563	12.7%	27.1	5.7%	3976
75th Percentile	1868.8	47.0%	1508.0	37.1%	535.1	13.5%	128.0	3.2%	624	15.8%	28.8	6.0%	4148
90th Percentile	2830.3	55.1%	1674.4	39.1%	612.0	15.5%	143.4	3.6%	687	17.4%	31.0	6.4%	5249
95th Percentile	2906.0	55.4%	1770.3	42.6%	615.8	15.6%	152.7	4.4%	692	18.6%	33.0	7.6%	5329
Count	154												

	Chaney Enterprises, Waldorf, MD													
	Course Aggregate			Sand		Cement		New Cem		Cement + New Cem		Water		Total weight
	(lbs/yard)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(gal/yard)	(weight %)	(lbs/yard)
Average	3141	1865	47.0%	1413	35.5%	504	12.7%	59	1.4%	563	14.1%	16	3.4%	3975
Standard Deviation	388	230	6.4%	218	5.4%	114	3.1%	161	3.7%	275	3.1%	4	1.1%	266
Median	3160	1876	47.8%	1386	35.1%	527	13.7%	0	0.0%	527	14.3%	16	3.4%	3931
5th Percentile	3041	1805	42.5%	1221	31.2%	260	6.1%	0	0.0%	260	7.3%	8	1.7%	3762
10th Percentile	3080	1829	44.1%	1252	32.6%	278	6.9%	0	0.0%	278	11.5%	10	2.1%	3814
25th Percentile	3128	1857	47.0%	1307	33.8%	469	11.9%	0	0.0%	469	12.7%	14	2.8%	3862
50th Percentile	3160	1876	47.8%	1386	35.1%	527	13.7%	0	0.0%	527	14.3%	16	3.4%	3931
75th Percentile	3253	1932	48.7%	1453	36.0%	565	14.5%	15	0.4%	580	15.5%	19	3.9%	4046
90th Percentile	3304	1962	49.5%	1620	38.4%	610	15.7%	467	10.6%	1077	17.5%	20	4.3%	4281
95th Percentile	3331	1978	50.3%	1640	41.6%	623	16.2%	515	11.6%	1138	18.6%	21	4.5%	4416
Count	266													

Values in first column of course aggregate are as reported on weigh sheets. Since the average value is significantly greater than the average for Concrete Ready Mix, typical formulations and results in a yard of concrete weight significantly higher than typical, all course aggregate weights were adjusted by a common ratio to achieve the average presented.

	Combined Summary Statistics for Two Plants													
		Course Aggregate		Sand		Cement		Fly Ash / New Cem		Cement + Pozolan		Water		Total weight
		(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(lbs/yard)	(weight %)	(gal/yard)	(weight %)	(lbs/yard)
Average		1864.9	46.3%	1428.4	35.5%	490.7	12.3%	73.0	1.8%	563.8	14.0%	20.1	4.2%	4024.6
Standard Deviation		403.4	8.4%	341.6	6.8%	137.4	3.4%	135.5	3.3%	140.4	3.4%	7.4	1.8%	503.3
Median		1864.4	47.3%	1394.5	35.0%	514.2	12.7%	3.4	0.1%	562.2	14.0%	18.9	3.9%	3956.4
5th Percentile		1699.0	41.8%	1210.0	29.3%	260.0	6.6%	0.0	0.0%	280.3	9.3%	8.8	1.9%	3710.3
10th Percentile		1788.8	43.0%	1233.3	30.9%	289.5	7.3%	0.0	0.0%	418.2	10.8%	10.8	2.3%	3812.8
25th Percentile		1833.1	45.6%	1300.8	33.0%	440.3	9.6%	0.0	0.0%	493.0	12.1%	15.2	3.2%	3892.0
50th Percentile		1864.4	47.3%	1394.5	35.0%	514.2	12.7%	3.4	0.1%	561.1	14.0%	18.9	3.9%	3956.9
75th Percentile		1907.6	48.5%	1477.6	36.4%	564.2	14.4%	116.7	2.7%	616.8	15.6%	26.8	5.6%	4071.5
90th Percentile		1971.3	50.2%	1624.6	38.9%	611.3	15.5%	144.0	3.7%	690.0	17.5%	28.8	6.1%	4406.8
95th Percentile		2750.0	52.7%	1703.2	41.7%	620.0	16.2%	470.0	11.6%	776.2	18.6%	30.6	6.4%	5240.9
Count		420												

Table 16.3

EMISSION FACTORS FOR AGGREGATE & SAND TRANSFER TO ELEVATED BINS

Aggregate Transfer Emission Factors			
PM-10		PM	
1.68E-003	kg/Mg	**3.54E-003**	kg/Mg
3.27E-003	lb/ton	**6.92E-003**	lb/ton

Sand Transfer Emission Factors			
PM-10		PM	
5.05E-004	kg/Mg	**1.07E-003**	kg/Mg
9.86E-004	lb/ton	**2.08E-003**	lb/ton

The emission factors were developed from the following formulas from AP-42 Section 13.2.4:

This formula was used to compute the emission factors for the metric units.

E = k (.0016) [(U/2.2)^1.3 / (M/2)^1.4]

This formula was used to compute the emission factors for the english units.

E = k (.0032) [(U/5)^1.3 / (M/2)^1.4]

E	=	emission factors (kg / Mg & lb / ton)								
k	=	particle size multiplier for PM-10	k	=	0.35					
k	=	particle size multiplier for PM	k	=	0.74					
U	=	mean wind speed (m/s & mph)	U	=	4.48	m/s	U	=	10	mph
M	=	material moisture content for aggregate (%)	M	=	1.77	%				
M	=	material moisture content for sand (%)	M	=	4.17	%				

4.7 Reference 6

Reference 6 concerned a series of emission test programs sponsored by The Ready Mixed Concrete Research Foundation (RMC Research Foundation) at six ready mixed concrete facilities located in North Carolina, Virginia, and South Carolina. The purpose of this project is to prepare an updated and expanded set of AP-42, Chapter 11.12 emission factors for total particulate matter, PM_{10}, $PM_{10\text{-}2.5}$, $PM_{2.5}$, and arsenic from truck mix and central mix process operations at ready mixed concrete plants.

Three truck mix operations and three central mix operations are included in the scope of this test program. Reference 6 presents the results of December 2003, February 2004 and May 2004 emission factor testing at the (1) Ready Mixed Concrete Company, Inc. (RMCC) truck mix and central mix operations at the Wake Forest, North Carolina plant, (2) the S.T. Wooten central mix plant in Raleigh, N.C., (3) the Chandler Concrete truck mix plant in Troutville, Virginia, (4) the Concrete Supply truck mix plant in Rock Hill, South Carolina, and (5) the RMC Carolina Materials central mix plant in Raleigh, North Carolina.

The test program was designed to provide emission factor data at the following locations at ready mixed concrete plants.

- Outlet of the fabric filter collector serving the mixing operation
- Inlet to the fabric filter collector serving the mixing operation
- Fugitive emissions from the mixing operations and trucks

The inlets of the fabric filters were tested using EPA reference methods in conventional ducts. During the tests at RMCC Wake Forest, EPA reference method tests were also conducted in the fabric filter outlet ducts. During the subsequent tests at S.T. Wooten Raleigh, Chandler Concrete Troutville, Concrete Supply Rock Hill, and RMC Carolina Materials, the fabric filter outlet PM_{10} emissions were measured using a continuous particulate matter monitor that was sensitive to the low mass loadings present in the effluent gas streams from the fabric filters.

Fugitive emissions from the mixing operations were measured simultaneously with the tests at the inlet and outlet to the fabric filter. The fugitive emissions were captured in a set of sampling arrays that were located immediately adjacent to the fugitive emission points.

U.S. EPA Conditional Test Method 040 was conducted at the inlets of the mixing operation fabric filter particulate matter control devices to simultaneously measure the concentrations of (1) total particulate matter, (2) PM_{10} particulate matter, (3) $PM_{10\text{-}2.5}$ particulate matter, and (4) $PM_{2.5}$ particulate matter. The PM_{10}, $PM_{10\text{-}2.5}$, and $PM_{2.5}$ emission concentrations were measured directly in this sampling train by partitioning the captured particulate matter into several size ranges. PM_{10} was measured as the sum of the $PM_{10\text{-}2.5}$ and $PM_{2.5}$ particulate matter. Total particulate matter was measured as the sum of PM_{10} particulate matter and all of the solids having a size greater than 10 micrometers that were captured in the cyclone and sampling train. There is a possible bias to higher-than-true total particulate matter concentration results due to the geometry of the PM_{10} cyclone, the short length of the sampling nozzle, and the inertia of particles larger than 10 micrometers in the sampling gas stream. Despite this possible bias, it was decided to measure the total particulate matter using the Preliminary Method 4 sampling train due to the ability to collect data in all size ranges simultaneously.

During the tests at RMCC Wake Forest, EPA Preliminary Method 4 was also used at the fabric filter outlet; however, the total particulate matter catch weights in the sampling trains ranged from only 1.0 to 2.3 milligrams. These small catch weights were distributed in several different particle size fractions. Air Control Techniques, P.C. determined that tests sponsored by EPA[1] in 1993 also experienced low catch weights. To minimize data precision problems at these low catch weights, Air Control Techniques, P.C. proposed to the RMC Research Foundation to modify the fabric filter outlet tests procedures to use a tapered element oscillating microbalance (TEOM) continuous particulate matter monitor. This instrument is sensitive down to particulate matter concentrations of less than 10 micrograms per cubic meter and is therefore very appropriate for testing low concentration particulate matter gas streams. During the tests at S.T. Wooten (central mix), Chandler Concrete (truck mix), Concrete Supply (truck mix) and RMC Carolina Materials (central mix), a PM_{10} TEOM was used at the fabric filter outlet, and EPA Preliminary Method 4 was used only at the fabric filter inlet.

The presently available hood capture efficiency data were obtained during 1993 tests sponsored by EPA at two plants: one in Maryland and one in Virginia. In both test programs, EPA used qualitative visible emission evaluations to estimate capture efficiency. Air Control Techniques, P.C. use of a TEOM based downwind emissions profiling sampling method provides a quantitative methodology to determine the emissions which escape capture of the batch loading system, thereby eliminating the subjective nature of determining capture efficiency using visible observation methods in the source tests documented in references 1 and 2. Based on the TEOM instrument system, Air Control Techniques, P.C. designed and used a downwind sampling array to quantify the capture efficiency of the ready mixed concrete plant hood systems. This sampling array design was based on the sampling principles adopted by EPA in Method 5D (40 CFR Part 60, Appendix A, Method 5D) used for sampling open top fabric filter systems. This sampling array is also similar to the traversing hood system designed and used by Air Control Techniques, P.C. to measure fugitive particulate matter emissions[2] from sloped vibrating screens at stone crushing plants.

Air Control Techniques, P.C. used a set of downwind sampling arrays mounted vertically on the side walls of the truck loading area and at the inlet of central mixing operations to measure the fugitive dust mass flux through a defined 200 square foot area[3]. Due to space constraints, the downwind sampling arrays were limited to a 140 square foot area for all of the following tests at both truck and central mix facilities. The sampling arrays were mounted directly adjacent to the transfer operations, and portions of the arrays were close to parts of the truck receiving concrete. There were sixty sampling points in the set of two arrays; this number of points exceeds the requirements of EPA Method 5D. The area monitored by the sampling arrays included all of the downwind area subject to dispersion of the fugitive particulate matter. The gas transport velocities through all sampling tubes and ductwork were maintained at a minimum of 3,500 feet per minute to prevent settling of dust in the tubes and ductwork. Method 22 visual observations were conducted during the run. These observations also provided qualitative supporting information concerning the fugitive particulate matter concentrations.

Each of the sampling arrays was ducted together to yield a single sample gas stream. This gas stream was directed past an enlarged duct with the intake for an ambient TEOM monitor meeting the requirements of Method IO-1.3 (the *Compendium of Methods for the Determination of PM_{10} In Inorganic Compounds in Ambient Air Using A Continuous Rupprecht And Patashnick [R&P] Teom® Particle Monitor*). The gas flow rate through this enclosure was maintained at less than 5 mph. The TEOM had a PM_{10} sampling head and operated at a flow rate of 16.67 liters per minute. The TEOM was operated in accordance with Method IO-1.3. The instrument was calibrated in accordance with Section 12.1 of Method IO-1.3.

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[1] EPA References 9 and 10 in AP-42 Section 11.12.

[2] The emission factors measured using the screening operation traversing hood system have been published in AP-42 Section 11.19.2 (Fifth Edition, 1995).

[3] The array area for the inlet to the central mixer was limited to 140 square feet due to space constraints.

The TEOM instrument was mounted on a secure base. The instrument was protected from severe vibration. The TEOM was equilibrated prior to the start of the first test run on each test day.
The fugitive PM_{10} emissions (PM_{10} escaping the plant hood system) were measured by multiplying the measured ambient PM_{10} concentration by the ambient air flow rate through the sampling array. A Davis Instruments, Inc. meteorological monitoring station was located within 20 feet of the sampling arrays and at the same elevation as the sampling arrays to measure the wind direction and wind speed through the arrays. During the initial set of tests at the RMCC Plant in December 2003, Air Control Techniques, P.C. determined that the meteorological monitoring equipment was subject to swirling and suppressed winds caused by the deflection of ambient wind by the plant equipment and trucks in the immediate vicinity of the monitoring equipment. Accordingly, Air Control Techniques, P.C. obtained confirming wind speed data from a local meteorological monitoring station located within ten miles of the plant site. During the tests at S.T. Wooten, Chandler Concrete, Concrete Supply, and RMC Carolina Materials, Air Control Techniques, P.C. used multiple wind speed and direction monitoring stations on the plant site located in areas immediately adjacent to the sampling array to provide confirmation data. Wind pennants were also mounted on the arrays to provide a direct indication of wind direction through the array.

All of the particulate matter measured by the TEOM during the time that the equipment being tested was operating was assumed to originate as fugitive emissions from the mixing operation being tested. This approach introduced a bias to lower-than-true capture efficiency due to the presence of ambient PM_{10} in the ambient air upwind of the plant and due to other fugitive PM_{10} sources in the plant area (i.e. roadways and truck exhaust). There was no practical means to identify and correct for these other sources of PM_{10} on a continuous basis.

During the initial set of tests at the RMCC plant sources, Air Control Techniques, P.C. determined that the particulate matter catch weights were extremely low due to the high efficiency of the fabric filter. Air Control Techniques, P.C revised the testing procedures prior to the tests at S.T. Wooten, Chandler Concrete, Concrete Supply, and RMC Carolina Materials to address this issue. A second TEOM monitor was used to provide a more sensitive and precise measurement of particulate matter emissions from the fabric filter. The entire fabric filter outlet gas stream was captured and directed through a duct with an installed TEOM monitor. The TEOM was used to provide a continuous indication of the PM_{10} concentration in the fabric filter effluent gas stream. Total particulate matter emissions were calculated based on (1) the measured PM_{10} emissions from the fabric filter and (2) the total PM/ PM_{10} ratio at the inlet to the fabric filter. The total PM/ PM_{10} ratio was checked based on scanning electron microscopy sizing of filter samples obtained at the fabric filter outlet.

The results of the controlled[4] emission factor tests are summarized in Table 17.1 for the truck mix sources and Table 17.2 for the central mix sources. Uncontrolled emission factor data for truck mix sources and central mix sources are provided in Tables 17.3 and 17.4 respectively.

The RMC Research Foundation measured emission factors for filterable particulate matter and PM_{10} particulate matter are compared with previously published AP-42 emission factors (controlled conditions). No emission factors were previously available for $PM_{10-2.5}$ (termed "coarse particulate matter") and $PM_{2.5}$ (termed "fine particulate matter"). The run-by-run data used in compiling Tables 17.1 and 17.2 are provided in Tables 17.5 through 17.10.

[4] Controlled emissions are the total of emissions from the fabric filter used to control the mixing operation plus the fugitive emissions not captured by the hood.

Table 17.1 Reference 6 Truck Mix Emission Factor Test Results

Emission Factors	RMCC Raleigh Truck Mix (Controlled)	Chandler Concrete Truck Mix (Controlled)	Concrete Supply Truck Mix (Controlled)	Reference 6 Truck Mix Average
Emission Factors	Lbs./ton	Lbs./ton	Lbs./ton	Lbs./ton
Total Particulate Matter	0.0094	0.0512	0.0197	0.0268
PM_{10}	0.0039	0.0225	0.0035	0.0100
$PM_{10-2.5}$	0.0033	0.0195	0.0032	0.0086
$PM_{2.5}$	0.0007	0.0031	0.0003	0.0013
Truck Hood, %	99.5	93.1	99.3	97.3

1. All emission factors expressed as pounds of mass per ton of cement and cement supplement processed.
2. Ratio calculated based on penetration; 100%-97.3% for RMC Research Foundation tests, 100% - 71% for previous tests.

Table 17.2. Reference 6 Central Mix Emission Factor Test Results

Emission Factors	RMCC Raleigh Central Mix (Controlled)	S.T. Wooten Raleigh Central Mix (Controlled)	RMC Carolina Materials Raleigh Central Mix (Controlled)	Reference Central Mix Average
Emission Factors	Lbs./ton	Lbs./ton	Lbs./ton	Lbs./ton
Total Particulate Matter	0.0042	0.0402	0.0191	0.0212
PM_{10}	0.0028	0.0095	0.0049	0.0057
$PM_{10-2.5}$	0.0014	0.0087	0.0043	0.0048
$PM_{2.5}$	0.0014	0.0007	0.0006	0.0009
Central Mix Hood, %	99.3	97.5	97.2	98.0

1. All emission factors expressed as pounds of mass per ton of cement and cement supplement processed
2. Ratio calculated based on penetration; 100%-98% for RMC Research Foundation tests, 100% - 94% for previous tests.

Table 17.3 Reference 6 Truck Mix Uncontrolled Emission Factor Test Results

Emission Factors	RMCC Raleigh Truck Mix (Uncontrolled)	Chandler Concrete Truck Mix (Uncontrolled)	Concrete Supply Truck Mix (Uncontrolled)	Reference 6 Truck Mix Average
Emission Factors	Lbs./ton	Lbs./ton	Lbs./ton	Lbs./ton
Total Particulate Matter	2.128	0.544	1.693	1.455
PM_{10}	0.726	0.232	0.291	0.416
$PM_{10-2.5}$	0.624	0.200	0.265	0.363
$PM_{2.5}$	0.102	0.032	0.026	0.053

1. All emission factors expressed as pounds of mass per ton of cement and cement supplement processed.

Table 17.4 Reference 6 Central Mix Uncontrolled Emission Factor Test Results

Emission Factors	RMCC Raleigh Central Mix (Uncontrolled)	S.T. Wooten Raleigh Central Mix (Uncontrolled)	RMC Carolina Materials Raleigh Central Mix (Uncontrolled)	Reference Central Mix Average
Emission Factors	Lbs./ton	Lbs./ton	Lbs./ton	Lbs./ton
Total Particulate Matter	0.155	1.254	0.654	0.688
PM_{10}	0.056	0.331	0.160	0.183
$PM_{10-2.5}$	0.047	0.306	0.141	0.165
$PM_{2.5}$	0.009	0.025	0.020	0.018

1. All emission factors expressed as pounds of mass per ton of cement and cement supplement processed.

Table 17.5 Wake Forest RMCC Truck Mix Emissions Data

Test Results	Run # 1 12/8/03	Run # 2 12/8/03	Run # 3 12/9/03	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	36.1	130.5	64.6	77.1
Measured PM_{10} Emissions Thru Array, lbs./hour	0.0026	0.0120	0.0043	0.0063
Calculated Total Emissions Thru Array, lbs./hour	0.0084	0.0465	0.0116	0.0222
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0003	0.0012	0.0006	0.0007
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0023	0.0109	0.0036	0.0056
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	3.2497	3.9991	32.1562	13.1350
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.0214	0.0139	0.0211	0.0188
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	1.0090	1.0351	11.8126	4.6189
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.0214	0.0042	0.0211	0.0156
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.1247	0.0989	1.7750	0.6662
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.00005	0.0014	0.00703	0.0028
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.8843	0.9362	10.0376	3.9527
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.0214	0.0028	0.0141	0.0128
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	3.22	3.86	2.72	3.27
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.12	0.10	0.15	0.12
$PM_{10-2.5}/PM_{10}$ Ratio for TEOM $PM_{10-2.5}$ Calculation	0.88	0.90	0.85	0.88
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	8.58	3.00	6.91	6.16
Total Particulate Emission Factor, lbs./ton	0.00347	0.02011	0.00468	0.00942
Total PM_{10} Emission Factor, lbs./ton	0.00280	0.00538	0.00362	0.00393
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.00276	0.00452	0.00253	0.00327
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.00003	0.00086	0.00109	0.00066
Collection Efficiencies				
Fabric Filter Total Efficiency	99.3%	99.7%	99.9%	99.6%
Truck Hood PM_{10} Efficiency	99.7%	98.8%	99.9%	99.5%
System Collection Efficiency	97.6%	98.4%	99.8%	98.6%

Table 17.6. Wake Forest RMCC Central Mix Emissions Data

Test Results	Run # 1 12/10/03	Run # 2 12/11/03	Run # 3 12/11/03	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	18.8	16.4	57.9	31.0
Measured PM_{10} Emissions Thru Array, lbs./hour	0.0009	0.0020	0.0067	0.0032
Calculated Total Emissions Thru Array, lbs./hour	0.0029	0.0053	0.0178	0.0087
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0003	0.0003	0.0010	0.0005
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0006	0.0018	0.0057	0.0027
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	0.6950	1.5389	1.3322	1.1887
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.0270	0.0198	0.0262	0.0243
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	0.2094	0.5922	0.4987	0.4334
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.0270	0.0128	0.0148	0.0182
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.0617	0.0799	0.0729	0.0715
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.0170	0.0000	0.0103	0.0091
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.1477	0.5123	0.4258	0.3619
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.0099	0.0128	0.0046	0.0091
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	3.32	2.60	2.67	2.86
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.29	0.13	0.15	0.19
$PM_{10-2.5}$/PM_{10} Ratio for TEOM $PM_{10-2.5}$ Calculation	0.71	0.87	0.85	0.81
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	6.82	8.88	7.18	7.63
Total Particulate Emission Factor, lbs./ton	0.00431	0.00232	0.00612	0.00425
Total PM_{10} Emission Factor, lbs./ton	0.00401	0.00134	0.00299	0.00278
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.00153	0.00130	0.00142	0.00142
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.00249	0.00003	0.00157	0.00136
Collection Efficiencies				
Fabric Filter Total Efficiency	96.1%	98.7%	98.0%	97.6%
Truck Hood PM_{10} Efficiency	99.6%	99.7%	98.7%	99.3%
System Collection Efficiency	86.7%	97.5%	95.7%	93.3%

Table 17.7. S.T. Wooten Central Mix Emissions Data

Test Results	Run # 1 3/2/04	Run # 2 3/2/04	Run # 3 3/2/04	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	80.86	426.70	402.62	303.4
Measured PM_{10} Emissions Thru Array, lbs./hour	0.0261	0.1616	0.0501	0.0792
Calculated Total Emissions Thru Array, lbs./hour	0.1088	0.9414	0.1119	0.3874
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0023	0.0136	0.0029	0.0063
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0238	0.1480	0.0471	0.0730
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	13.46	14.82	12.74	13.67
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.047	0.049	0.274	0.123
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	3.22	2.54	5.7	3.82
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.011	0.008	0.122	0.047
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.28	0.21	0.33	0.28
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.00098	0.00070	0.0071	0.00294
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	2.94	2.33	5.36	3.55
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.0103	0.0076	0.1152	0.0444
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	4.17	5.83	2.24	4.08
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.09	0.08	0.06	0.08
$PM_{10-2.5}$/PM_{10} Ratio for TEOM $PM_{10-2.5}$ Calculation	0.91	0.92	0.94	0.92
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	7.90	13.10	15.27	12.09
Total Particulate Emission Factor, lbs./ton	0.01972	0.07560	0.02526	0.04020
Total PM_{10} Emission Factor, lbs./ton	0.00470	0.01240	0.01127	0.00945
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.00428	0.01131	0.01061	0.00873
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.00042	0.00109	0.00065	0.00072
Collection Efficiencies				
Fabric Filter Total Efficiency	99.6%	99.7%	97.9%	99.0%
Truck Hood PM_{10} Efficiency	99.2%	94.0%	99.1%	97.5%
System Collection Efficiency	98.8%	93.3%	97.0%	96.4%

Table 17.8. Chandler Concrete, Troutville Truck Mix Emissions Data

Test Results	Run # 1 12/8/03	Run # 2 12/8/03	Run # 3 12/9/03	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	983.4	495.3	1511.2	996.6
Measured PM_{10} Emissions Thru Array, lbs./hour	0.0786	0.0991	0.0886	0.0887
Calculated Total Emissions Thru Array, lbs./hour	0.1623	0.2099	0.2410	0.2044
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0163	0.0098	0.0108	0.0123
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0622	0.0893	0.0777	0.0764
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	2.52	1.80	5.62	3.32
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.065	0.064	0.150	0.093
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	1.221	0.851	2.066	1.380
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.031	0.030	0.055	0.039
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.254	0.084	0.252	0.197
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.007	0.003	0.007	0.005
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.967	0.767	1.814	1.183
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.025	0.027	0.048	0.033
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	2.07	2.12	2.72	2.30
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.21	0.10	0.12	0.14
$PM_{10-2.5}$/PM_{10} Ratio for TEOM $PM_{10-2.5}$ Calculation	0.79	0.90	0.88	0.86
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	6.19	4.12	7.75	6.02
Total Particulate Emission Factor, lbs./ton	0.03673	0.06647	0.05045	0.05122
Total PM_{10} Emission Factor, lbs./ton	0.01771	0.03133	0.01853	0.02252
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.01395	0.02823	0.01623	0.01947
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.00377	0.00311	0.00230	0.00306
Collection Efficiencies				
Fabric Filter Total Efficiency	97.4%	96.5%	97.3%	97%
Truck Hood PM_{10} Efficiency	94.0%	89.6%	95.9%	93.1%
System Collection Efficiency	91.0%	84.8%	93.0%	89.6%

Table 17.9. Concrete Supply, Rock Hill Truck Mix Emissions Data

Test Results	Run # 1 5/12/04	Run # 2 5/12/04	Run # 3 5/13/04	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	351.0	854.6	527.0	577.5
Measured PM_{10} Emissions Thru Array, lbs./hour	0.0170	0.0585	0.0378	0.0378
Calculated Total Emissions Thru Array, lbs./hour	0.0885	0.2154	0.2897	0.1979
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0025	0.0049	0.0026	0.0034
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0145	0.0536	0.0351	0.0344
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	15.992	24.505	43.483	27.99
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.070	0.132	0.192	0.131
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	3.071	6.654	5.668	5.131
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.013	0.036	0.025	0.025
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.456	0.561	0.393	0.470
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.002	0.003	0.002	0.002
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	2.615	6.093	5.275	4.6609
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.011	0.033	0.023	0.023
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	5.21	3.68	7.67	5.52
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.15	0.08	0.07	0.10
$PM_{10-2.5}$/PM_{10} Ratio for TEOM $PM_{10-2.5}$ Calculation	0.85	0.92	0.93	0.90
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	20.24	21.73	13.91	18.63
Total Particulate Emission Factor, lbs./ton	0.00783	0.01599	0.03538	0.01973
Total PM_{10} Emission Factor, lbs./ton	0.00148	0.00435	0.00461	0.00348
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.00126	0.00399	0.00427	0.00317
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.00022	0.00036	0.00034	0.00031
Collection Efficiencies				
Fabric Filter Total Efficiency	99.6%	99.5%	99.6%	99.5%
Truck Hood PM_{10} Efficiency	99.4%	99.1%	99.3%	99.3%
System Collection Efficiency	99.0%	98.6%	98.9%	98.8%

Table 17.10. RMC Carolina Materials Central Mix Emissions Data

Test Results	Run # 1 5/19/04	Run # 2 5/19/04	Run # 3 5/20/04	Averages
Method 5 D-Sampling Array Results				
Average Array PM_{10} Particulate Concentration, ug/m^3	309.2	223.7	193.3	242.1
Measured PM_{10} Emissions Thru Array, lbs./hour	0.1013	0.0456	0.0132	0.0534
Calculated Total Emissions Thru Array, lbs./hour	0.3972	0.1761	0.0601	0.2111
Calculated $PM_{2.5}$ Emissions Thru Array, lbs./hour	0.0072	0.0083	0.0013	0.0056
Calculated $PM_{10-2.5}$ Emissions Thru Array, lbs./hour	0.0942	0.0373	0.0119	0.0478
Fabric Filter Results				
Fabric Filter Inlet, Total Particulate Concentration, lbs./hr	7.580	5.823	10.254	7.886
Fabric Filter Outlet, Total Particulate Concentration, lbs./hr	0.0056	0.0064	0.0058	0.0060
Fabric Filter Inlet, PM_{10} Particulate Concentration, lbs./hr	1.934	1.508	2.245	1.896
Fabric Filter Outlet, PM_{10} Particulate Concentration, lbs./hr	0.0014	0.0017	0.0013	0.0015
Fabric Filter Inlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.137	0.274	0.219	0.2098
Fabric Filter Outlet, $PM_{2.5}$ Particulate Concentration, lbs./hr	0.0001	0.0003	0.0001	0.0002
Fabric Filter Inlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	1.797	1.235	2.027	1.6860
Fabric Filter Outlet, $PM_{10-2.5}$ Particulate Concentration, lbs./hr	0.001	0.001	0.001	0.001
Particulate Size Ratios based on Fabric Filter Inlet Data				
Total / PM_{10} for TEOM Total Calculation	3.92	3.86	4.57	4.12
$PM_{2.5}$ / PM_{10} for TEOM $PM_{2.5}$ Calculation	0.07	0.18	0.10	0.12
$PM_{10-2.5}$/PM_{10} Ratio for TEOM $PM_{10-2.5}$ Calculation	0.93	0.82	0.90	0.88
Emission Factor Results				
Average Plant Production Levels During Tests, Tons/Hour	13.01	8.15	16.82	12.66
Total Particulate Emission Factor, lbs./ton	0.03097	0.02240	0.00392	0.01909
Total PM_{10} Emission Factor, lbs./ton	0.00790	0.00581	0.00086	0.00485
Total $PM_{10-2.5}$ Emission Factor, lbs./ton	0.00733	0.00475	0.00078	0.00429
Total $PM_{2.5}$ Emission Factor, lbs./ton	0.000561	0.0010555	0.0000835	0.00057
Collection Efficiencies				
Fabric Filter Total Efficiency	99.9%	99.9%	99.9%	99.9%
Truck Hood PM_{10} Efficiency	95.0%	97.1%	99.4%	97.2%
System Collection Efficiency	94.7%	96.9%	99.4%	97.0%

The total amount of concrete processed by the concrete mixing trucks during each test run was recorded in units of yards. The five plants tested recorded the amount of each raw material used for each order. The mix composition information and processing rate information are summarized for each test run in Tables 17.11 through 17.16. All of the processes operated in a normal manner during the test program.

Table 17.11. Wake Forest, RMCC Truck Mix Production Data

Parameters	Truck Mix Run # 1	Truck Mix Run # 2	Truck Mix Run # 3	Averages
Test Date	12/8/03	12/8/03	12/9/03	N/A
Run Start Time	9:01	12:14	7:53	N/A
Run Stop Time	11:12	14:14	10:03	N/A
Number of Truck Loads	11	6	7	8
Sand, lbs.	104,440	30,280	80,360	71,693
Stone 67 Size, lbs.	118,840	25,480	72,440	72,253
Stone 78 Size, lbs.	14,480	9,960	20,680	15,040
Cement, lbs.	28,170	9,540	21,480	19,730
Flyash, lbs.	9,350	2,460	7,180	6,330
Liquid Air, lbs.	26.06	4.56	19.50	16.71
Water Reducer, lbs.	11.81	16.94	37.25	22.00
Retarder, lbs.	0	0	0	0
High Range Water Reducer, lbs.	0	3.44	0	1.15
Calcium Accelerator, lbs.	175	0	71.88	82.29
Non-Chloride Accelerator, lbs.	210	0	0	70
Water, lbs.	9,552	1,872	5,552	5,658.7
Total Process Weight, lbs.	285,255	79,617	207,821	190,897.7
Total Process Weight, tons	142.6	39.8	103.9	95.4
Total Process Weight, yards	75	23	54	50.7
Tons / Yard	1.91	1.77	1.92	1.87

Table 17.12. Wake Forest, RMCC Central Mix Production Data

Parameters	Run # 1	Run # 2	Run # 3	Averages
Test Date	12/10/03	12/11/03	12/11/03	N/A
Run Start Time	8:22	7:31	12:21	N/A
Run Stop Time	13:24	9:37	15:35	N/A
Number of Truck Loads	5	7	7	6.3
Sand, lbs.	66,560	96,560	88,640	83,920
Stone 67 Size, lbs.	88,240	124,120	113,240	108,533
Stone 78 Size, lbs.	0	0	0	0
Cement, lbs.	22,230	29,680	26,320	26,076.7
Flyash, lbs.	4,770	7,430	6,970	6,390
Liquid Air, lbs.	14.44	21.88	21.5	19.27
Water Reducer, lbs.	34.81	11.88	45.31	30.67
Retarder, lbs.	0	0	0	0
High Range Water Reducer, lbs.	0	0	0	0
Calcium Accelerator, lb	65.63	66.25	17.50	49.79
Non-Chloride Accelerator, lbs.	0	280	0	93.3
Water, lbs.	3,160	6,564	3,888	4,537.3
Total Process Weight, lbs	185,075	264,734	239,142	296,317
Total Process Weight, tons	92.5	132.4	119.6	114.8
Total Process Weight, yards	49	69	64	60.7
Tons / Yard	1.89	1.92	1.87	1.89

Table 17.13. S.T. Wooten Concrete Central Mix Production Data

Parameters	Run # 1	Run # 2	Run # 3	Averages
Test Date	3/2/04	3/2/04	3/2/04	N/A
Run Start Time	9:10	11:12	13:04	N/A
Run Stop Time	10:10	12:12	14:05	N/A
Number of Truck Loads	5	5	6	5.3
Sand, lbs.	41,380	68,780	79,100	63,090
Stone 57 Size, lbs.	53,620	88,800	101,880	81,433
Cement, lbs.	12,540	19,310	23,800	18,550
Flyash, lbs.	3,460	6,580	7,190	5,743
Liquid Air, lbs.	5.43	6.18	9.06	6.90
Polyheed, lbs.	52.5	157.25	153.5	121.1
Water, lbs.	2,804	6,192	6,885	5,294
Total Process Weight, lbs	113,862	189,815	219,018	174,238
Total Process Weight, tons	56.94	94.91	109.51	87.12
Total Process Weight, yards	29.500	50.000	57.50	45.67
Tons / Yard	1.98	1.90	1.90	1.93

Table 17.14. Chandler Concrete Truck Mix Production Data

Parameters	Run # 1	Run # 2	Run # 3	Averages
Test Date	3/17/04	3/17/04	3/18/04	N/A
Run Start Time	7:17	9:17	12:40	N/A
Run Stop Time	8:34	13:21	14:50	N/A
Number of Truck Loads	4	4	4	4
Stone 57, lbs.	43,180	28,700	56,960	42,946.7
Limestone, lbs.	33,040	17,220	28,260	26,173.3
Type 1-2 Cement, lbs.	12,245	6,690	11,915	10,283.3
Castle	5,100	6,620	19,120	10,280.0
Flyash, lbs.	1,220	1,495	4,105	2,273.3
Liquid Air, lbs.	1.75	2.25	3.00	2.33
Water Reducer, lbs.	12.81	14.50	38.38	21.90
Polarset, lbs.	69	0	0	23.0
Water, lbs.	5315.95	2,995.96	6,993.36	5,101.8
Total Process Weight, lbs.	100,185	63,738	127,395	97,105.7
Total Process Weight, tons	50.092	31.869	63.697	48.6
Total Process Weight, yards	24.5	14.50	32.0	23.7
Tons / Yard	2.03	2.16	1.99	2.1

Table 17.15. Concrete Supply Truck Mix Production Data

Parameters	Run # 1	Run # 2	Run # 3	Averages
Test Date	5/12/04	5/12/04	5/13/04	N/A
Run Start Time	7:50	10:07	9:06	N/A
Run Stop Time	8:50	11:06	10:10	N/A
Number of Truck Loads	8	9	5	7.3
Sand, lbs.	95,731	80,700	51,080	75,837
Stone, lbs.	130,660	107,130	66,750	101,513
Type 1-2 Cement, lbs.	38,490	33,525	21,380	31,131
Flyash, lbs.	1,785	9,160	5,910	5,618
Water, lbs.	11,082.16	9,897.17	6,225.37	9,068.23
Water Reducer, lbs.	58.5	55.31	6.5	40.1
Liquid Air, lbs.	3.81	13.88	10.06	9.25
M.S. Sand, lbs.	5,970	26,150	17,740	16,620
Retarder, lbs.	42.81	29.13	46.56	39.29
Adva, lbs.	53.13	0	0	17.71
Delvo, lbs	75.06	0	0	25.02
Total Process Weight, lbs.	283,951	266,660	169,148	239,919
Total Process Weight, tons	141.976	133.330	84.574	119.96
Total Process Weight, yards	71.250	67.20	43.00	60.48
Tons / Yard	1.99	1.99	1.97	1.98

Table 17.16. RMC Carolina Materials Central Mix Production Data

Parameters	Run # 1	Run # 2	Run # 3	Averages
Test Date	5/19/04	5/19/04	5/20/04	N/A
Run Start Time	8:10	10:08	8:52	N/A
Run Stop Time	9:09	11:11	9:52	N/A
Number of Truck Loads	5	4	8	5.7
Sand, lbs.	65,120	39,700	81,320	62,046
Stone, lbs.	78,860	51,840	100,700	77,133
Type 1-2 Cement, lbs.	20,860	13,100	27,280	20,413
Flyash, lbs.	4,990	3,190	6,580	4,920
Water, lbs.	66,092.4	40,256.28	61,763.04	56,037.24
Water Reducer, lbs.	64.69	34.94	67.31	55.65
Liquid Air, lbs.	0	3.06	18.25	7.10
Retarder, lbs.	0	0	6.5	2.2
Total Process Weight, lbs.	235,987	148,124	277,735	220,614
Total Process Weight, tons	117.994	74.052	138.868	110.307
Total Process Weight, yards	45.0	29.0	58.0	44
Tons / Yard	2.62	2.55	2.42	2.51

The raw materials for both the truck and central mix processes come from the same sources and, therefore, were sampled only once at the Wake Forest, RMCC plant. The raw material size distribution, moisture levels, and silt contents are summarized in Table 17.17.

Table 17.17. Raw Material Particle Size Distribution, Moisture Levels and Silt Contents

Raw Material	Date of Test	Time Sample Taken	% Greater than 75 mm	% Greater than 19 mm	% Greater than #20 Mesh	% Greater than 100 Mesh	% Greater than 200 Mesh	Pan % Less than # 200 Mesh (Silt)	% Moisture
RMCC, Wake Forest Plants (Truck Mix and Central Mix)									
Sand	12/8/03	13:00	0.0	0.0	41.06	56.61	1.56	0.77	12.87[5]
Stone	12/8/03	13:00	0.0	33.59	64.93	0.77	0.34	0.38	1.44
Cement	12/8/03	14:00	0.0	0.0	0.0	79.96	10.01	10.03	0.27
Flyash	12/9/03	08:07	0.0	0.0	0.0	4.14	11.13	84.73	0.21
S.T. Wooten, Raleigh Plant									
Cement	3/2/04	11:52	0.0	0.0	0.0	37.7	12.5	49.8	0.30
Flyash	3/2/04	13:06	0.0	0.0	0.31	1.78	10.3	87.6	0.09
Sand	3/2/04	9:11	0.0	0.0	19.3	79.1	0.7	0.8	6.3
Stone	3/2/04	11:18	0.0	18.8	78.9	1.1	0.4	0.8	1.1
Chandler Concrete, Troutville Plant									
Cement	3/16/04	13:15	0.0	0.0	0.0	73.5	21.94	4.56	0.39
Flyash	3/16/04	13:22	0.0	0.0	37.2	3.18	9.63	86.81	0.16
Sand	3/16/04	10:57	0.0	0.0	5.80	92.57	1.43	0.2	8.01
Stone	3/16/04	12:24	0.0	9.92	89.05	0.35	0.18	0.50	2.07
Concrete Supply, Rock Hill Plant									
Cement	5/11/04	13:15	0.0	0.0	0.09	80.68	18.12	1.11	0.31
Flyash	5/11/04	14:38	0.0	0.0	0.189	3.89	12.28	83.64	0.07
Sand	5/11/04	15:21	0.0	0.0	24.96	72.59	1.96	0.48	3.43
Stone	5/11/04	16:33	0.0	18.87	80.41	0.17	0.11	0.44	0.46
RMC Carolina Materials, Raleigh Plant									
Cement	5/18/04	15:13	0.0	0.0	0.70	91.74	5.26	2.30	1.07
Flyash	5/18/04	16:13	0.0	0.0	0.24	4.07	26.87	68.82	0.19
Sand	5/18/04	12:45	0.0	0.0	23.89	73.25	2.25	0.62	7.70
Stone	5/18/04	17:08	0.0	22.05	76.94	0.39	0.19	0.42	0.86

Wind Speed and Direction

Meteorological data were monitored on a continuous basis on the downwind side of the process being tested. During the first test run at the RMCC plant, it was determined that the wind speed and direction were erratic due to constant truck traffic moving from the loading areas to the wash-off area and the topography of the surrounding plant area. Earth berms and trees surround the plant and form a bowl shaped depression around the plant. The topography causes

[5] The sand moisture content of 12.87% is higher than levels in some parts of the U.S. This sand moisture value has been confirmed for this facility.

swirling wind conditions, especially during truck movement in and out of the loading areas. For this reason, the data were erratic and could not be used to evaluate wind direction. Air Control Techniques, P.C. visually observed wind direction to confirm that fugitive emissions were passing through the array. The rapid response of the TEOM monitor to the fugitive emissions during each truck and central mixer loading operation also provided direct confirmation that the wind direction was in the appropriate direction during the test program. Table 17.18 summarizes the average wind speeds during both the truck and central mix tests for the five plants tested.

Table 17.18. Wind Speed Averages

Test Run	Average Wind Speed, MPH
RMCC Wake Forest	
Truck Mix Run # 1	1.1
Truck Mix Run # 2	1.4
Truck Mix Run # 3	1[1]
Average	1.2
RMCC Wake Forest	
Central Mix Run # 1	1[1]
Central Mix Run # 2	2.7
Central Mix Run # 3	2.5
Average	2.1
S.T. Wooten, Raleigh	
Central Mix Run # 1	7.0
Central Mix Run # 2	8.2
Central Mix Run # 3	2.7
Average	6.0
Chandler Concrete[2]	
Truck Mix Run # 1	1.7
Truck Mix Run # 2	4.3
Truck Mix Run # 3	1.3
Average	2.4
Concrete Supply	
Truck Mix Run # 1	1.1
Truck Mix Run # 2	1.5
Truck Mix Run # 3	1.6
Average	1.4
RMC Carolina Materials	
Central Mix Run # 1	7.1
Central Mix Run # 2	4.4
Central Mix Run # 3	1.5
Average	4.3

1. One mph was used as a default value during tests in which the meteorological monitoring station was blocked by trucks being loaded.
2. Wind speed potentially biased low due to wind blocking effect of truck on meteorological monitoring station.

REFERENCES FOR SECTION 4

1. *Final Test Report for USEAP* [sic] Test *Program Conducted at Chaney Enterprises Cement Plant*, ETS, Inc. Roanoke, VA, April 1994.

2. *Final Test Report for USEPA* [sic] *Test Program Conducted at Concrete Ready Mixed Corporation,* ETS, Inc. Roanoke, VA, April 1994.

3. *Emission Test for Tiberi Engineering Compan*y, Alar Engineering Corporation, Burbank, IL, October 1972.

4. *Stack Test "Confidential*" (Test obtained from State of Tennessee,), Environmental Consultants, Oklahoma City, OK, February 1976.

5. Source Sampling Report, Particulate Emissions from Cement Silo Loading, Specialty Alloys Corporation, Gallaway, Tennessee, Reference Number 24-00051-02, State of Tennessee, Department of Health and Environmental, Division of Air Pollution Control, June 12, 1984.

6. Richards, J. and T. Brozell. "*Ready Mixed Concrete Emission Factors, Final Report*" Report to the Ready Mixed Concrete Research Foundation, Silver Spring, Maryland. August 2004.

5. FINAL EMISSION FACTORS

5.1 Truck Mix and Central Mix Loading Particulate Matter Emission Factors

Emission factor data (run-by-run) applicable to controlled truck mix and central mix loading operations are summarized in Tables 18.1 and 18.2. The emission factor data for uncontrolled conditions are summarized in Tables 18.3 and 18.4.

The emission factor data for the six plants summarized in reference 6 are rated A because the fugitive emission rates were measured directly using EPA reference methods. The emission factor data for the plant summarized in reference 1 and the two plants summarized in reference 2 are rated B because the fugitive emission rates from the loading operations were estimated based on qualitative visible emission observations.

Table 18.1. Central Mix Loading Operation (Controlled) Emission Factor Data.

Reference	Plant	Run	Cement Moisture %	Cement Supplement Moisture, %	Minimum Moisture of Cement and Supplement, %	Tons per Hour of Cement and Cement Supplement	Wind Speed, mph	Total PM, lbs/ton	PM_{10}, lbs/ton	$PM_{2.5}$, lbs/ton	Report Format
6	RMCC	1	0.27	0.21	0.21	6.82	1	0.0043	0.0041	0.00259	A
6	RMCC	2	0.27	0.21	0.21	8.88	2.7	0.0023	0.0013	0.00003	A
6	RMCC	3	0.27	0.21	0.21	7.18	2.5	0.0030	0.0030	0.00157	A
Test Average			**0.27**	**0.21**	**0.21**	**7.63**	**2.1**	**0.0032**	**0.0028**	**0.00140**	
6	S.T.Wooten	1	0.30	0.09	0.09	7.90	1.0	0.0197	0.0047	0.00042	A
6	S.T.Wooten	2	0.30	0.09	0.09	13.10	8.2	0.0756	0.0124	0.00109	A
6	S.T.Wooten	3	0.30	0.09	0.09	15.27	2.7	0.0253	0.0114	0.00066	A
Test Average			**0.3**	**0.09**	**0.09**	**12.09**	**4.0**	**0.0402**	**0.0095**	**0.00072**	
6	Carolina Mat'l	1	1.07	0.19	0.19	13.01	7.1	0.0310	0.0079	0.00056	A
6	Carolina Mat'l	2	1.07	0.19	0.19	8.15	4.4	0.0224	0.0058	0.00106	A
6	Carolina Mat'l	3	1.07	0.19	0.19	16.80	1.5	0.0039	0.0039	0.00008	A
Test Average			**1.07**	**0.19**	**0.19**	**12.65**	**4.3**	**0.0191**	**0.0059**	**0.00057**	
1	Cheney Enterprises	10	0.13	0.06	0.13	15.09	ND	0.0081	0.0057	ND	B
1	Cheney Enterprises	11	0.13	0.06	0.13	15.61	ND	0.0391	0.0101	ND	B
1	Cheney Enterprises	12	0.13	0.06	0.13	15.72	ND	0.0048	0.0002	ND	B
1	Cheney Enterprises	13	0.13	0.06	0.13	14.01	ND	0.0020	0.0014	ND	B
1	Cheney Enterprises	17	0.13	0.06	0.13	22.43	ND	0.0019	0.0015	ND	B
Test Average			**0.13**	**0.06**	**0.13**	**16.572**		**0.0111**	**0.0038**		
Average, Central Mix Controlled								**0.0184**	**0.0055**	**0.0009**	

Table 18.2. Truck Mix Loading Operation (Controlled) Emission Factor Data.

Reference	Plant	Run	Cement Moisture %	Cement Supplement Moisture, %	Minimum Moisture, %	Tons per Hour of Cement and Cement Supplement	Wind Speed, mph	Total PM, lbs/ton	PM_{10}, lbs/ton	$PM_{2.5}$, lbs/ton	Report Rating
6	RMCC	1	0.27	0.21	0.21	8.58	1.0	0.0035	0.0028	3.50E-05	A
6	RMCC	2	0.27	0.21	0.21	3.00	1.4	0.0201	0.0054	8.63E-04	A
6	RMCC	3	0.27	0.21	0.21	6.91	1.0	0.0047	0.0036	1.09E-03	A
Test Average			**0.27**	**0.21**	**0.21**	**6.16**	**1.13**	**0.0094**	**0.0039**	**6.63E-04**	
6	Chandler	1	0.39	0.16	0.16	6.19	1.7	0.0367	0.0177	3.77E-03	A
6	Chandler	2	0.39	0.16	0.16	4.12	4.3	0.0665	0.0313	3.11E-03	A
6	Chandler	3	0.39	0.16	0.16	7.75	1.3	0.0504	0.0185	2.30E-03	A
Test Average			**0.39**	**0.16**	**0.16**	**6.02**	**2.43**	**0.0512**	**0.0225**	**3.06E-03**	
6	Concrete Supply	1	0.31	0.07	0.07	20.24	1.1	0.0078	0.0015	2.22E-04	A
6	Concrete Supply	2	0.31	0.07	0.07	21.73	1.5	0.0160	0.0044	3.64E-04	A
6	Concrete Supply	3	0.31	0.07	0.07	13.61	1.6	0.0354	0.0046	3.38E-04	A
Test Average			**0.31**	**0.07**	**0.07**	**18.53**	**1.40**	**0.0197**	**0.0035**	**3.08E-04**	
2	CRMC	1	0.03	NA	0.03	16.86	ND	0.0985	0.0308	ND	B
2	CRMC	2	0.03	NA	0.03	20.27	ND	0.1349	0.0333	ND	B
2	CRMC	3	0.03	NA	0.03	18.61	ND	0.1096	0.0275	ND	B
2	CRMC	4	0.03	NA	0.03	16.92	ND	0.0849	0.0180	ND	B
2	CRMC	5	0.03	NA	0.03	11.83	ND	0.0856	0.0233	ND	B
2	CRMC	6	0.03	NA	0.03	ND	ND	0.9854	0.2067	ND	B
2	CRMC	7	0.03	NA	0.03	29.00	ND	0.0305	0.0289	ND	B
2	CRMC	8	0.03	NA	0.03	26.30	ND	0.0072	0.0055	ND	B
2	CRMC	9	0.03	NA	0.03	18.61	ND	0.0120	0.0070	ND	B
2	CRMC	10	0.03	NA	0.03	16.55	ND	0.0084	0.0053	ND	B
Test Average			**0.03**		**0.03**	**19.44**		**0.1557**	**0.0386**		
1	Chaney	2	0.13	0.06	0.06	14.60	ND	0.0721	0.0540	ND	B
1	Chaney	4	0.13	NA	0.13	13.92	ND	0.0396	0.0285	ND	B
1	Chaney	9	0.13	NA	0.13	19.56	ND	0.0261	0.0116	ND	B
1	Chaney	14	0.13	0.06	0.06	14.70	ND		0.0980	ND	B
1	Chaney	15	0.13	0.06	0.06	17.88	ND	0.6304	0.0706	ND	B
1	Chaney	16	0.13	NA	0.13	11.01	ND	0.5054	0.1144	ND	B
Test Average			**0.13**	**0.06**	**0.095**	**15.28**		**0.2547**	**0.0629**		
Average, Truck Mix Controlled								**0.098**	**0.0263**	**0.00134**	

Table 18.3. Central Mix Loading Operation (Uncontrolled) Emission Factor Data.

Reference	Plant	Run	Cement Moisture %	Cement Supplement Moisture, %	Minimum Moisture of Cement and Supplement, %	Tons per Hour of Cement and Cement Supplement	Wind Speed, mph	Total PM, lbs/ton	PM_{10}, lbs/ton	$PM_{2.5}$, lbs/ton	Report Format
6	RMCC	1	0.27	0.21	0.21	6.82	1	0.102	0.031	0.009	A
6	RMCC	2	0.27	0.21	0.21	8.88	2.7	0.174	0.067	0.009	A
6	RMCC	3	0.27	0.21	0.21	7.18	2.5	0.188	0.070	0.009	A
		Test Average	**0.27**	**0.21**	**0.21**	**7.63**	**2.1**	**0.155**	**0.056**	**0.009**	
6	S.T.Wooten	1	0.30	0.09	0.09	7.90	1.0	1.718	0.411	0.0357	A
6	S.T.Wooten	2	0.30	0.09	0.09	13.10	8.2	1.203	0.206	0.017	A
6	S.T.Wooten	3	0.30	0.09	0.09	15.27	2.7	0.841	0.376	0.022	A
		Test Average	**0.3**	**0.09**	**0.09**	**12.09**	**4.0**	**1.254**	**0.331**	**0.0249**	
6	Carolina Mat'l	1	1.07	0.19	0.19	13.01	7.1	0.613	0.156	0.011	A
6	Carolina Mat'l	2	1.07	0.19	0.19	8.15	4.4	0.736	0.191	0.035	A
6	Carolina Mat'l	3	1.07	0.19	0.19	16.80	1.5	0.613	0.134	0.0131	A
		Test Average	**1.07**	**0.19**	**0.19**	**12.65**	**4.3**	**0.654**	**0.160**	**0.0197**	
1	Cheney Enterprises	10	0.13	0.06	0.13	15.09	ND	0.0794	0.0564	ND	B
1	Cheney Enterprises	11	0.13	0.06	0.13	15.61	ND	0.242	0.0622	ND	B
1	Cheney Enterprises	12	0.13	0.06	0.13	15.72	ND	0.4568	0.01	ND	B
1	Cheney Enterprises	13	0.13	0.06	0.13	14.01	ND	0.166	0.123	ND	B
1	Cheney Enterprises	17	0.13	0.06	0.13	22.43	ND	0.17	0.137	ND	B
		Test Average	**0.13**	**0.06**	**0.13**	**16.572**		**0.223**	**0.078**		
							Average, Central Mix Uncontrolled	**0.572**	**0.156**	**0.018**	

Table 18.4. Truck Mix Loading Operation (Uncontrolled) Emission Factor Data.

Reference	Plant	Run	Cement Moisture %	Cement Supplement Moisture, %	Minimum Moisture, %	Tons per Hour of Cement and Cement Supplement	Wind Speed, mph	Total PM, lbs/ton	PM_{10}, lbs/ton	$PM_{2.5}$, lbs/ton	Report Rating
6	RMCC	1	0.27	0.21	0.21	8.58	1.0	0.380	0.118	1.46E-02	A
6	RMCC	2	0.27	0.21	0.21	3.00	1.4	1.349	0.349	3.34E-02	A
6	RMCC	3	0.27	0.21	0.21	6.91	1.0	4.655	1.710	2.57E-01	A
	Test Average		**0.27**	**0.21**	**0.21**	**6.16**	**1.13**	**2.128**	**0.726**	**1.02E-01**	
6	Chandler	1	0.39	0.16	0.16	6.19	1.7	0.388	0.188	3.91E-02	A
6	Chandler	2	0.39	0.16	0.16	4.12	4.3	0.488	0.231	2.28E-02	A
6	Chandler	3	0.39	0.16	0.16	7.75	1.3	0.756	0.278	3.39E-02	A
	Test Average		**0.39**	**0.16**	**0.16**	**6.02**	**2.43**	**0.544**	**0.232**	**3.19E-02**	
6	Concrete Supply	1	0.31	0.07	0.07	20.24	1.1	0.795	0.153	2.27E-02	A
6	Concrete Supply	2	0.31	0.07	0.07	21.73	1.5	1.1378	0.309	2.60E-02	A
6	Concrete Supply	3	0.31	0.07	0.07	13.61	1.6	3.1470	0.410	2.84E-02	A
	Test Average		**0.31**	**0.07**	**0.07**	**18.53**	**1.40**	**1.693**	**0.291**	**2.57E-02**	
2	CRMC	1	0.03	NA	0.03	16.86	ND	0.500	0.1256	ND	B
2	CRMC	2	0.03	NA	0.03	20.27	ND	0.822	0.1680	ND	B
2	CRMC	3	0.03	NA	0.03	18.61	ND	0.650	0.1460	ND	B
2	CRMC	4	0.03	NA	0.03	16.92	ND	0.474	0.0894	ND	B
2	CRMC	5	0.03	NA	0.03	11.83	ND	0.496	0.1215	ND	B
2	CRMC	6	0.03	NA	0.03	ND	ND	2.128	0.4406	ND	B
2	CRMC	7	0.03	NA	0.03	29.00	ND	0.098	0.0960	ND	B
2	CRMC	8	0.03	NA	0.03	26.30	ND	0.009	0.0070	ND	B
2	CRMC	9	0.03	NA	0.03	18.61	ND	0.018	0.0090	ND	B
2	CRMC	10	0.03	NA	0.03	16.55	ND	0.015	0.0076	ND	B
	Test Average		**0.03**		**0.03**	**19.44**		**0.5210**	**0.1211**		
1	Chaney	2	0.13	0.06	0.06	14.60	ND	0.2564	0.1922	ND	B
1	Chaney	4	0.13	NA	0.13	13.92	ND	0.1872	0.135	ND	B
1	Chaney	9	0.13	NA	0.13	19.56	ND	0.1178	0.0522	ND	B
1	Chaney	14	0.13	0.06	0.06	14.70	ND		0.2224	ND	B
1	Chaney	15	0.13	0.06	0.06	17.88	ND	1.7494	0.1956	ND	B
1	Chaney	16	0.13	NA	0.13	11.01	ND	1.2026	0.2718	ND	B
	Test Average		**0.13**	**0.06**	**0.095**	**15.28**		**0.703**	**0.178**		
						Average, Truck Mix Uncontrolled		**1.118**	**0.310**	**0.053**	

The emission factors for the truck mix and central mix loading operations have been compiled in two different formats: (1) a general factor that is based strictly on cement and cement supplement loading rates, and (2) predictive equations that take into account site specific information. The latter approach is preferred whenever the site specific information is available.

5.1.1 General Emission Factors

The general emission factors have been compiled based on the test average values summarized in Tables 18.1 through 18.4.

Previously, EPA has determined that Run 14 conducted at the truck mix loading operation at Chaney Enterprises (Reference 1) was an outlier. This was confirmed during this update to the data tables. Several additional high and low outliers were identified in references 1 and 2 for the truck mix operations. However, the removal of these outliers had essentially no impact on the final emission factor test results. Accordingly, all of the test average values shown in Tables 18.1 through 18.2 have been used without any adjustments to correct for outliers with the exception or Reference 1, Run 14. The general emission factors for total particulate matter, PM_{10}, and $PM_{2.5}$ are summarized in Tables 18.5 and 18.6.

The results of the controlled truck mix loading data analyses (Table 18.5) yield an arithmetic emission factor value of 0.026 pounds PM_{10} per ton of cement and cement supplement loaded. The 90% confidence interval for this data set of is 0.010 pounds PM_{10}/ton of cement and cement supplement (minimum) and 0.043 pounds PM_{10}/ton of cement and cement supplement (maximum). The standard deviation for the data set of five test averages is 0.022 pounds PM_{10}/ton of cement and cement supplement loaded.

The results of the controlled central mix loading data analyses (Table 18.5) yield an arithmetic emission factor value of 0.006 pounds PM_{10} per ton of cement and cement supplement loaded. The 90% confidence interval for this data set is 0.003 pounds PM_{10}/ton of cement and cement supplement loaded and 0.008 pounds PM_{10}/ton of cement and cement supplement loaded. The standard deviation for the data set of five test averages is 0.003 pounds PM_{10}/ton of cement and cement supplement loaded.

Table 18.5. General Emission Factors, Loading Operations, Controlled.

Type of Loading Operation	Analyte	Emissions, pounds per ton of cement and cement supplement loaded			
		Average	Standard Deviation	Minimum of 90% Confidence Interval	Maximum of 90% Confidence Interval
Truck Mix	PM	0.098	0.094	0.029	0.167
	PM_{10}	0.026	0.022	0.010	0.043
	$PM_{2.5}$	0.001	0.001	0.000	0.003
Central Mix	PM	0.018	0.016	0.005	0.031
	PM_{10}	0.006	0.003	0.003	0.008
	$PM_{2.5}$	0.001	0.000	0.000	0.001

Similar analyses were conducted for the uncontrolled emission factor data. With respect to the Reference 6 data, the uncontrolled emissions were calculated as the total of the fugitive emissions plus the inlet mass flow rate to the fabric filter. The results of the analyses of the uncontrolled emission factor data are provided in Table 18.6.

The results of the uncontrolled truck mix loading data analyses (Table 18.6) yield an arithmetic emission factor value of 0.031 pounds PM_{10} per ton of cement and cement supplement loaded. The 90% confidence interval for this data set of is 0.132 pounds PM_{10}/ton of cement and cement supplement (minimum) and 0.487 pounds PM_{10}/ton of cement and cement supplement (maximum). The standard deviation for the data set of five test averages is 0.241 pounds PM_{10}/ton of cement and cement supplement loaded.

The results of the uncontrolled central mix loading data analyses (Table 18.6) yield an arithmetic emission factor value of 0.156 pounds PM_{10} per ton of cement and cement supplement loaded. The 90% confidence interval for this data set is 0.054 pounds PM_{10}/ton of cement and cement supplement loaded and 0.259 pounds PM_{10}/ton of cement and cement supplement loaded. The standard deviation for the data set of five test averages is 0.125 pounds PM_{10}/ton of cement and cement supplement loaded.

Table 18.6. General Emission Factors, Loading Operations, Uncontrolled.

Type of Loading Operation	Analyte	Emissions, pounds per ton of cement and cement supplement loaded			
		Average	Standard Deviation	Minimum of 90% Confidence Interval	Maximum of 90% Confidence Interval
Truck Mix	PM	1.118	0.743	0.571	1.664
	PM_{10}	0.310	0.241	0.132	0.487
	$PM_{2.5}$	0.053	0.042	0.013	0.093
Central Mix	PM	0.572	0.506	0.156	0.987
	PM_{10}	0.156	0.125	0.054	0.259
	$PM_{2.5}$	0.018	0.008	0.010	0.026

5.1.2 Site Specific Equations

In the previous edition of Section 11.12 and in Section 5.1.1 of this document, the truck mix and central mix loading emission factors for particulate matter have been expressed on the basis of pounds of emission per ton of cement and cement supplement loaded. In the planning for the emissions test program documented in reference 6, several previously unmeasured variables that may affect emissions were identified for improved monitoring. Several other AP-42 emissions factors have used material surface moisture levels and wind speed to increase the predictive precision of the resulting emissions factor equation over the traditional single value emissions factor. As with most particulate matter emissions factors, the within source and between source variability is significant. As presented in Tables 18.5 and 18.6, the Standard Deviation of the data is approximately equal in magnitude to the emissions factors. An examination of the test data supporting these emission factors indicated that the production rate (tons of cement and cement supplement) alone did not serve as an adequate parameter to explain the variability and improve the predictive capability of the emissions factor. For example, in Figure 5.1, the reference 1 and 2 PM_{10} controlled emissions data applicable to truck mix operations are illustrated along with the emission factor values that would be calculated based on the AP-42 factor of 0.051 pounds per ton of cement and cement supplement. Similar data are shown in Figure 5.2, for reference 1 PM_{10} controlled emissions data applicable to central mix loading operations. In the case of Figure 5.2, the data should fall on the emission factor line having a slope of 0.0038 pounds PM_{10} per ton of cement and cement supplement.

The lack of a strong relationship between the measured emission rate in pounds per hour and the production rate in tons of cement and supplement per hour is also apparent in the truck mix data provided in reference 6 (Figure 5.3). The emission factor data in references 1, 2, and 6 for truck mix and central mix loading operations indicates that there are variables in addition to production rate that affect particulate matter emissions.

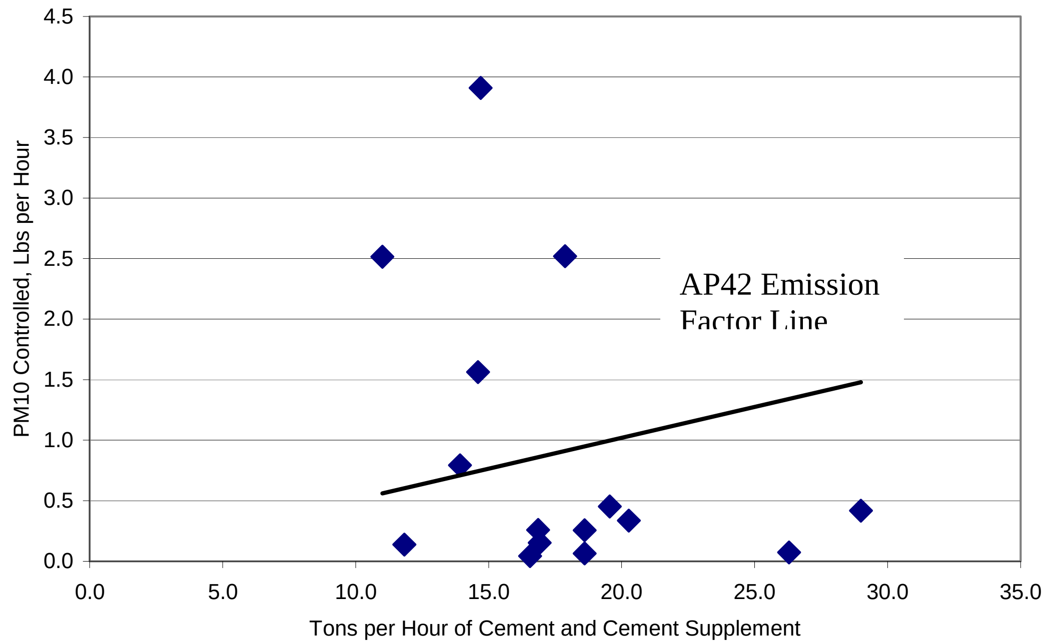

Figure 5.1. Truck Mix Emission Factor Data, EPA AP-42 Section 11.12 References 1 and 2 (Note: Data should be on a line with a slope of 0.051 lbs PM_{10}/ton of cement.)

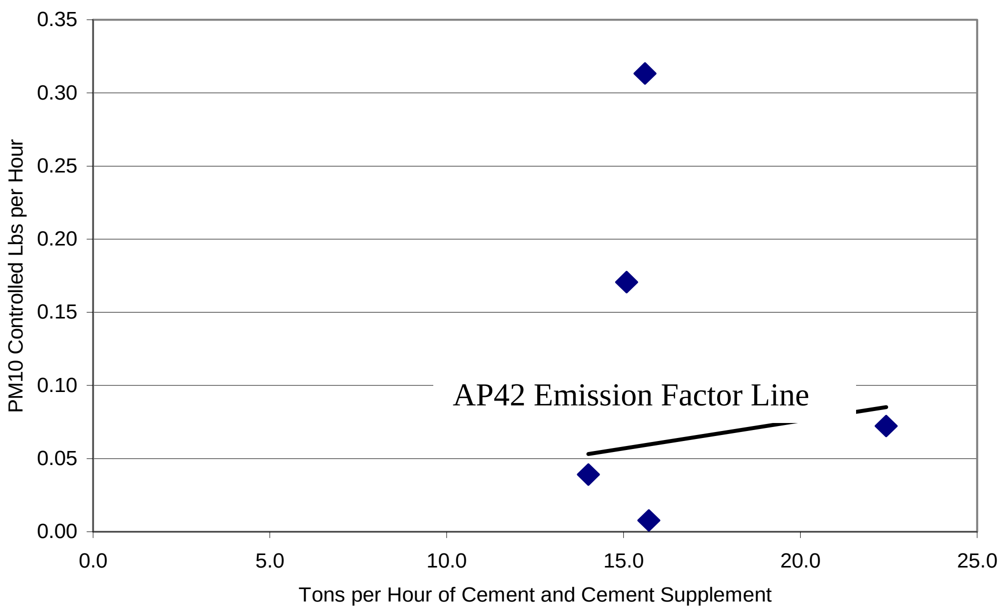

Figure 5.2. Central Mix Emission Factor Data, EPA AP-42 Section 11.12 Reference 1 (Note: Data should be a line with a slope of 0.0038 lbs PM_{10}/ton of cement.)

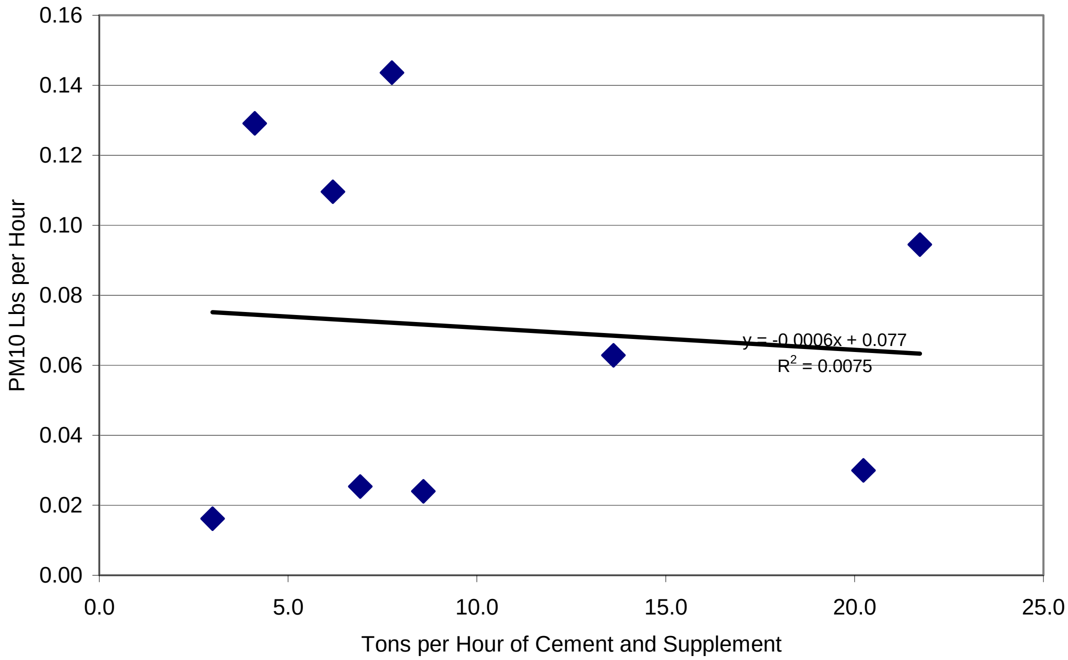

Figure 5.3. Truck Mix Emission Factor Data, Reference 6
(Note: Data should be on a line with a slope of 0.051 lbs PM_{10}/ton of cement.)

Since Reference 6 included documentation of the moisture content of the cement and cement supplement (fly ash) and the air velocity near the drop point, the effect of these variables on the emissions factors is possible. Performing a polynomial regression analysis mathematically evaluates the appropriate exponential relationship between the independent variables (moisture content, air velocity and production rate) and the dependent variable emissions per unit activity. Microsoft Excel® provides a multiple linear regression analysis capability in the analysis tools. Prior to using the regression analysis tool, the dependent (emissions) and independent (moisture and air velocity) data are log transformed. A regression analysis is performed on the log transformed data to generate the exponents for the independent variables and to determine the statistical significance that these variables provide to explain the variability of the data. Following determining the exponents and the strength of the relationship, those parameters exhibiting an R2 greater than approximately 0.5 are carried forward where a second regression analysis determines the slope multipliers to use with the polynomials and any constant to use with the equation. Tables 18.7 through 18.13 present the results of the regression analyses for Total PM, PM_{10} and $PM_{2.5}$ for truck mix operations and Tables 18.14 through 18.23 present similar results for central mix operations.

Table 18.7. Regression Output for Air Velocity and Moisture for Uncontrolled PM for Truck Mix Operations.

SUMMARY OUTPUT
Uncontrolled Total PM

Regression Statistics	
Multiple R	0.38
R Square	0.15
Adjusted R Square	-0.14
Standard Error	0.94
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The low (0.15) R Square indicates that wind and moisture have little influence on the variability of the uncontrolled emissions. In addition, the negative value for the air velocity exponent is counter to the engineering analysis

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.91	0.46	0.51	0.62
Residual	6	5.35	0.89		
Total	8	6.26			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.38	1.43	-0.27	0.80	-3.88	3.11	-3.88	3.11
X Variable 1	-0.33	0.67	-0.48	0.65	-1.97	1.32	-1.97	1.32
X Variable 2	-0.69	0.77	-0.89	0.41	-2.57	1.19	-2.57	1.19

Table 18.8. Regression Output for Air Velocity and Moisture for Uncontrolled PM_{10} Emissions from Truck Mix Operations.

SUMMARY OUTPUT
Uncontrolled PM10

Regression Statistics	
Multiple R	0.25
R Square	0.06
Adjusted R Square	-0.25
Standard Error	0.86
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The low (0.06) R Square indicates that wind and moisture have little influence on the variability of the uncontrolled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.31	0.15	0.21	0.82
Residual	6	4.46	0.74		
Total	8	4.77			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.57	1.30	-0.44	0.68	-3.76	2.62	-3.76	2.62
X Variable 1	0.25	0.62	0.41	0.69	-1.25	1.76	-1.25	1.76
X Variable 2	-0.34	0.70	-0.49	0.64	-2.06	1.37	-2.06	1.37

Table 18.9. Regression Output for Air Velocity and Moisture for Uncontrolled $PM_{2.5}$ from Truck Mix Operations.

SUMMARY OUTPUT
Uncontrolled PM2.5

Regression Statistics	
Multiple R	0.44
R Square	0.19
Adjusted R Square	-0.08
Standard Error	0.84
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The low (0.19) R Square indicates that wind and moisture has little influence on the variability of the uncontrolled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.00	0.50	0.71	0.53
Residual	6	4.25	0.71		
Total	8	5.26			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.10	1.27	-1.65	0.15	-5.22	1.01	-5.22	1.01
X Variable 1	0.52	0.60	0.86	0.42	-0.95	1.99	-0.95	1.99
X Variable 2	-0.56	0.68	-0.81	0.45	-2.23	1.12	-2.23	1.12

Table 18.10. Regression Output for Moisture and Air Velocity for Controlled PM from Truck Mix Operations.

SUMMARY OUTPUT
Controlled Total PM

Regression Statistics	
Multiple R	0.74
R Square	0.55
Adjusted R Square	0.40
Standard Error	0.81
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The moderate (0.55) R Square indicates that wind and moisture explain about 55% of the variability of the controlled emissions. The exponents of -0.29 for moisture and 1.75 for air velocity will be carried forward to determine the multiplier and intercept for the final emissions factor equation.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	4.80	2.40	3.64	0.09
Residual	6	3.96	0.66		
Total	8	8.77			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-5.33	1.23	-4.34	0.00	-8.34	-2.32	-8.34	-2.32
X Variable 1	-0.29	0.58	-0.49	0.64	-1.70	1.13	-1.70	1.13
X Variable 2	1.75	0.66	2.65	0.04	0.13	3.37	0.13	3.37

Table 18.11. Regression Output for Slope and Intercept Coefficients for Controlled PM for Truck Mix Operations.

SUMMARY OUTPUT
Controlled Total PM

Regression Statistics	
Multiple R	0.75
R Square	0.56
Adjusted R Square	0.50
Standard Error	0.02
Observations	9

This is the output from the MS Excel regression analysis from selecting the parameter value as the independent (X) variables and controlled emissions as the dependent (Y) variable. The moderate (0.56) R Square indicates that wind and moisture explain about 56% of the variability of the controlled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.00212	0.00212	8.94373	0.02021
Residual	7	0.00166	0.00024		
Total	8	0.00378			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.0129	0.0068	1.8959	0.0998	-0.0032	0.0290	-0.0032	0.0290
X Variable 1	0.00258	0.00086	2.99061	0.02021	0.00054	0.00463	0.00054	0.00463

Table 18.12. Regression Output for Moisture and Air Velocity Exponents for Controlled PM_{10} Emissions From Truck Mix Operations.

SUMMARY OUTPUT
Controlled PM10

Regression Statistics	
Multiple R	0.82
R Square	0.67
Adjusted R Square	0.56
Standard Error	0.66
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The moderate (0.67) multiple R Square indicates that wind and moisture explain about 67% of the variability of the controlled emissions. However, the predicted exponent for moisture would indicate that emissions increase with increasing moisture. This is counter to good engineering analysis. As a result, the use of these parameters should not be used.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	5.30	2.65	6.09	0.04
Residual	6	2.61	0.43		
Total	8	7.90			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-4.35	1.00	-4.36	0.00	-6.79	-1.91	-6.79	-1.91
X Variable 1	0.70	0.47	1.49	0.19	-0.45	1.85	-0.45	1.85
X Variable 2	1.70	0.54	3.17	0.02	0.39	3.01	0.39	3.01

Table 18.13. Regression Output for Moisture and Air Velocity Exponents for Controlled $PM_{2.5}$ Emissions for Truck Mix Operations.

SUMMARY OUTPUT
Controlled PM2.5

Regression Statistics	
Multiple R	0.57
R Square	0.33
Adjusted R Square	0.10
Standard Error	1.37
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The moderate (0.33) multiple R Square indicates that wind and moisture may explain about 33% of the variability of the controlled emissions. However, the predicted exponent for moisture would indicate that emissions increase with increasing moisture. This is counter to good engineering analysis. As a result, the use of these parameters should not be used.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	5.49	2.75	1.47	0.30
Residual	6	11.23	1.87		
Total	8	16.72			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-6.53	2.07	-3.16	0.02	-11.59	-1.47	-11.59	-1.47
X Variable 1	0.74	0.98	0.75	0.48	-1.65	3.13	-1.65	3.13
X Variable 2	1.72	1.11	1.54	0.17	-1.01	4.44	-1.01	4.44

Table 18.14 Regression Output for Moisture and Air Velocity for Uncontrolled PM Emissions from Central Mix Operations.

SUMMARY OUTPUT
Uncontrolled Total PM

Regression Statistics	
Multiple R	0.86
R Square	0.74
Adjusted R Square	0.65
Standard Error	0.57
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The good (0.74) R Square indicates that wind and moisture explain about 74% of the variability of the uncontrolled emissions. The exponents of -1.27 for moisture and 0.59 for air velocity will be carried forward to determine the multiplier and intercept for the final emissions factor equation.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	5.44	2.72	8.40	0.018
Residual	6	1.94	0.32		
Total	8	7.38			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-3.81	0.98	-3.88	0.01	-6.21	-1.41	-6.21	-1.41
X Variable 1	-1.27	0.59	-2.14	0.08	-2.72	0.18	-2.72	0.18
X Variable 2	0.59	0.33	1.82	0.12	-0.20	1.39	-0.20	1.39

Table 18.15 Regression Output for Moisture and Air Velocity for Controlled PM Emissions from Central Mix Operations.

SUMMARY OUTPUT
Controlled Total PM

Regression Statistics	
Multiple R	0.87
R Square	0.75
Adjusted R Square	0.67
Standard Error	0.65
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The good (0.75) R Square indicates that wind and moisture explain about 75% of the variability of the uncontrolled emissions. The exponents of -1.04 for moisture and 0.95 for air velocity will be carried forward to determine the multiplier and intercept for the final emissions factor equation.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	7.74	3.87	9.19	0.015
Residual	6	2.53	0.42		
Total	8	10.27			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-7.47	1.12	-6.68	0.00	-10.21	-4.74	-10.21	-4.74
X Variable 1	-1.04	0.68	-1.54	0.17	-2.70	0.61	-2.70	0.61
X Variable 2	0.95	0.37	2.57	0.04	0.04	1.86	0.04	1.86

Table 18.16 Regression Output for Slope and Intercept Coefficients for Uncontrolled PM Emissions for Central Mix Operations.

SUMMARY OUTPUT
Uncontrolled Total PM

Regression Statistics	
Multiple R	0.90
R Square	0.80
Adjusted R Square	0.77
Standard Error	0.25
Observations	9

This is the output from the MS Excel regression analysis from selecting the parameter value as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The good (0.80) R Square indicates that wind and moisture explain about 80% of the variability of the uncontrolled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.78	1.78	28.37	0.0011
Residual	7	0.44	0.063		
Total	8	2.22			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.12	0.13	0.92	0.39	-0.20	0.44	-0.20	0.44
X Variable 1	0.019	0.0035	5.33	0.0011	0.010	0.027	0.010	0.027

Table 18.17 Regression Output for Moisture and Air Velocity for Controlled PM Emissions from Central Mix Operations.

SUMMARY OUTPUT

Controlled Total PM

Regression Statistics	
Multiple R	0.82
R Square	0.67
Adjusted R Square	0.62
Standard Error	0.014
Observations	9

This is the output from the MS Excel regression analysis from selecting the parameter value as the independent (X) variables and controlled emissions as the dependent (Y) variable. The modest (0.67) R Square indicates that wind and moisture explain about 67% of the variability of the controlled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.0028	0.0028	14.22229	0.0070
Residual	7	0.0014	0.00020		
Total	8	0.0042			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.0012	0.0071	0.16	0.87	-0.016	0.018	-0.016	0.018
X Variable 1	0.00060	0.00016	3.77	0.0070	0.00023	0.00098	0.00023	0.0010

Table 18.18 Regression Output for Moisture and Air Velocity for Uncontrolled PM_{10} Emissions from Central Mix Operations.

SUMMARY OUTPUT
Uncontrolled PM10

Regression Statistics	
Multiple R	0.85
R Square	0.72
Adjusted R Square	0.62
Standard Error	0.52
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The good (0.72) R Square indicates that wind and moisture explain about 72% of the variability of the uncontrolled emissions. The exponents of -1.28 for moisture and 0.40 for air velocity will be carried forward to determine the multiplier and intercept for the final emissions factor equation.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	4.09	2.05	7.61	0.023
Residual	6	1.61	0.27		
Total	8	5.70			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-4.87	0.89	-5.44	0.00	-7.05	-2.68	-7.05	-2.68
X Variable 1	-1.28	0.54	-2.37	0.06	-2.60	0.04	-2.60	0.040
X Variable 2	0.40	0.30	1.36	0.22	-0.32	1.13	-0.32	1.13

Table 18.19 Regression Output for Moisture and Air Velocity for Controlled PM_{10} Emissions from Central Mix Operations.

SUMMARY OUTPUT
Contorlled PM10

Regression Statistics	
Multiple R	0.69
R Square	0.47
Adjusted R Square	0.29
Standard Error	0.74
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The modest (0.47) R Square indicates that wind and moisture explain about 47% of the variability of the controlled emissions. The exponents of -0.91 for moisture and 0.45 for air velocity will be carried forward to determine the multiplier and intercept for the final emissions factor equation.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.93	1.46	2.67	0.15
Residual	6	3.29	0.55		
Total	8	6.22			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-7.68	1.28	-6.01	0.00	-10.80	-4.55	-10.80	-4.55
X Variable 1	-0.91	0.77	-1.17	0.28	-2.80	0.98	-2.80	0.98
X Variable 2	0.45	0.42	1.06	0.33	-0.59	1.49	-0.59	1.49

Table 18.20 Regression Output for Slope and Intercept Coefficients for Uncontrolled PM_{10} Emissions for Central Mix Operations.

SUMMARY OUTPUT
Uncontrolled PM-10

Regression Statistics	
Multiple R	0.78
R Square	0.60
Adjusted R Square	0.55
Standard Error	0.090
Observations	9

This is the output from the MS Excel regression analysis from selecting the parameter value as the independent (X) variables and uncontrolled PM-10 emissions as the dependent (Y) variable. The moderately good (0.60) R Square indicates that wind and moisture explain about 60% of the variability of the uncontrolled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.086	0.086	10.72	0.014
Residual	7	0.056	0.0080		
Total	8	0.14			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.043	0.052	0.83	0.43	-0.080	0.17	-0.080	0.17
X Variable 1	0.0061	0.0019	3.27	0.014	0.0017	0.011	0.002	0.011

Table 18.21 Regression Output for Slope and Intercept Coefficients for Controlled PM_{10} Emissions for Central Mix Operations.

SUMMARY OUTPUT
Controlled PM-10

Regression Statistics	
Multiple R	0.70
R Square	0.49
Adjusted R Square	0.41
Standard Error	0.0032
Observations	9

This is the output from the MS Excel regression analysis from selecting the parameter value as the independent (X) variables and controlled PM-10 emissions as the dependent (Y) variable. The modest (0.49) R Square indicates that wind and moisture explain about 49% of the variability of the controlled emissions.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6.75E-05	6.75E-05	6.62	0.037
Residual	7	7.14E-05	1.02E-05		
Total	8	0.00014			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.0011	0.0021	0.54	0.61	-0.0038	0.0061	-0.0038	0.0061
X Variable 1	0.00042	0.00016	2.57	0.037	3.40E-05	0.00081	3.40E-05	0.00081

Table 18.22 Regression Output for Moisture and Air Velocity for Uncontrolled $PM_{2.5}$ Emissions from Central Mix Operations.

SUMMARY OUTPUT
Uncontrolled PM2.5

Regression Statistics	
Multiple R	0.66
R Square	0.43
Adjusted R Square	0.24
Standard Error	0.47
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and uncontrolled emissions as the dependent (Y) variable. The modest (0.43) R Square indicates that wind and moisture explain about 43% of the variability of the uncontrolled emissions. The relatively low R squared combined with difference between the moisture and air velocity exponents (-0.66 for moisture and 0.18 for air velocity) from PM and PM-10 preclude carrying these exponents forward.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.01	0.51	2.26	0.19
Residual	6	1.34	0.22		
Total	8	2.35			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-5.62	0.82	-6.89	0.00	-7.61	-3.62	-7.61	-3.62
X Variable 1	-0.66	0.49	-1.34	0.23	-1.87	0.55	-1.87	0.55
X Variable 2	0.18	0.27	0.68	0.52	-0.48	0.85	-0.48	0.85

Table 18.23 Regression Output for Moisture and Air Velocity for Controlled $PM_{2.5}$ Emissions from Central Mix Operations.

SUMMARY OUTPUT
Controlled PM2.5

Regression Statistics	
Multiple R	0.14
R Square	0.02
Adjusted R Square	-0.31
Standard Error	1.60
Observations	9

This is the output from the MS Excel regression analysis from selecting minimum moisture and wind speed as the independent (X) variables and controlled emissions as the dependent (Y) variable. The very low (0.02) R Square indicates that wind and moisture explain only 2% of the variability of the controlled emissions. The very low R squared precludes carrying these exponents forward.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.32	0.16	0.062	0.94
Residual	6	15.40	2.57		
Total	8	15.72			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-8.55	2.76	-3.09	0.021	-15.31	-1.79	-15.31	-1.79
X Variable 1	-0.53	1.67	-0.32	0.76	-4.61	3.56	-4.61	3.56
X Variable 2	-0.033	0.92	-0.036	0.97	-2.27	2.21	-2.27	2.21

An examination of all of the emission factor data now available in reference 6 (six separate plants, A-rated tests) indicates that there is a strong relationship between the air velocity close to the drop point and the emissions factors. In addition, a weaker relationship exists between the fine material (cement or cement supplement) moisture content and the emissions factors. Except for uncontrolled truck mix operations, the use of equations based upon these relationships improves the predictive accuracy of the emissions factors by a factor of approximately two. For controlled truck mix operations, the dependency with air velocity is consistent for all particle sizes while the dependency with moisture content is neither as strong nor consistent. Rather than presenting three equations with different constants for exponents, slope and intercept, the equations for PM_{10} and $PM_{2.5}$ are based upon the average ratio of these particle sizes to total particulate and the equation developed for total particulate matter. For central mix operations, there are different air velocity dependencies for uncontrolled emissions than for controlled emissions and there are different air velocity dependencies for total particulate matter than for PM_{10} or $PM_{2.5}$. As a result, different constants for exponents, slope and intercept are presented. Because of the lack of a good relationship between $PM_{2.5}$ and the independent variables, the average ratio of $PM_{2.5}$ to PM_{10} will be applied to the equation developed for PM_{10}. Emissions factors of the general form presented by equation 5-1 provide for a more predicatively accurate estimate of emissions than a single value emissions factor based solely on production rate. Equation 5-1 includes parameters that take into account the moisture content of the cement and cement supplement (minimum value) and the air velocity at the point of material transfer. Both of these additional parameters are logically related to fugitive particulate matter emissions. Equation 5-1 is conceptually similar to a variety of emission factor equations presented in AP-42 Section 13.2, *Fugitive Dust Sources* due to the inclusion of material moisture content and wind speed. Tables 18.24 and 18.25 present the constants for the exponent for air velocity, the exponent for the moisture content, the slope of the curve (divided by 0.0032 to allow for particle size multipliers closer to unity) and the intercept.

$$E = xk\ \frac{U^{a}}{M^{b}} + c \qquad (5-1)$$

E	=	Emission factor in lbs/ton of cement and cement supplement
k	=	Particle size multiplier (dimensionless)
U	=	Air velocity at drop point, miles per hour (mph)
M	=	Minimum moisture (% by weight) of cement and cement supplement
a,b	=	Exponents
x	=	Slope constant (0.0032)
c	=	Intercept constant

These parameters provide the best fit of the measured emission factor data for controlled particulate matter emissions. The $PM_{10\text{-}2.5}$ emissions factors are calculated by subtracting the $PM_{2.5}$ values from the PM_{10} values.

Table 18.24 Equation Parameters for Controlled Truck Mix Operations.

Condition	Parameter Category	k	a	b	c
Controlled	Total PM	0.8	1.75	0.3	0.013
	PM_{10}	0.32	1.75	0.3	0.0052
	$PM_{2.5}$	0.048	1.75	0.3	0.00078

Table 18.25 Equation Parameters for Central Mix Operations.

Condition	Parameter Category	k	a	b	c
Controlled	Total PM	0.19	0.95	0.9	0.0010
	PM_{10}	0.13	0.45	0.9	0.0010
	$PM_{2.5}$	0.03	0.45	0.9	0.0002
Uncontrolled	Total PM	5.90	0.6	1.3	0.120
	PM_{10}	1.92	0.4	1.3	0.040
	$PM_{2.5}$	0.38	0.4	1.3	0.0

The relationship between the $\mathbf{PM_{10}}$ (controlled) emission factor calculated using Equation 5-1 and the measured $\mathbf{PM_{10}}$ (controlled) emission factors are shown in Figures 5.4 and 5.5. These figures present only the A-rated data from the six tests described in reference 6. Wind speed data were unavailable in the B-rated data from references 1 and 2.

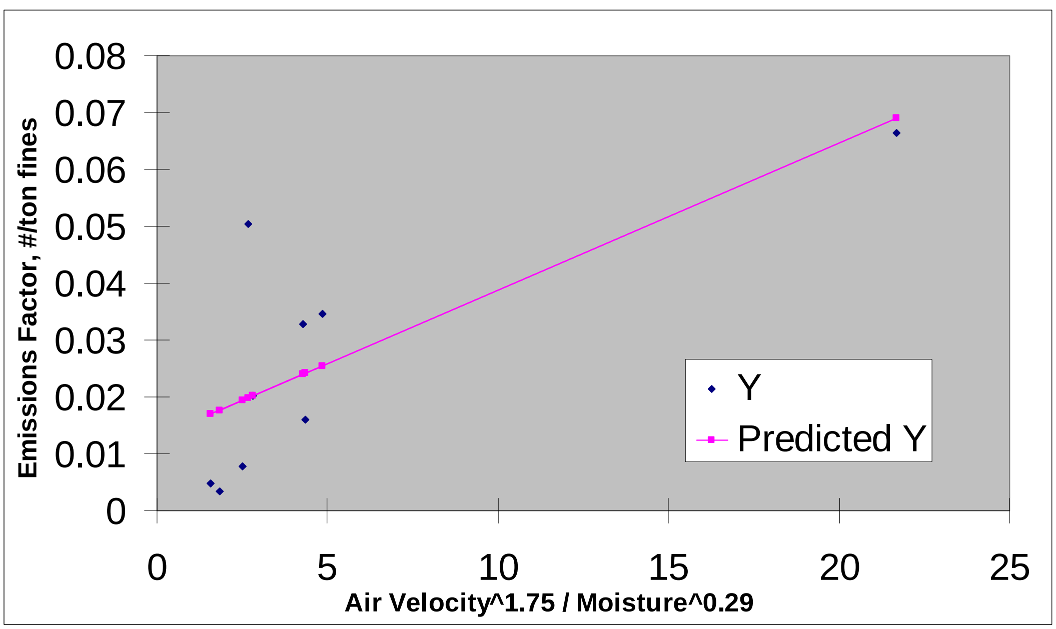

Figure 5.4 Controlled Particulate Matter Emissions from Truck Mix Operations.

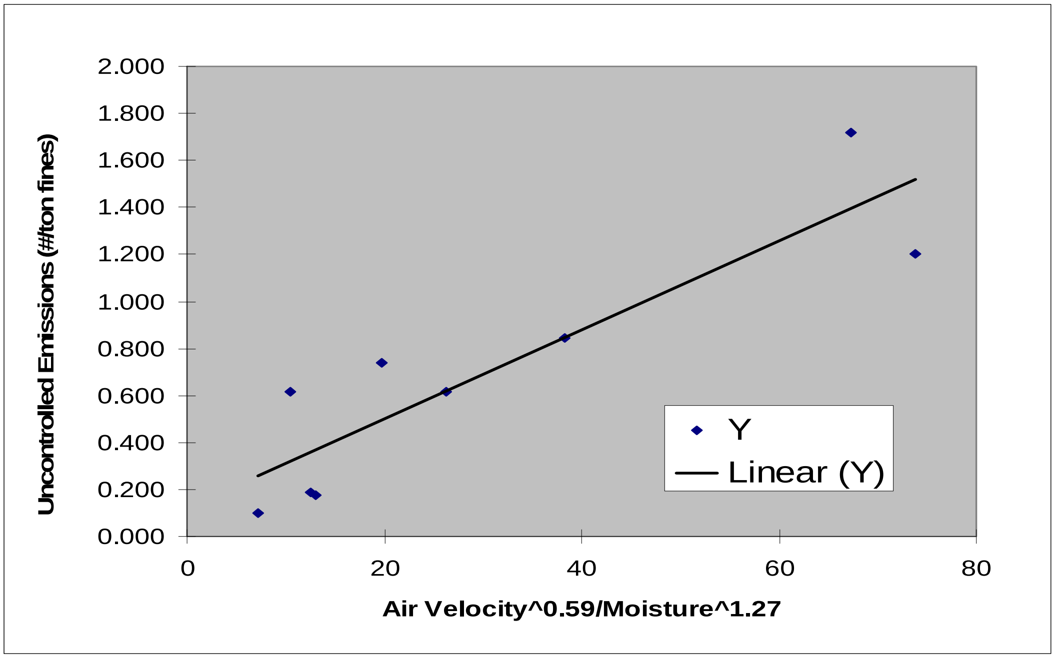

Figure 5.5 Uncontrolled Particulate Matter Emissions for Central Mix Operations.

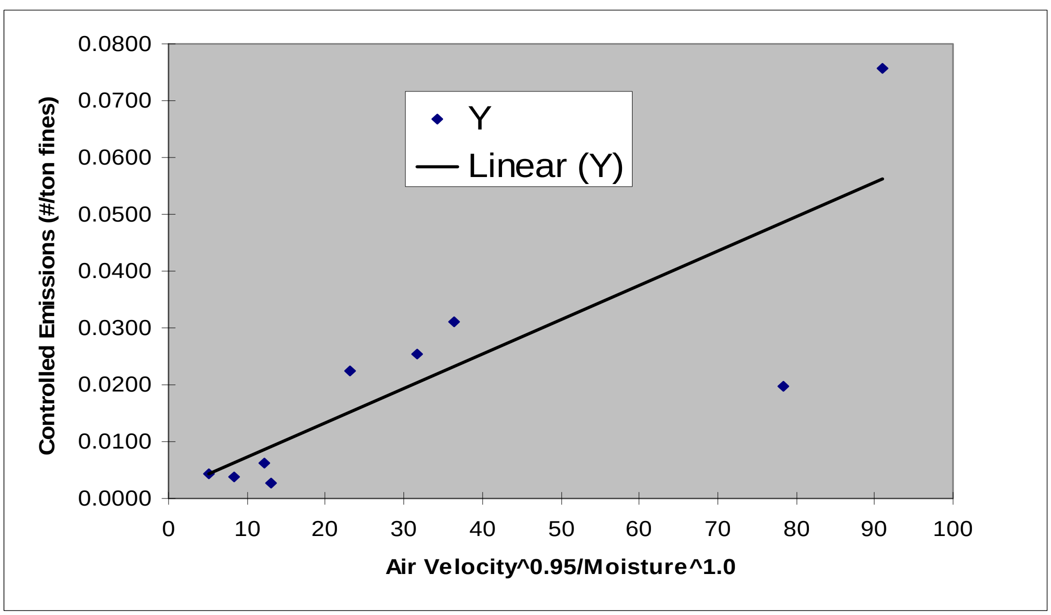

Figure 5.6 Controlled Particulate Matter Emissions for Central Mix Operations.

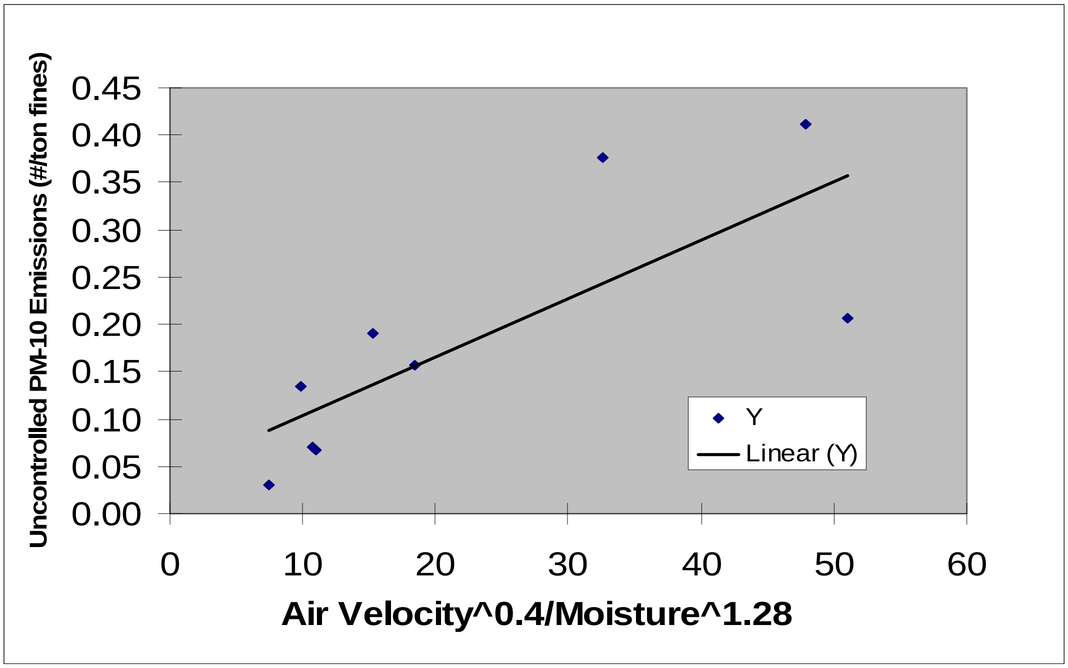

Figure 5.7 Uncontrolled PM_{10} Emissions from Central Mix Operations.

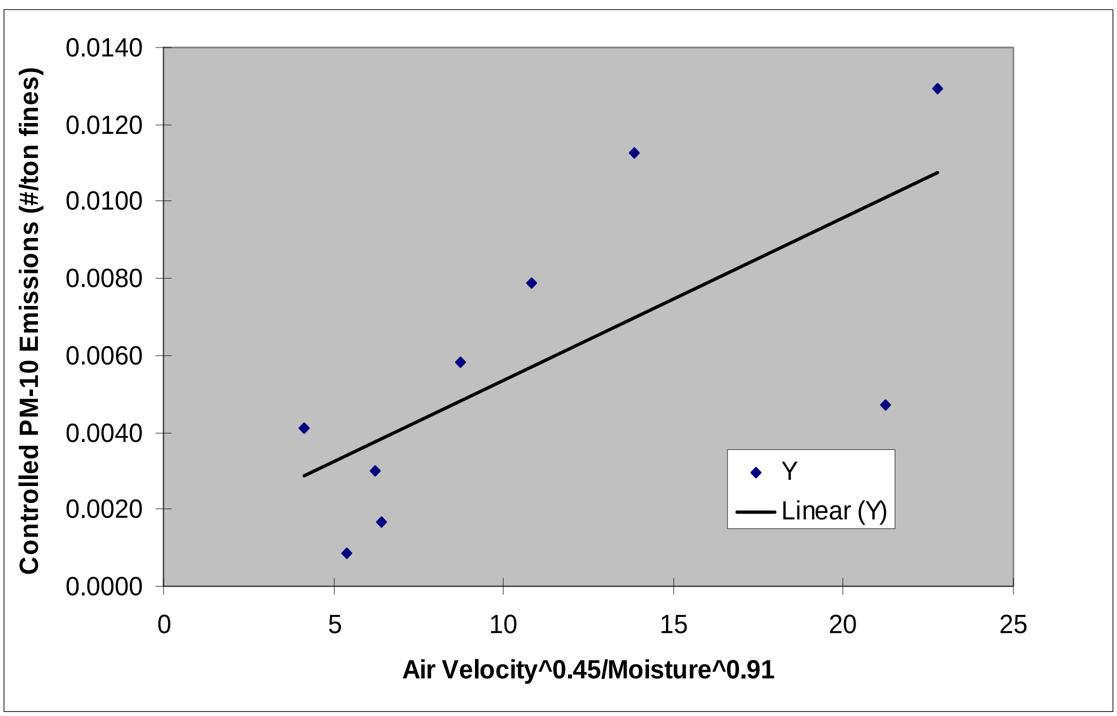

Figure 5.8 Controlled PM_{10} Emissions from Central Mix Operations.

Using Equation 5-1, it is possible to tailor emission factors to site specific conditions. It is also possible for plant operators to take steps to minimize particulate matter emissions by slightly increasing the moisture levels in the cement and cement supplement materials and by shielding the loading areas to reduce the wind speed in the areas immediately adjacent to the loading operations.

Equation 1 and the Table 18.7 equation parameters are based on the six plants tests described in reference 6. There was no wind speed data available for references 1 and 2. However, if a wind speed of approximately 3 mph is assumed for references 1 and 2, the emission factor data are generally comparable to those in Figures 5.3 and 5.4.

5.2 Truck Mix and Central Mix Loading Metals Emission Factors

Metals emissions from truck and central mix loading operations are summarized in Tables 18.26 and 18.27. These are based on data provided in reference 6 (six plants, A-rated metals data), reference 1 (two plants, C rated metals data), and reference 2 (one plant, B rated metals data).

There is considerable variability in the metals content of cement and cement supplement. These are the dominant sources of particulate matter and metals emissions from truck mix and central mix loading operations. As an alternative to the emission factors presented in Tables 18.5 and 18.6, sources can estimate metals emissions based on the total PM emission factor and site specific analyses of the metals contents of the cement and cement supplement. For example, the arsenic emissions can be expressed by Equation 5-2 as a function of the total particulate matter.

$$Metal_{EF} = PM_{EF}\left(\frac{aC + bS}{C + S}\right) \qquad \text{Equation 5-2}$$

Where:

$Metal_{EF}$	=	Metal Emissions, Lbs. As per Ton of Cement and Cement Supplement
PM_{EF}	=	Controlled Particulate Matter Emission Factor Lbs. per Ton of Cement and Cement Supplement
a	=	ppm of Metal in Cement
C	=	Quantity of Cement Used, Lbs. per hour
b	=	ppm of Metal in Cement Supplement
S	=	Quantity of Cement Supplement Used, Lbs. per hour

Table 18.26. Truck Mix Loading Metals Emission Factors

Metal Emission	Reference Number	Number of Test Runs	Data Rating	Emission Factors		Final Emission Factor Rating
				Pounds per cubic yard of Concrete	Pounds per 1000 pounds of Cement and Cement Supplement	
Uncontrolled						
Arsenic	1	1	C	2.37E-7	3.94E-7	
	2	4	B	1.37E-6	2.65E-6	
	6a	3	A	1.07E-5	2.09E-5	
	6b	3	A	5.82E-7	1.10E-6	
	6c	3	A	3.29E-6	5.42E-6	
			Average	3.24E-6	6.09E-6	D
Beryllium	1	1	C	2.15E-8	3.6E-8	
	2	4	B	1.06E-7	2.07E-7	
			Average	6.38E-8	1.22E-7	E
Cadmium	1	1	C	1.19E-8	1.99E-8	
	2	4	B	7.77E-9	1.43E-8	
			Average	9.84E-9	1.77E-8	E
Chromium	1	1	C	4.20E-6	7.03E-6	
	2	4	B	2.27E-6	4.39E-6	
			Average	3.24E-6	5.71E-6	E
Lead	1	1	C	3.29E-7	5.51E-7	
	2	4	B	1.59E-6	3.07E-6	
			Average	9.60E-7	1.81E-6	E
Manganese	1	1	C	2.76E-5	4.61E-5	
	2	4	B	7.82E-6	1.50E-5	
			Average	1.77E-5	3.06E-5	E
Mercury	1					
	1					
Nickel	1	1	C	3.28E-6	5.49E-6	
	2	4	B	3.35E-6	6.48E-6	
			Average	3.32E-6	5.99E-6	E
Phosphorus	1	1		1.15E-5	1.92E-5	
Selenium	2	3		6.75E-7	1.31E-6	E

Table 18.26. Truck Mix Loading Metals Emission Factors (Continued)

Metal Emission	Reference Number	Number of Test Runs	Data Rating	Emission Factors		Final Emission Factor Rating
				Pounds per cubic yard of Concrete	Pounds per 1000 pounds of Cement and Cement Supplement	
Controlled						
Arsenic	1	1	C	7.69E-8	1.29E-7	
	2	4	B	5.30E-7	1.03E-6	
	6a	3	A	8.58E-08	1.67E-7	
	6b	3	A	6.05E-08	1.14E-7	
	6c	3	A	3.95E-08	6.50E-8	
			Average	1.59E-7	3.01E-7	D
Beryllium	1	1	C	6.88E-9	1.15E-8	
	2	4	B	4.70E-8	9.21E-8	
			Average	2.69E-8	5.18E-8	E
Cadmium	1	1	C	3.80E-9	6.36E-9	
	2	4	B	1.46E-9	2.70E-9	
			Average	2.63E-9	4.53E-9	E
Chromium	1	1	C	1.36E-6	2.27E-6	
	2	4	B	9.36E-7	1.82E-6	
			Average	1.15E-6	2.05E-6	E
Lead	1	1	C	1.10E-7	1.84E-7	
	2	4	B	6.94E-7	1.35E-6	
			Average	4.02E-7	7.67E-7	E
Manganese	1	1	C	8.86E-6	1.48E-5	
	2	4	B	3.21E-6	6.03E-6	
			Average	5.99E-6	1.04E-5	E
Mercury	1					
	1					
Nickel	1	1	C	1.07E-6	1.778E-6	
	2	4	B	1.53E-6	2.99E-6	
			Average	1.30E-6	2.39E-6	E
Phosphorus	1	1		3.68E-6	6.16E-6	
Selenium	2	3		2.97E-8	5.64E-8	E

Table 18.27 Central Mix Loading Metals Emission Factors

Metal Emission	Reference Number	Number of Test Runs	Data Rating	Emission Factors: Pounds per cubic yard of Concrete	Emission Factors: Pounds per 1000 pounds of Cement and Cement Supplement	Final Emission Factor Rating
Uncontrolled						
Arsenic	1	1	C	7.54E-8	1.16E-7	
	6d	3	A	6.16E-7	1.15E-6	
	6e	3	A	5.81E-6	1.10E-5	
	6f	3	A	2.60E-6	4.48E-6	
			Average	2.28E-6	4.19E-6	D
Beryllium	1	1				
Cadmium	1	1	C	3.84E-9	5.92-9	E
Chromium	1	1	C	4.60E-7	7.11E-7	E
Lead	1	1	C	1.24E-7	1.91E-7	E
Manganese	1	1	C	1.98E-5	3.06E-5	E
Mercury	1					
Nickel	1	1	C	1.06E-6	1.64E-6	E
Phosphorus	1	1	C	6.52E-6	1.01E-5	E
Selenium	2	3				
Controlled						
Arsenic	1	1	C	6.05E-9	9.35E-9	
	6d	3	A	1.91E-08	3.57E-8	
	6e	3	A	2.15E-07	4.07E-7	
	6f	3	A	8.06E-08	1.39E-7	
			Average	8.02E-08	1.48E-07	D
Beryllium	1	1				
Cadmium	1	1	C	2.30E-10	3.55E-10	E
Chromium	1	1	C	4.11E-8	6.34E-8	E
Lead	1	1	C	1.19E-8	1.83E-8	E
Manganese	1	1	C	1.23E-6	1.89E-6	E
Mercury	1	1				
Nickel	1	1	C	8.01E-8	1.24E-7	E
Phosphorus	1	1	C	3.91E-7	6.04E-7	E
Selenium	1	1				

Note: Reference 6, Plant d - RMCC Wake Forest; Plant e, S.T. Wooten Raleigh, and Plant f, RMC Carolina, Raleigh

5.3 Emission Factor Values

The emission factors for cement silo filling, cement supplement silo filling, transfer of aggregate and sand to elevated bins, and weight hoppers are summarized in Tables 19.1 through 19.4.
The two main issues in rating the final emission factors were the number of facilities tested and the ratings of the test data sets. An emission factor as low as a C generally requires that a reasonable number of facilities be tested and that the test data ratings for each of these facilities be an A or B (see Section 3.1). The emission factor ratings for these sources are based on no more than four facilities, none are rated above D.

Unless noted otherwise, the following criteria were used to rate the final emission factors in Tables 19.1 through 19.4.

Rating D
1. At least two facilities were tested.
2. One of the test data sets is rated A or all of the test data sets are rated B.

Rating E
1. Fails to meet the above criteria for Rating D

b

19.1 CEMENT SILO FILLING EMISSION FACTORS

EMISSION TYPE	REFERENCE NUMBER	NUMBER OF TEST RUNS	DATA RATING	EMISSION FACTOR per 1000 lb CEMENT LOADED (lb)	FINAL EMISSION FACTORS RATING
PM-10	1	1	C	**0.23672**	**E**
CONTROLLED PM-10	1	1	C	6.00E-005	
	2	3	A	2.79E-004	
	AVERAGE			**1.70E-004**	**D**
PM	1	1	C	**0.36297**	**E**
CONTROLLED PM	1	1	C	1.10E-004	
	2	3	A	3.68E-004	
	3	1	C	3.10E-004	
	4	3	D	1.20E-003	
	AVERAGE			**4.97E-004**	**D**
METALS - UNCONTROLLED					
ARSENIC	1	1	C	**8.38E-007**	**E**
BERYLLIUM	1	1	C	**8.97E-009**	**E**
CADMIUM	1	1	C	**1.17E-007**	**E**
CHROMIUM	1	1	C	**1.26E-007**	**E**
LEAD	1	1	C	**3.68E-007**	**E**
MANGANESE	1	1	C	**1.01E-004**	**E**
MERCURY	1	--	--	**--**	--
NICKEL	1	1	C	**8.83E-006**	**E**
PHOSPHORUS	1	1	C	**5.88E-005**	**E**
SELENIUM	1	--	--	**--**	--
METALS - CONTROLLED					
ARSENIC	1	1	C	**2.12E-009**	**E**
	2	--	--	--	
BERYLLIUM	1	--	--	--	
	2	1	B	**2.43E-010**	**E**
CADMIUM	1	--	--	--	
	2	--	--	--	
CHROMIUM	1	1	C	1.87E-008	
	2	1	B	1.02E-008	
	AVERAGE			**1.45E-008**	**E**
LEAD	1	1	C	6.16E-009	
	2	1	B	4.75E-009	
	AVERAGE			**5.46E-009**	**E**
MANGANESE	1	1	C	4.96E-008	
	2	1	B	6.78E-008	
	AVERAGE			**5.87E-008**	**E**
MERCURY	1	--	--	--	
	2	--	--	--	
NICKEL	1	1	C	2.25E-008	
	2	1	B	1.93E-008	
	AVERAGE			**2.09E-008**	**E**
PHOSPHORUS	1	--	--	--	
	2	--	--	--	
SELENIUM	1	--	--	--	
	2	--	--	--	

19.2 CEMENT SUPPLEMENT SILO FILLING EMISSION FACTORS[c]

EMISSION TYPE	REFERENCE NUMBER	NUMBER OF TEST RUNS	DATA RATING	EMISSION FACTOR lb per 1000 lb CEMENT SUPPLEMENT LOADED	FINAL EMISSION FACTORS RATING
PM-10	1	2	C	**0.64611**	**E**
PM	1	2	C	**1.56773**	**E**
CONTROLLED PM-10	2	3	A	**2.43E-003**	**E**
CONTROLLED PM	2	3	A	7.92E-003	
	4	3	D	1.01E-003	
	AVERAGE			**4.47E-003**	**D**
CONTROLLED ARSENIC	2	1	C	**5.02E-007**	**E**
CONTROLLED BERYLLIUM	2	1	C	**4.52E-008**	**E**
CONTROLLED CADMIUM	2	1	C	**9.92E-009**	**E**
CONTROLLED CHROMIUM	2	1	C	**6.10E-007**	**E**
CONTROLLED LEAD	2	1	C	**2.60E-007**	**E**
CONTROLLED MANGANESE	2	1	C	**1.28E-007**	**E**
CONTROLLED MERCURY	2	--	--	--	--
CONTROLLED NICKEL	2	1	C	**1.14E-006**	**E**
CONTROLLED PHOSPHORUS	2	1	C	**1.77E-006**	**E**
CONTROLLED SELENIUM	2	1	C	**3.62E-008**	**E**

19.3 EMISSION FACTORS FOR AGGREGATE & SAND TRANSFER TO ELEVATED BINS[d]

	EMISSION TYPE	REFERENCE NUMBER	NUMBER OF SAMPLES	DATA RATING	EMISSION FACTORS per Mg transferred (kg)	EMISSION FACTORS per ton transferred (lb)	FINAL EMISSION FACTOR RATING
AGGREGATE	**PM-10**	1	2	A			
		2	1	A			
		1 & 2			**1.68E-003**	**3.27E-003**	**D**
	PM	1	2	A			
		2	1	A			
		1 & 2			**3.54E-003**	**6.92E-003**	**D**
SAND	**PM-10**	1	3	A			
		2	2	A			
		1 & 2			**5.05E-004**	**9.86E-004**	**D**
	PM	1	2	A			
		2	2	A			
		1 & 2			**1.07E-003**	**2.08E-003**	**D**

19.4 WEIGH HOPPER LOADING EMISSION FACTORS [d]

English Unit Emission Factors		FINAL
PM-10	PM	RATING
0.00375 lb/yd³	**0.00794** lb/yd³	D
0.00228 lb/ton	**0.00482** lb/ton	D

Metric Unit Emission Factors		FINAL
PM-10	PM	RATING
0.00117 kg/Mg	**0.00247** kg/Mg	D

The emission factors were developed from the Aggregate and Sand Transfer to Elevated Bins Emission Factors as follows:

This formula was used to compute the lb of emissions per yd³ of concrete.
E = (AEF)(AYD3) + (SEF)(SYD3)

This formula was used to compute the lb of emissions per ton of aggregate and sand.
E = (AEF)(ATON) + (SEF)(STON)

This formula was used to compute the kg of emissions per Mg of aggregate and sand.
E = (AEF)(AMG) + (SEF)(SMG)

E	=	Emission Factors (lb / ton, lb / yd³, & kg / Mg)				
AEF	=	Aggregate Transfer Emission Factor for PM-10	AEF	=	3.27E-003	lb/ton
SEF	=	Sand Transfer Emission Factor for PM-10	SEF	=	9.86E-004	lb/ton
AEF	=	Aggregate Transfer Emission Factor for PM	AEF	=	6.92E-003	lb/ton
SEF	=	Sand Transfer Emission Factor for PM	SEF	=	2.08E-003	lb/ton
AEF	=	Aggregate Transfer Emission Factor for PM-10	AEF	=	1.68E-003	kg/Mg
SEF	=	Sand Transfer Emission Factor for PM-10	SEF	=	5.05E-004	kg/Mg
AEF	=	Aggregate Transfer Emission Factor for PM	AEF	=	3.54E-003	kg/Mg
SEF	=	Sand Transfer Emission Factor for PM	SEF	=	1.07E-003	kg/Mg
AYD3	=	Aggregate per Yd³ of Concrete (see Appendix C)	AYD3	=	1,865	lb
SYD3	=	Sand per Yd³ of Concrete (see Appendix C)	SYD3	=	1,428	lb
ATON	=	Aggregate per Ton of Aggregate and Sand	ATON	=	1,133	lb
STON	=	Sand per Ton of Aggregate and Sand	STON	=	867	lb
AMG	=	Aggregate per Mg of Aggregate and Sand	AMG	=	566	kg
SMG	=	Sand per Mg of Aggregate and Sand	SMG	=	434	kg

ATON + [ATON * (SYD3 / AYD3)] = Ton of Aggregate and Sand (TAS)
ATON = TAS / (1+ SYD3 / AYD3)
STON = [ATON * (SYD3 / AYD3)]

AMG and SMG are calculated in the same manner.

19.5 PLANT WIDE EMISSION FACTORS [e]

Truck Mix

	Uncontrolled PM (lb/yd³)	Uncontrolled PM-10 (lb/yd³)	Controlled PM (lb/yd³)	Controlled PM-10 (lb/yd³)	FINAL RATING
Aggregate delivery to ground storage	0.0064	0.0031	0.0064	0.0031	
Sand delivery to ground storage	0.0015	0.0007	0.0015	0.0007	
Aggregate transfer to conveyor	0.0064	0.0031	0.0064	0.0031	
Sand transfer to conveyor	0.0015	0.0007	0.0015	0.0007	
Aggregate transfer to elevated storage	0.0064	0.0031	0.0064	0.0031	
Sand transfer to elevated storage	0.0015	0.0007	0.0015	0.0007	
Cement delivery to Silo (Controlled)	0.0002	0.0001	0.0002	0.0001	
Cement Supplement delivery to Silo (Controlled)	0.0003	0.0002	0.0003	0.0002	
Weigh Hopper Loading	0.0079	0.0038	0.0079	0.0038	
Truck Mix Loading	0.1725	0.0422	0.0579	0.0143	
Total	**0.2048**	**0.0576**	**0.0902**	**0.0297**	**E**

Central Mix

	Uncontrolled PM (lb/yd³)	Uncontrolled PM-10 (lb/yd³)	Controlled PM (lb/yd³)	Controlled PM-10 (lb/yd³)	FINAL RATING
Aggregate delivery to ground storage	0.0064	0.0031	0.0064	0.0031	
Sand delivery to ground storage	0.0015	0.0007	0.0015	0.0007	
Aggregate transfer to conveyor	0.0064	0.0031	0.0064	0.0031	
Sand transfer to conveyor	0.0015	0.0007	0.0015	0.0007	
Aggregate transfer to elevated storage	0.0064	0.0031	0.0064	0.0031	
Sand transfer to elevated storage	0.0015	0.0007	0.0015	0.0007	
Cement delivery to Silo (Controlled)	0.0002	0.0001	0.0002	0.0001	
Cement Supplement delivery to Silo (Controlled)	0.0003	0.0002	0.0003	0.0002	
Weigh Hopper Loading	0.0079	0.0038	0.0079	0.0038	
Central Mix Loading	0.0628	0.0219	0.0031	0.0011	
Total	**0.0951**	**0.0373**	**0.0355**	**0.0165**	**E**

Based on truck and central mix emission factors of lb/1,000 lb of cement and cement supplement presented in section 5.2 and 5.3, emission factors of lb/1,000 lb material transferred from tables 19.1 through 19.4 and the following average composition of concrete as presented in Table 16.1.

Course Aggregate	1865	pounds
Sand	1428	pounds
Cement	491	pounds
Pozolan Material	73	pounds
Water	20	gallons

5.4 Notes for the Final Emission Factors

[a] The emission factors based on total cement and cement supplements (natural pozolans, NewCem™ or fly ash) are used to compute the final emission factors for truck mix loading and central mix loading. Most facilities should have an accurate record of the weight of these materials used to manufacture concrete. Emission factors based upon the weight of fine material in the batches may be a more reliable metric. However, this information would be more difficult to obtain for existing plants and to predict for new plants. Most of the emissions from concrete batching come from the "fines" that are used to make the concrete. Over 95% of the "fines" are composed of the dry cement and cement supplement. The remaining "fines" are contained in the course aggregate and sand and are partially bound to the larger material by surface moisture. Therefore, emission factors based upon the mass of cement and cement supplement may be useful for a broad range of facilities including those that specialize in a product composed of raw materials significantly different than typical concrete. As shown in Table 16.2 batch formulation summary statistics derived from reference 1 and 2 information indicates that over 90% of the batches contained between 9 and 18 weight percent cement and cement supplement. Batch formulations outside this range may be used at facilities that have a specialized product line but would constitute a minor portion of the typical concrete batch plants product line.

Since information on the amount of concrete produced may be more readily available than for the amounts of cement and cement supplements, the emission factor based on concrete will also be presented in the AP-42 section.

The emission factors based on cement are not used because they do not account for the relationship between the amount of **cement supplement** used and the amount of emissions released. This issue is significant since cement supplements are used in sizable quantities and are often "finer" than cement. The emission factors based on total dry materials used are not used because they do not accommodate formulations that may be used at some specialized but large facilities.

[b] The controlled cement silo filling emission factors derived from test runs that included emissions from the loading of transit-mix trucks are not used because of their apparent lack of precision and accuracy. Consequently, only "Run 7" is used from Reference 1, since it was the only Reference 1 test run that captured emission solely from the cement silo filling process.

[c] The controlled cement supplement silo filling emission factors derived from test runs that included emissions from the loading of transit-mix trucks are not used because of their apparent lack of precision and accuracy. Consequently, none of the emission factors from Reference 1 are used to develop these emission factors.

[d] These emission factors are based on the material transfer equation 1 in AP-42 section 13.2.4, *Aggregate Handling and Storage Piles*, (1/95) using average amounts of aggregate and sand used per yd^3 of concrete at References 1 and 2. These emission factors are rated D, since only two test references were used for estimating material moisture content and a wind speed of 10 mph.

[e] The calculated plant wide emission factors are rated E, since they are used in conjunction with the average composition of concrete from only two facilities.

Appendix A

Technical Notes for Reference 1 Tables

Tables 1.2, 1.3, 2.2, 2.3, 3.2, 3.3, 4.2, 4.3, 5.3, 5.4, 6.3, 6.4

1. Each of the estimated emission amounts due solely to silo fillings can be reproduced in the following stepwise manner. First, divide the total amount of "fines" (cement, NewCem™, and silt from sand and coarse aggregate) used during the particular silo filling and truck mix loading test run by one thousand. Next, multiply the resulting number by the average truck mix loading emission factor for the same type emission based on fines. Third, subtract this result from the total amount of emission from the particular silo filling and truck mix loading test. The result of this calculation is an estimate of the emissions form the silo filling.

2. The amount of cement or NewCem™ loaded during each of the silo loading test runs was approximated by analyzing information from Appendix B.2 and the Process Notes Section of the test report. Reproduction of each of these values can be accomplished stepwise as follows. First, compute the rate at which any relevant silo filling (a filling that occurred in part or whole during the test run of interest) was occurring by dividing the amount of material loaded by the time required for the loading to be accomplished. Next, multiply this rate buy the amount of time in which **both** the silo filling and emission testing were occurring simultaneously (this computation relies on the assumption that the loading rates were constant throughout the loading process). Repeat this procedure for each of the other relevant silo fillings that occurred during the test run of interest. Finally, sum the results together to determine the total amount of cement or NewCem™ loaded during the test run.

Tables 2.1 – 2.3, 4.1 – 4.3. 6.1 – 6.4

1. Each of the emission rates at the dust collector's outlet was estimated by averaging all of the outlet rates for the same emission type. The outlet rates were averaged because the individual outlet runs listed in the test report occurred over the course of several inlet runs. The outlet runs lasted longer than the inlet runs, since longer sampling times were required to collect measurable amounts of emissions from the outlet.

Tables 2.2, 2.3, 4.2, 4.3, 5.4, 5.5, 6.1 – 6.5

1. The designation "—" was substituted for every value in the tables that was less than or equal to zero.

Tables 3.1, 4.1

1. The following statistical method indicated that the emission rate for PM during test run 14 was an extreme value relative to the other central batch loading emission rates for PM. In this statistical method a value *r* is computed for a given number of observations as follows:

If *r* is greater than the **critical value** that is associated with the given number of observations, then the extreme value is outside the 99 percentile. Specific critical values for certain numbers of observations are given in the following table:[1]

Number of Observations, *n*	Critical Value
	=.01
3	.988
4	.889
5	.780
6	.698
7	.637

Tables 3.1 – 3.3, 4.1 – 4.3, 5.1 – 5.5, 6.1 – 6.5

The metal emission factors were based on the test report's "Case 2" emission rates. In "Case 2," the captured and/or the background metal concentrations from which the metal emissions rates were derived were designated to be zero when actual concentrations were below detection limits.

1. The metal emission rates at the inlet of the dust collector were given for several test runs at a time in the test report. As a result, the group of test runs used to develop the individual emission factors are listed above the names of the metals. Accordingly, the estimated capture efficiencies were developed by averaging the capture efficiencies of the listed runs.

Tables, 5.5, 6.5

1. The average metal emission factors were developed only from the emission factors with explicit numerical values

Reference for Appendix A

1. Dixon, Wilfrid J. and Massey, Frank J., Jr., *Introduction to Statistical Analysis,* Second Edition, McGraw-Hill Book Company, Inc., New York, NY, 1957.

Appendix B

Technical Notes for Reference 2 Tables

Tables 7, 8, 9, 10

1. The Estimated Capture Efficiency values were taken from the test report's capture efficiency averages weighted by the amounts and fly ash loaded.

Tables 8, 10, 14.1, 14.2

1. The outlet emission rates given the test report were for emissions coming from both the plant being examined (the Eerie Plant) and another adjacent plant (the Johnson Plant). Consequently, it was necessary to approximate the outlet emission rates due solely to the Eerie Plant during the inlet runs.

   These approximations relied on the assumption that the ration of the Outlet Emission Rate of the Eerie Plant (OERE) to the outlet emission rate of both plants (OERBP) was about the same as the ration of the actual air flow rate of the Eerie Plant (AFRE) to the actual air flow rate of both plants (AFRBP). The formula that shows how this assumption was used to approximate the outlet emission rate due to the Eerie Plant is as follows:

   However, the *AFRE* was measured for each inlet run, whereas the *OERBP* and *AFRBP* were measured for each outlet run. Therefore, the *OERBP* and *AFRBP* are not known for any given measurement of the *AFRE*, since each of the test report's outlet runs typically occurred over the course of several inlet runs. Consequently, the *OERBP* and the *AFRBP* during a particular inlet run were approximated by the *OERBP* and *AFRBP* that were measured for the outlet run that **included** emissions from the particular inlet run respectively.

   On the other hand, the metal inlet **rates** were typically given for several inlet runs at a time. Thus, when calculating the *OERE* for a particular metal inlet rate, the *AFRE* is simply the sum of the *AFRE*s that were measured for the individual inlet runs over which the metal inlet rate was measured. However, the group of inlet runs over which a metal inlet rate were measured does not usually correspond to any group of inlet runs over which an outlet run was preformed. Therefore, both the *OERBP* and *AFRBP* are not necessarily known for any particular metal inlet rate. Consequently, the *OERBP* and *AFRBO* that were used to determine the *OERE* for a particular metal emission rate were approximated by the average of **all** of the *OERBP*s for the same type of metal emission and the average of **all** of the *AFRBP*s respectively.

Table 11

1. Since the three silo emission test runs were performed on three separate days, it was assumed that a given test run collected the emissions resulting from all of the silo loadings that occurred on the day of the test run. Consequently, the "cement loaded" amount associated with each test run was assumed to be the same as the total amount of cement delivered on the particular day of the test run. The total amount of cement delivered on a given day was determined by summing together the amounts of cement delivered as indicated on the bills of sale for the given day. The bills of sale for each day were found in the Process Notes Section of the test report.

Table 12

1. The amount of fly ash loaded for each run was assumed to be the same for each run, since only one fly ash loaded amount was found in the Process Notes Section of the test report.

Tables 13.1 – 13.3, 14.1 – 14.3

1. The metal emission factors were based on the test report's "Case 2" emission rates. In "Case 2," the captured and/or the background metal concentrations from which the metal emission rates were derived were designated to be zero when the actual concentrations were below the detection limits.

2. The designation "- -" was substituted for every value in the tables that was less than or equal to zero

3. Each group of metal emission rates at the inlet were measured for several test runs at a time in the test report. As a result, the test runs over which a given group of metal emission rates were measured are listed above the group. Accordingly, the estimated capture efficiency associated with a particular group of metal inlet rates was developed by a straight average of the capture efficiencies of the test runs listed above the group.

Tables 13.3, 14.3

1. The average emission factors were developed from only those emission factors in the table with explicit numerical values.