United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park, NC 277

EMB Report No. 88-MIN-09A
January 1989

Air

A-89-08

II-A-23

EPA

Municipal Waste C
Multipollutant Study:
Refuse - Derived Fuel

Summary Report

Mid-Connecticut
Resource Recovery Facility
Hartford, Connecticut

DCN: 89-222-124-24-03 EMB Report No. 88-MIN-09A

CDD/CDF, METALS AND PARTICULATE EMISSIONS SUMMARY REPORT

MID-CONNECTICUT RESOURCE RECOVERY FACILITY HARTFORD, CONNECTICUT

TSD Project No. 86/19
EPA Contract No. 68-02-4338
Work Assignment 21

Prepared for:

Dr. Theodore Brna, Task Manager
Air and Energy Engineering Research Laboratory
Office of Research and Development

and

Clyde E. Riley, Task Manager
Emission Measurement Branch
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Prepared by:

Carol L. Anderson, P.E.
Radian Corporation
Post Office Box 13000
Research Triangle Park, North Carolina 27709

January 1989

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DISCLAIMER

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1.0 PROJECT OVERVIEW

1.1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) published in the Federal Register (52 FR 25399) an advance notice of proposed rulemaking to regulate new municipal waste combustors (MWC) under Section 111(b) of the Clean Air Act and to regulate one or more designated pollutants (pollutants not regulated under Sections 100-108 or 112), thus invoking Section 111(d) of the Subpart B regulations. This action requires EPA to issue existing source guidelines. Development by States of specific emission standards for existing municipal waste combustors and development of new source performance standards for new or modified MWCs would follow. The schedule for regulation calls for proposal of new source standards and issuance of draft emission guidelines for existing sources in November 1989. Promulgation of new source standards and finalization of emission guidelines in December 1990 will follow.

The Emission Standards Division of the Office of Air Quality Planning and Standards (OAQPS) is responsible for developing the technical basis for the MWC regulations. One of the key activities in this process involves reviewing the existing MWC emission data base, identifying gaps in the existing data base, and generating additional information to fill any existing data gaps. As a result, several MWC emissions tests have been performed and several others are in the planning stages. The data gathered from these tests will supplement the existing data base and will support regulatory development. The four classes of air pollutants included in this study are: criteria pollutants, organics (including chlorinated dibenzo-p-dioxins [CDD] and chlorinated dibenzofurans [CDF]), heavy metals, and acid gases.

1.2 BACKGROUND

The Mid-Connecticut Resource Recovery Facility was required by the Connecticut Department of Environmental Protection to conduct a compliance test program to measure controlled particulate, CDD/CDF, and metals emissions from their three state-of-the-art refuse-derived fuel (RDF) combustor systems. Process data were also collected as part of the compliance test program.

Limited emissions data (uncontrolled or controlled) are currently available for state-of-the-art RDF facilities under normal operating conditions. Thus, in order to provide data to evaluate the CDD/CDF, metals and particulate removal efficiency of the spray dryer/fabric filter (SD/FF) emission control system, the Mid-Connecticut facility and EPA agreed to jointly sponsor an expanded program during the compliance test period. The Mid-Connecticut facility sponsored measurements of the controlled emissions that were performed by TRC, Inc. The EPA sponsored measurements that were performed by Radian Corporation of the uncontrolled emissions prior to the spray dryer. The test program was conducted during July 12-16, 1988.

This report combines the uncontrolled and controlled emission results into a summary report. Detailed emission test reports were prepared separately for the EPA-sponsored uncontrolled emissions results[1] and the controlled emissions results measured by TRC, Inc.[2]

1.3 PURPOSE AND OBJECTIVES

The specific objectives of the Mid-Connecticut test program were:

1. To determine the level of uncontrolled MWC emissions, including CDD/CDF, metals, and particulate from a state-of-the-art RDF facility.
2. To determine the control efficiency of a spray dryer/fabric filter (SD/FF) system for CDD/CDF, metals, and particulate over the normal operating range of the combustor.

1.4 BRIEF PROCESS DESCRIPTION

Figure 1-1 is a process diagram of one of the three combustor systems at the Mid-Connecticut facility. The three units are designated #11, #12, and #13. Each combustor is designed to burn a maximum of 675 tons per day (TPD) of RDF or 236 TPD of coal and to produce 231,000 lb/hr of steam on RDF and 192,000 lb/hr steam on coal. After the combustion gases pass through

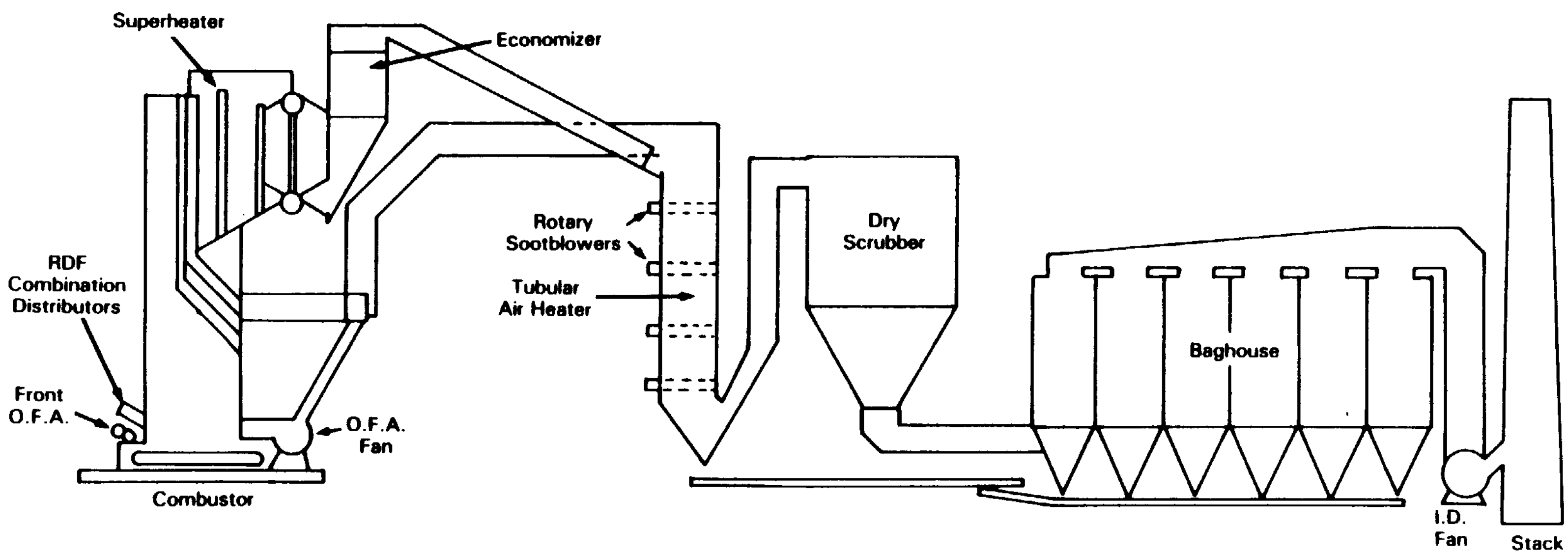

Figure 1-1. Mid-Connecticut Facility Layout

superheater and economizer sections, the cooled gases pass through a spray dryer and fabric filter and exit through the stack. During this test program, sampling was conducted at Unit #11 and 100 percent RDF was fired.

1.5 TEST PROGRAM

The test program was conducted over the period of July 12 to July 16, 1988 on Unit #11. CDD/CDF sampling was conducted on July 12 and 13. Mercury sampling by EPA Method 101A was conducted on July 14 and toxic metals sampling was conducted on July 15. The sampling log is summarized in Table 1-1.

There was a leak in the sampling collection system during inlet CDD/CDF Run 2. The flue gas volume was adjusted by eight percent based on a final leakrate of 0.2 cfm.

The measured flue gas moisture content was used as another estimate of the amount of leakage. The moisture value for Run 2 agreed with Run 3 indicating that the leak was small.

During the metals/particulate Run 3, the sampling period included a sootblowing cycle. Thus, the uncontrolled particulate and uncontrolled metals results for this run are expected to be higher than those from Runs 1 and 2.

The sampling and analytical procedures used for this test program are summarized in Table 1-2. The target CDD/CDF congeners for the flue gas analyses are listed in Table 1-3.

1.6 ORGANIZATION

Mr. Mike Johnston of OAQPS and Dr. Ted Brna of the Air and Energy Engineering Research Laboratory (AEERL) were the EPA program coordinators. Mr. Gene Riley, of OAQPS, was the EPA Task Coordinator responsible for coordinating Radian Corporation's efforts. Mr. Winton Kelly was the Radian on-site field team leader. The test program coordinators were responsible for

TABLE 1-1. SUMMARY OF SAMPLING LOG FOR TESTING AT THE MID-CONNECTICUT RESOURCE RECOVERY FACILITY

Date	Run	Parameter Measured	Sampling Period[a]	Notes
7/12/88	1	CDD/CDF	I 11:50-14:48 O 10:02-14:04	--
7/13/88	2	CDD/CDF	I 9:44-12:53 O 9:13-12:29	Uncontrolled CDD/CDF train had a leak in transfer line after Port E.
7/13/88	3	CDD/CDF	I 15:12-18:08 O 14:16-17:33	--
7/14/88	1	Mercury	I 9:44-11:57 O 9:44-11:49	--
7/14/88	2	Mercury	I 13:34-15:48 O 13:33-15:39	--
7/14/88	3	Mercury	I 16:49-19:04 O 16:43-18:48	--
7/15/88	1	Particulate, Toxic Metals[b]	I 10:00-11:30 O 10:02-11:16	--
7/15/88	2	Particulate, Toxic Metals[b]	I 12:34-14:05 O 12:33-13:48	--
7/15/88	3	Particulate, Toxic Metals[b]	I 15:14-16:46 O 15:13-16:29	The sampling period included a sootblowing cycle from 15:25-16:07.

[a] I = inlet; O = outlet.

[b] The uncontrolled flue gas was sampled according to the draft EMSL metals method which has 16 target metals. The controlled flue gas was sampled according to a combination of EPA Methods 12 (lead) and 108 (arsenic). The controlled samples were analyzed for lead, mercury, arsenic, nickel, and chromium.

TABLE 1-2. SUMMARY OF SAMPLING AND ANALYTICAL PROCEDURES FOR THE MID-CONNECTICUT TEST PROGRAM

Parameter	Sampling Method	Analytical Method
CDD/CDF	Environmental Standards Workshop Protocol (December 1984 Draft)	High Resolution GC/MS
Mercury	EPA Method 101A	Cold Vapor AA
Particulate/ Metals[a]	Draft EMSL Method (inlet) EPA Methods 12 and 108 (outlet)	Draft EMSL Method[b] Atomic Adsorption[c]
NO_x	EPA Method 7E	Chemiluminescent gas analyzer
CO	EPA Method 10	Nondispersive infrared gas analyzer
Moisture	EPA Method 4	--
Volumetric Flowrate	EPA Methods 1 and 2	--
Fixed Gases[d] (O_2, CO_2, N_2)	EPA Method 3 and 3A	Orsat, paramagnetic (O_2), infrared (CO_2)

[a]Target metals are Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Mn, Ni, P, Pb, Sb, Se, Tl, Zn.

[b]Analytical Methods for uncontrolled samples:

Graphite furnace atomic absorption (GF AA): Ag, As, Pb, Se

Inductively coupled argon plasma emission spectroscopy (ICPES): Ba, Cd, Cr, Cu, Mn, Ni, P, Sb, Tl, Zn, Be

Cold Vapor Atomic Adsorption Spectroscopy (CV AAS): Hg

[c]Controlled samples were analyzed for As, Cr, Hg, Ni, Pb.

[d]The fixed gases (O_2, CO_2 and N_2) samples were collected and analyzed by TRC, Inc.

TABLE 1-3. TARGET CDD/CDF CONGENERS FOR THE MID-CONNECTICUT TEST PROGRAM

DIOXINS

Total trichlorinated dibenzo-p-dioxins (TrCDD)[a]

2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD)

Total tetrachlorinated dibenzo-p-dioxins (TCDD)

1,2,3,7,8 pentachlorodibenzo-p-dioxin (1,2,3,7,8 PeCDD)

Total pentachlorinated dibenzo-p-dioxins (PeCDD)

1,2,3,4,7,8 hexachlorodibenzo-p-dioxin (1,2,3,4,7,8 HxCDD)

1,2,3,6,7,8 hexachlorodibenzo-p-dioxin (1,2,3,6,7,8 HxCDD)

1,2,3,7,8,9 hexachlorodibenzo-p-dioxin (1,2,3,7,8,9 HxCDD)

Total hexachlorinated dibenzo-p-dioxins (HxCDD)

1,2,3,4,6,7,8 heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8 HpCDD)

Total heptachlorinated dibenzo-p-dioxins (HpCDD)

Total octachlorinated dibenzo-p-dioxins (OCDD)

FURANS

Total trichlorinated dibenzofurans (TrCDF)[a]

2,3,7,8 tetrachlorodibenzofurans (2,3,7,8 TCDF)

Total tetrachlorinated dibenzofurans (TCDF)

1,2,3,7,8 pentachlorodibenzofuran (1,2,3,7,8 PeCDF)

2,3,4,7,8 pentachlorodibenzofuran (2,3,4,7,8 PeCDF)

Total pentachlorinated dibenzofurans (PeCDF)

1,2,3,4,7,8 hexachlorodibenzofuran (1,2,3,4,7,8 HxCDF)

1,2,3,6,7,8 hexachlorodibenzofuran (1,2,3,6,7,8 HxCDF)

2,3,4,6,7,8 hexachlorodibenzofuran (2,3,4,6,7,8 HxCDF)

1,2,3,7,8,9 hexachlorodibenzofuran (1,2,3,7,8,9 HxCDF)

Total hexachlorinated dibenzofurans (HxCDF)

1,2,3,4,6,7,8 heptachlorodibenzofuran (1,2,3,4,6,7,8 HpCDF)

1,2,3,4,7,8,9 heptachlorodibenzofuran (1,2,3,4,7,8,9 HpCDF)

Total heptachlorinated dibenzofurans (HpCDF)

Total octachlorinated dibenzofurans (OCDF)

[a]The controlled samples were not analyzed for trichlorinated CDD/CDF.

coordinating the overall test program with the plant officials and ensuring that the process and control equipment operating conditions were suitable for testing.

1.7 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The test program was designed and executed with emphasis on completeness and data quality. A comprehensive QA/QC program was an integral part of Radian's test program. The goal of the QA/QC effort was to ensure that the data collected were of known precision and accuracy and that they were complete, representative and comparable. Data comparability was achieved by using standard units of measure as specified by the methods.

In addition to Radian's internal QC program, two independent CDD/CDF audit samples prepared by EMSL were submitted for analysis along with the flue gas samples. These results are presented in Reference 3.

1.8 DESCRIPTION OF REPORT SECTIONS

The remaining sections of this volume are organized as follows:

Section 2.0 - Summary of Results
Section 3.0 - Process Description and Operation
Section 4.0 - Sampling Locations
Section 5.0 - Sampling and Analytical Procedures
Section 6.0 - Quality Assurance/Quality Control
Section 7.0 - References
Section 8.0 - Metric-to-English Conversion Table

The supporting data and calculations for this summary report are contained in the emission test reports for the inlet[3] and outlet.[4] The emission test reports include appendices containing field data sheets, analytical reports, calculations and other related information.

2.0 SUMMARY OF RESULTS

The results of the flue gas sampling at the Mid-Connecticut MWC are presented in this section. English and metric units are used to present the results. Typically, results of the sampling parameters (such as volumetric flowrate) are presented in English units and concentrations of pollutants are reported in metric units. Metric units are preferable for reporting the relatively low concentrations that were measured. The flue gas concentrations are presented on a dry basis. For the reader's convenience, a Metric-to-English table is included in Section 8.0.

A summary of the CDD/CDF, metals, particulate and operating data is presented in Table 2-1. The average total tetra- through octa-chlorinated uncontrolled dioxins concentration was 328 ng/dscm @ 12% CO_2 and the average total tetra- through octa-chlorinated uncontrolled furans concentration was 668 ng/dscm @ 12% CO_2. The average 2378-TCDD toxic equivalency concentration was 11.8 ng/dscm @ 12% CO_2.

For the controlled flue gas, 2378-TCDD and 2378-TCDF were not detected. The minimum detection limit was 3 picograms for 2378-TCDD and 9 picograms for 2378-TCDF. The average total tetra- through octa- chlorinated controlled CDD/CDF concentration was 0.646 ng/dscm adjusted to 12 percent CO_2. The average control efficiency was 99.94 percent.

The average uncontrolled particulate loading for Runs 1 and 2 was 2.409 grains/dscf @ 12% CO_2. Run 3 included a sootblowing cycle and the particulate loading was measured at 4.778 grains/dscf @ 12% CO_2. The average controlled particulate loading was 0.0040 grains/dscf adjusted to 12 percent CO_2. The average control efficiency was 99.85 percent.

For the metals, lead and zinc were measured at the highest concentrations in the uncontrolled flue gas. The average uncontrolled lead concentration was 35,974 ug/dscm @ 12% CO_2 and the average uncontrolled zinc concentration was

TABLE 2-1. SUMMARY OF MID-CONNECTICUT MWC RESULTS

Parameter	Run 1	Run 2	Run 3	Average				
Steam load (10^3 lb/hr) 7/13/88	204	198	197	--				
7/14/88	203	195	211	--				
7/15/88	222	207	202	--				
Flue Gas CDD/CDF Concentration[a]	Uncontrolled				Controlled			
(ng/dscm @ 12% CO_2)	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
2378-TCDD	1.96	1.34	2.11	1.81	[0.002]	[0.002][g]	[0.004]	[0.003]
Total tetra-octa CDD	366	239	378	328	0.605	0.207	[0.01]	0.271
2378-TCDF	16.0	11.2	10.8	12.7	0.028	[0.014]	[0.003]	[0.009]
Total tetra-octa CDF	893	544	568	668	0.769	0.357	[0.005]	0.375
Total tetra-octa CDD & CDF	1259	783	946	996	1.37	0.564	[0.01]	0.646
2378-TCDD Toxic Equivalents	14.5	9.36	11.4	11.8	0.0044	0.0007	0.0	0.0017
Particulate Loading[b]								
(mg/dscm @ 12% CO_2)	5,872	5,154	10,926[c]	5,513[d]	4.66	9.33	13.3	9.10
(gr/dscf @ 12% CO_2)	2.565	2.252	4.778[c]	2.409[d]	0.0021	0.0041	0.0059	0.0040
Flue Gas Metals Concentration[d,e] (ug/dscm @ 12% CO_2)								
Antimony	2,989	2,763	NR[f]	2,876	--	--	--	--
Arsenic	1,234	808	NR	1,021	[4.9]	[5.9]	[0.65]	[3.8]
Barium	1,225	225	NR	725	--	--	--	--
Beryllium	[174]	[117]	NR	[146]	--	--	--	--
Cadmium	859	1,196	NR	1,027	--	--	--	--
Total Chromium	920	863	NR	892	111	[98]	[49]	[86]
Copper	2,302	2,630	NR	2,466	--	--	--	--
Lead	41,694	30,254	NR	35,974	[9.9]	[9.1]	[14]	[11]
Manganese	3,052	4,662	NR	3,857	--	--	--	--
Mercury (EMSL Method)	802	1,138	NR	970	--	--	--	--
Mercury (EPA Method 101A)[h]	320	1,163	1,051	845	126	3.5	16	49
Nickel	560	481	NR	520	439	454	[335]	409
Phosphorus	25,048	29,486	NR	27,267	--	--	--	--
Selenium	[13.5]	[14.3]	NR	[13.9]	--	--	--	--
Silver	17.2	20.8	NR	19.0	--	--	--	--
Thallium	[14.0]	[14.6]	NR	[14.3]	--	--	--	--
Zinc	43,458	51,423	NR	47,441	--	--	--	--

[a] CDD/CDF samples were collected on 7/12/88 for Run 1 and on 7/13/88 for Runs 2 and 3. Standard conditions are 68°F and 1 atm.

[b] Particulate loading samples were collected on 7/15/88 for all three runs.

[c] The sampling interval for particulate/EMSL metal Run 3 included a sootblowing cycle.

[d] The uncontrolled particulate and metals averages are for Runs 1 and 2 only.

[e] EMSL metals samples were collected on 7/15/88 in the same train as the particulate samples.

[f] NR = not reported.

[g] Values in brackets are minimum detection limits for compounds that were not detected. For calculational purposes, not detected compounds are considerd zeros.

[h] The EPA Method 101A mercury samples were collected on 7/14/88.

47,441 ug/dscm @ 12% CO_2. Metals that were found to be below detection limits in the uncontrolled flue gas were beryllium, selenium and thallium.

Of the five metals measured in the controlled flue gas: arsenic, chromium, lead, mercury, and nickel, the nickel concentration was the highest at 409 ug/dscm adjusted to 12 percent CO_2. The average controlled mercury concentration was 49 ug/dscm adjusted to 12 percent CO_2 and arsenic, chromium, and lead were measured below detection limits.

The control device was most efficient at removing lead at 99.97 percent, followed by arsenic at 99.36 percent, chromium at 86.36 percent and mercury at 93.45 percent. The control device was least efficient at removing nickel; the average nickel removal efficiency was 4.14 percent.

2.1 CDD/CDF RESULTS

The uncontrolled and controlled CDD/CDF results are summarized with the sampling parameters in Table 2-2. The results for the individual congeners and the 2,3,7,8-TCDD toxic equivalents adjusted to 12 percent CO_2 are presented in Table 2-3 for the uncontrolled flue gas and in Table 2-4 in the controlled flue gas. The totals represent the sum of just the tetra- through octa-chlorinated homologues. Not detected values are considered zero for calculating averages, totals and toxic equivalents.

The uncontrolled flue gas samples were analyzed as front half and back half fractions. The front half fraction includes the probe rinse, filter and front half of the filter housing. The back half fraction includes the coil condenser, XAD trap, teflon transfer line, impingers and back half of the filter housing. The uncontrolled results for the front half and back half fractions that are not adjusted to 12 percent CO_2 are presented in Table 2-5. The controlled results that are not adjusted to 12 percent CO_2 are presented in Table 2-6.

TABLE 2-2. SUMMARY OF CDD/CDF EMISSIONS FOR THE MID-CONNECTICUT MWC

Run No.	Run 1 (7-12-88) 11:50-14:48 Uncontrolled	Run 1 (7-12-88) 10:02-14:04 Controlled	Run 2 (7-13-88) 9:44-12:53 Uncontrolled	Run 2 (7-13-88) 9:13-12:29 Controlled	Run 3 (7-13-88) 15:13-18:08 Uncontrolled	Run 3 (7-13-88) 14:16-17:33 Controlled
Flue Gas Characteristics[a]						
Volume gas sampled (dscf)	62.2	88.1	57.5[e]	85.7	60.0	83.6
Flue gas flow rate (dscfm)	87,777	99,100	91,177	97,000	88,287	100,000
Flue gas temperature (^{o}F)	381	241	379	239	384	248
Moisture (percent by volume)	16.2	17.9	12.5	17.4	13.0	16.8
Isokinetics (percent)	103.0	106.3	99.6	103.1	98.8	102.4
CO_2 (percent by volume, dry)[b]	9.7	9.7	10.2	10.1	9.4	9.4
O_2 (percent by volume, dry)[b]	9.8	9.8	9.6	9.7	10.2	10.3
Process Operations						
Steam load (10^3 lb/hr)	203.6		197.9		198.6	
CDD Results[c]						
Total CDD (ng/dscm)	296	0.489	203	0.174	296	ND [0.01][f]
Total CDD (corrected to 12% CO_2, ng/dscm)	366	0.605	239	0.207	378	ND [0.01]
Control Efficiency (%)	99.83		99.91		99.99	
CDF Results[c]						
Total CDF (ng/dscm)	722	0.621	463	0.301	445	ND [0.005]
Total CDF (corrected to 12% CO_2, ng/dscm)	893	0.769	544	0.357	568	ND [0.005]
Control Efficiency (%)	99.91		99.93		99.99	
Total CDD/CDF Results[c]						
Total CDD/CDF (ng/dscm)	1018	1.11	666	0.475	741	ND [0.01]
Total CDD/CDF (corrected to 12% CO_2, ng/dscm)	1259	1.37	783	0.564	946	ND [0.01]
Control Efficiency (%)	99.89		99.93		99.99	
2378-TCDD Toxic Equivalent[d] (ng/dscm @ 12% CO_2)	14.5	0.0044	9.36	0.0007	11.4	<0.0237

[a]Metric-to-English conversion factors are in Section 8.0. Standard conditions are 68^{o}F and 1 atm.

[b]These values are averages of data taken over the sampling period. Inlet values were collected according to EPA Method 3 with Orsat analysis. Outlet values are from CEM data. Sampling and analysis was performed by TRC, Inc.

[c]CDD/CDF results are adjusted for internal standard recoveries and sample blank results. Totals are for tetra- through octa-homologues.

[d]Toxic equivalency factors developed by the U.S. EPA.[5]

[e]The flue gas sample volume was reduced by 5.02 dscf due to a leak in the teflon transfer line during Port E.

[f][ ] indicates minimum detection limit.

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TABLE 2-3. UNCONTROLLED CDD/CDF FLUE GAS CONCENTRATIONS ADJUSTED TO 12 PERCENT CO_2 FOR THE MID-CONNECTICUT MWC

CONGENER	CONCENTRATION[a] (ng/dscm, adjusted to 12 percent CO_2) RUN 1	RUN 2[c]	RUN 3	AVERAGE	2378-TCDD[b] Toxic Equivalency Factor	2378 TOXIC EQUIVALENCIES (ng/dscm, adjusted to 12 percent CO_2) RUN 1	RUN 2[c]	RUN 3	AVERAGE
DIOXINS									
Mono-CDD	[0.093][d]	[0.036]	[0.096]	0.0	0	0	0	0	0
Di-CDD	0.503	[0.106]	[0.267]	0.168	0	0	0	0	0
Tri-CDD	10.3	8.24	[4.89]	6.19	0	0	0	0	0
2378 TCDD	1.96	1.34	2.11	1.81	1.0	1.96	1.34	2.11	1.81
Other TCDD	54.9	20.9	38.4	38.0	0.01	0.549	0.209	0.384	0.380
12378 PCDD	5.43	4.01	5.18	4.87	0.500	2.71	2.01	2.59	2.44
Other PCDD	69.7	35.5	46.2	50.5	0.005	0.349	0.177	0.231	0.252
123478 HxCDD	4.85	3.71	6.79	5.12	0.04	0.194	0.149	0.272	0.205
123678 HxCDD	7.49	5.32	8.13	6.98	0.04	0.300	0.213	0.325	0.279
123789 HxCDD	6.41	7.35	11.6	8.44	0.04	0.256	0.294	0.462	0.338
Other HxCDD	84.1	48.9	74.7	69.2	0.0004	0.034	0.020	0.030	0.028
1234678-HpCDD	46.4	35.8	62.6	48.3	0.001	0.046	0.036	0.063	0.048
Other Hepta-CDD	38.0	28.3	48.2	38.2	0.00001	0.000	0.000	0.000	0.000
Octa-CDD	46.7	48.1	74.4	56.4	0	0	0	0	0
TOTAL CDD[e]	366	239	378	328					
FURANS									
Mono-CDF	[0.059]	[0.039]	[0.079]	0.0	0	0	0	0	0
Di-CDF	7.42	[0.168]	[0.434]	2.47	0	0	0	0	0
Tri-CDF	117	170	50.9	113	0	0	0	0	0
2378 TCDF	16.0	11.2	10.8	12.7	0.100	1.60	1.12	1.08	1.27
Other TCDF	313	172	206	230	0.001	0.313	0.172	0.206	0.230
12378 PCDF	24.1	12.2	12.3	16.2	0.1	2.41	1.22	1.23	1.62
23478 PCDF	27.2	15.9	22.0	21.7	0.1	2.72	1.59	2.20	2.17
Other PCDF	219	116	175	170	0.001	0.219	0.116	0.175	0.170
123478 HxCDF	36.0	28.8	[32.2]	21.6	0.01	0.360	0.288	0.000	0.216
123678 HxDCF	18.2	15.0	[17.7]	11.1	0.01	0.182	0.150	0.000	0.111
234678 HxCDF	24.7	18.8	[28.3]	14.5	0.01	0.247	0.188	0.000	0.145
123789 HxCDF	1.48	1.43	0.869	1.26	0.01	0.015	0.014	0.009	0.013
Other HxCDF	113	65.5	11.8	63.4	0.0001	0.011	0.007	0.001	0.006
1234678-HpCDF	52.9	47.5	63.7	54.7	0.001	0.053	0.047	0.064	0.055
1234789-HpCDF	6.29	5.26	9.22	6.92	0.001	0.006	0.005	0.009	0.007
Other Hepta-CDF	27.7	23.5	38.7	30.0	0.00001	0.000	0.000	0.000	0.000
Octa-CDF	14.0	11.4	17.6	14.3	0	0	0	0	0
TOTAL CDF[e]	893	544	568	668					
TOTAL CDD+CDF[e]	1259	783	946	996		14.5	9.36	11.4	11.8

[a] Standard conditions are 68°F and 1 atm.

[b] Toxic equivalency factors developed by U.S. EPA.[5]

[c] Average of duplicate analyses. The flue gas sample volume was reduced by 5.02 dscf due to a leak in the teflon transfer line during Port E.

[d] [] = minimum detection limit (MDL). () = estimated maximum possible concentration (EMPC). MDLs and EMPCs are considered zeros for calculational purposes.

[e] Totals are for tetra- through octa- homologues.

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TABLE 2-4. CONTROLLED CDD/CDF FLUE GAS CONCENTRATIONS ADJUSTED TO 12 PERCENT CO_2 FOR THE MID-CONNECTICUT MWC

Congener	CONCENTRATION[a] (ng/dscm, adjusted to 12 percent CO_2) Run 1	Run 2	Run 3	Average	2378-TCDD[b] Toxic Equivalency Factor	2378 TOXIC EQUIVALENCIES (ng/dscm, adjusted to 12 percent CO_2) Run 1	Run 2	Run 3	Average
DIOXINS									
Mono-CDD	NR[c]	NR	NR	NR	0	NR	NR	NR	NR
Di-CDD	NR	NR	NR	NR	0	NR	NR	NR	NR
Tri-CDD	NR	NR	NR	NR	0	NR	NR	NR	NR
2378 TCDD	[0.002][d]	[0.002]	[0.004]	0.000	1.0	0.0000	0.0000	0.0000	0.0000
Other TCDD	0.022	[0.005]	[0.015]	0.007	0.01	0.0002	0.0000	0.0000	0.0001
12378 PCDD	[0.016]	[0.005]	[0.028]	0.000	0.5	0.0000	0.0000	0.0000	0.0000
Other PCDD	[0.167]	[0.005]	[0.028]	0.000	0.005	0.0000	0.0000	0.0000	0.0000
123478 HxCDD	[0.021]	[0.004]	[0.031]	0.000	0.04	0.0000	0.0000	0.0000	0.0000
123678 HxCDD	[0.020]	[0.004]	[0.029]	0.000	0.04	0.0000	0.0000	0.0000	0.0000
123789 HxCDD	[0.026]	[0.005]	[0.037]	0.000	0.04	0.0000	0.0000	0.0000	0.0000
Other HxCDD	0.074	0.026	[0.032]	0.033	0.0004	0.0000	0.0000	0.0000	0.0000
1234678-HpCDD	0.160	0.091	[0.147]	0.084	0.001	0.0002	0.0001	0.0000	0.0001
Other Hepta-CDD	0.350	0.091	[0.147]	0.147	0.00001	0.0000	0.0000	0.0000	0.0000
Octa-CDD	[0.220]	[0.160]	[0.566]	0.000	0	0.0000	0.0000	0.0000	0.0000
TOTAL PCDD[e]	0.605	0.207	0.000	0.271					
FURANS									
Mono-CDF	NR	NR	NR	NR	0	NR	NR	NR	NR
Di-CDF	NR	NR	NR	NR	0	NR	NR	NR	NR
Tri-CDF	NR	NR	NR	NR	0	NR	NR	NR	NR
2378 TCDF	0.028	[0.014]	[0.003]	0.009	0.1	0.0028	0.0000	0.0000	0.0009
Other TCDF	0.359	0.119	[0.009]	0.159	0.001	0.0004	0.0001	0.0000	0.0002
12378 PCDF	[0.010]	[0.004]	[0.018]	0.000	0.1	0.0000	0.0000	0.0000	0.0000
23478 PCDF	[0.059]	[0.004]	[0.018]	0.000	0.1	0.0000	0.0000	0.0000	0.0000
Other PCDF	0.190	0.050	[0.018]	0.080	0.001	0.0002	0.0000	0.0000	0.0001
123478 HxCDF	0.060	0.033	[0.015]	0.031	0.01	0.0006	0.0003	0.0000	0.0003
123678 HxDCF	[0.007]	[0.002]	[0.015]	0.000	0.01	0.0000	0.0000	0.0000	0.0000
234678 HxCDF	[0.015]	[0.002]	[0.018]	0.000	0.01	0.0000	0.0000	0.0000	0.0000
123789 HxCDF	[0.019]	[0.004]	[0.024]	0.000	0.01	0.0000	0.0000	0.0000	0.0000
Other HxCDF	0.132	0.036	[0.018]	0.056	0.0001	0.0000	0.0000	0.0000	0.0000
1234678-HpCDF	[0.088]	0.055	[0.047]	0.018	0.001	0.0000	0.0001	0.0000	0.0000
1234789-HpCDF	[0.042]	[0.006]	[0.069]	0.000	0.001	0.0000	0.0000	0.0000	0.0000
Other Hepta-CDF	[0.105]	0.065	[0.055]	0.022	0.00001	0.0000	0.0000	0.0000	0.0000
Octa-CDF	[0.144]	[0.015]	[0.368]	0.000	0	0.0000	0.0000	0.0000	0.0000
TOTAL PCDF[e]	0.769	0.357	0.000	0.375					
TOTAL PCDD+PCDF[e]	1.37	0.564	0.000	0.646		0.0044	0.0007	0.0000	0.0017

[a]Standard conditions are 68 F and 1 atm.

[b]Toxic equivalency factors developed by U.S. EPA.[5]

[c]NR = Not reported by TRC, Inc.

[d][] indicates minimum detection limit (MDL). MDLs are considered zeros for calculational purposes.

[e]Totals are for tetra- through octa- homologues.

TABLE 2-5. UNCONTROLLED CDD/CDF FLUE GAS CONCENTATIONS FOR THE MID-CONNECTICUT MWC

	CONCENTRATION (ng/dscm, as measured)[a]											
	RUN 1			RUN 2			RUN 3			AVERAGE		
CONGENER	Front Half	Back Half	TOTAL	Front Half[b]	Back Half[b]	TOTAL	Front Half	Back Half	TOTAL	Front Half	Back Half	TOTAL
DIOXINS												
Mono-CDD	[0.075][c]	[0.129]	[0.075]	[0.031]	[0.100]	[0.031]	[0.075]	[0.041]	[0.075]	ND[d]	ND	ND
Di-CDD	0.407	[0.150]	0.407	[0.090]	[0.290]	[0.090]	[0.209]	[0.115]	[0.209]	0.136	ND	0.136
Tri-CDD	7.04	1.31	8.35	7.00	[0.585]	7.00	[3.83]	[0.167]	[3.834]	4.68	0.436	5.12
2378 TCDD	1.59	[0.031]	1.59	1.14	[0.013]	1.14	1.65	[0.006]	1.65	1.46	ND	1.46
Other TCDD	38.3	6.06	44.4	17.7	0.017	17.7	30.0	[0.045]	30.0	28.7	2.03	30.7
12378 PCDD	4.14	0.247	4.39	3.41	[0.269]	3.41	4.06	[0.075]	4.06	3.87	0.082	3.95
Other PCDD	51.2	5.19	56.4	30.1	[0.269]	30.1	36.2	[0.075]	36.2	39.2	1.73	40.9
123478 HxCDD	3.75	0.171	3.92	3.16	[0.285]	3.16	5.32	[0.063]	5.32	4.08	0.057	4.13
123678 HxCDD	6.06	[0.279]	6.06	4.52	[0.282]	4.52	6.37	[0.056]	6.37	5.65	ND	5.65
123789 HxCDD	4.70	0.479	5.18	6.25	[0.340]	6.25	9.05	[0.075]	9.05	6.67	0.160	6.83
Other HxCDD	64.3	3.68	68.0	41.5	(2.699)	41.5	58.5	(0.096)	58.5	54.8	1.23	56.0
1234678-HpCDD	35.7	1.80	37.5	30.0	0.465	30.5	49.0	[0.088]	49.0	38.2	0.755	39.0
Other Hepta-CDD	28.8	1.92	30.7	23.5	0.541	24.0	37.7	[0.088]	37.7	30.0	0.822	30.8
Octa-CDD	34.8	3.00	37.8	39.1	1.81	40.9	58.3	(0.204)	58.3	44.0	1.60	45.6
TOTAL CDD[e]	273	22.6	296	200	2.83	203	296	0.00	296	257	8.46	265
FURANS												
Mono-CDF	[0.048]	[0.107]	[0.048]	[0.033]	[0.103]	[0.033]	[0.062]	[0.040]	[0.062]	ND	ND	ND
Di-CDF	5.99	[0.308]	5.99	[0.143]	[0.455]	[0.143]	[0.340]	[0.218]	[0.340]	2.00	ND	2.00
Tri-CDF	83.1	11.3	94.4	145	[0.171]	145	39.9	[0.118]	39.9	89.3	3.76	93.1
2378 TCDF	12.4	0.538	12.9	9.53	[0.011]	9.53	8.47	0.024	8.49	10.1	0.187	10.3
Other TCDF	225	27.7	253	146	0.131	146	161	0.273	162	177	9.37	187
12378 PCDF	18.6	0.854	19.5	10.3	[0.160]	10.3	9.65	[0.053]	9.65	12.9	0.285	13.2
23478 PCDF	20.2	1.73	22.0	13.5	[0.171]	13.5	17.2	[0.059]	17.2	17.0	0.578	17.6
Other PCDF	154	23.5	177	98.2	0.104	98.3	137	(0.186)	137	130	7.87	137
123478 HxCDF	25.3	3.73	29.1	24.4	0.040	24.4	[25.2]	[0.032]	[25.2]	16.6	1.26	17.8
123678 HxDCF	13.4	1.31	14.7	12.7	[0.156]	12.7	[13.8]	[0.026]	[13.8]	8.72	0.436	9.16
234678 HxCDF	17.2	2.78	20.0	16.0	0.037	16.0	[22.2]	[0.043]	[22.1]	11.1	0.941	12.0
123789 HxCDF	1.19	[0.174]	1.19	1.22	[0.273]	1.22	0.681	[0.050]	0.681	1.03	ND	1.03
Other HxCDF	75.6	15.6	91.3	55.5	0.225	55.7	9.16	0.071	9.24	46.8	5.30	52.1
1234678-HpCDF	38.3	4.46	42.8	40.2	0.178	40.4	49.8	0.096	49.9	42.8	1.58	44.4
1234789-HpCDF	4.56	0.523	5.09	4.47	[0.361]	4.47	7.22	[0.068]	7.22	5.42	0.174	5.59
Other Hepta-CDF	20.4	2.02	22.4	19.9	0.037	20.0	30.2	0.116	30.3	23.5	0.726	24.2
Octa-CDF	11.3	[1.138]	11.3	9.69	[0.558]	9.69	13.8	[0.112]	13.8	11.6	ND	11.6
TOTAL CDF[e]	637	84.8	722	462	0.752	463	444	0.580	445	514	28.7	543
TOTAL CDD+CDF[e]	911	107	1018	662	3.58	666	740	0.580	741	771	37.2	808

[a] Standard conditions are 68°F and 1 atm. The values presented in this table have not been adjusted to a standard CO_2 concentration (i.e., 12% CO_2).

[b] Average of duplicate analyses. The flue gas sample volume was reduced by 5.02 dscf due to a leak in the teflon transfer during Port E.

[c] [] = minimum detection limit (MDL). () = estimated maximum possible concentration (EMPC). MDLs and EMPCs are considered zeros for calculational purposes.

[d] ND = not detected

[e] Totals are for tetra- through octa- homologues.

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TABLE 2-6. CONTROLLED CDD/CDF FLUE GAS CONCENTRATIONS FOR THE MID-CONNECTICUT MWC

CONGENER	CONCENTRATION[a] (ng/dscm, as measured) Run 1	Run 2	Run 3	Average
DIOXINS				
Mono-CDD	NR[b]	NR	NR	NR
Di-CDD	NR	NR	NR	NR
Tri-CDD	NR	NR	NR	NR
2378 TCDD	[0.002][c]	[0.002]	[0.003]	ND[d]
Other TCDD	0.018	[0.004]	[0.012]	0.006
12378 PCDD	[0.013]	[0.004]	[0.022]	ND
Other PCDD	[0.135]	[0.004]	[0.022]	ND
123478 HxCDD	[0.017]	[0.003]	[0.024]	ND
123678 HxCDD	[0.016]	[0.003]	[0.023]	ND
123789 HxCDD	[0.021]	[0.004]	[0.029]	ND
Other HxCDD	0.060	0.022	[0.025]	0.027
1234678-HpCDD	0.129	0.076	[0.115]	0.069
Other Hepta-CDD	0.283	0.076	[0.115]	0.120
Octa-CDD	[0.178]	[0.135]	[0.443]	ND
TOTAL PCDD[e]	0.489	0.174	0.00	0.221
FURANS				
Mono-CDF	NR	NR	NR	NR
Di-CDF	NR	NR	NR	NR
Tri-CDF	NR	NR	NR	NR
2378 TCDF	0.022	[0.012]	[0.002]	0.007
Other TCDF	0.290	0.100	[0.007]	0.130
12378 PCDF	[0.008]	[0.003]	[0.014]	ND
23478 PCDF	[0.048]	[0.003]	[0.014]	ND
Other PCDF	0.154	0.042	[0.014]	0.065
123478 HxCDF	0.048	0.027	[0.012]	0.025
123678 HxDCF	[0.006]	[0.002]	[0.012]	ND
234678 HxCDF	[0.012]	[0.002]	[0.014]	ND
123789 HxCDF	[0.015]	[0.003]	[0.019]	ND
Other HxCDF	0.107	0.030	[0.014]	0.046
1234678-HpCDF	[0.071]	0.046	[0.037]	0.015
1234789-HpCDF	[0.034]	[0.005]	[0.054]	ND
Other Hepta-CDF	[0.085]	0.054	[0.043]	0.018
Octa-CDF	[0.116]	[0.013]	[0.288]	ND
TOTAL PCDF[e]	0.621	0.301	0.000	0.307
TOTAL PCDD+PCDF[e]	1.11	0.475	0.000	0.529

[a]Standard conditions are 68 F and 1 atm. The results in this table have not been adjusted to a standard CO_2 concentrations (i.e., 12% CO_2).

[b]NR = Not reported by TRC, Inc.

[c][ ] indicates minimum detection limit (MDL). MDLs are considered zeros for calculational purposes.

[d]ND = Not detected.

[e]Totals are for tetra- through octa- homologues.

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Since the controlled flue gas contained little or no CDD/CDF, the control efficiencies were high. The control efficiencies were calculated for each individual tetra- through octa- chlorinated homologue which are presented in Table 2-7. The control efficiencies ranged from 99.08 to 99.99 percent indicating high removal efficiency for all congeners.

The CDD/CDF congener distributions were calculated for the uncontrolled flue gas samples only since the controlled flue gas contained little or no CDD/CDF. The distributions are based on mole fractions of each congener which are plotted in a bar graph for easy comparison in Figure 2-1.

For the uncontrolled CDD congeners, about 50 percent of the congeners were hexa, hepta, and octa-CDDs. For the uncontrolled CDF congeners, about 70% of the congeners were tri-, tetra- and penta-CDFs.

2.2 TOXIC METALS RESULTS

The uncontrolled toxic metals results adjusted to 12 percent CO_2 are presented in Table 2-8. Results are presented only for Runs 1 and 2, because the front half fraction of Run 3 was lost during analysis due to analyst error. Lead, zinc, and phosphorus were found in the highest concentrations while beryllium, selenium and thallium were found to be below detection limits.

The uncontrolled flue gas samples were analyzed as three fractions: 1) the front half, 2) the first three impingers, and 3) the fourth impinger. The first two fractions were analyzed for all sixteen metals and the third fraction was analyzed for mercury only as specified in the method. The results are presented for each fraction that are not adjusted to 12 percent CO_2 in Table 2-9. Most of the metals were collected in the front half fraction although mercury was measured in all three fractions.

Due to the configuration of the inlet sampling location, Port A was not traversed and the first point of the remaining ports was moved in six inches

TABLE 2-7. CDD/CDF CONCENTRATIONS AND CONTROL EFFICIENCIES FOR THE MID-CONNECTICUT MWC[a]

	RUN 1			RUN 2			RUN 3			Average Reduction Efficiency
	Concentration (ng/dscm, adjusted to 12% CO2)		Reduction Efficiency	Concentration (ng/dscm, adjusted to 12% CO2)		Reduction Efficiency	Concentration (ng/dscm, adjusted to 12% CO2)		Reduction Efficiency	
CONGENER	Uncontrolled	Controlled	(%)	Uncontrolled	Controlled	(%)	Uncontrolled	Controlled	(%)	(%)
DIOXINS										
Mono-CDD	[0.093][b]	NR[c]	NR	[0.036]	NR	NR	[0.096]	NR	NR	NR
Di-CDD	0.503	NR	NR	[0.106]	NR	NR	[0.267]	NR	NR	NR
Tri-CDD	10.3	NR	NR	8.24	NR	NR	[4.894]	NR	NR	NR
2378 TCDD	1.96	[0.002]	99.99	1.34	[0.002]	99.99	2.11	[0.004]	99.99	99.99
Other TCDD	54.9	0.022	99.96	20.9	[0.005]	99.99	38.4	[0.015]	99.99	99.98
12378 PCDD	5.43	[0.016]	99.99	4.01	[0.005]	99.99	5.18	[0.028]	99.99	99.99
Other PCDD	69.7	[0.167]	99.99	35.5	[0.005]	99.99	46.2	[0.028]	99.99	99.99
123478 HxCDD	4.85	[0.021]	99.99	3.71	[0.004]	99.99	6.79	[0.031]	99.99	99.99
123678 HxCDD	7.49	[0.020]	99.99	5.32	[0.004]	99.99	8.13	[0.029]	99.99	99.99
123789 HxCDD	6.41	[0.026]	99.99	7.35	[0.005]	99.99	11.6	[0.037]	99.99	99.99
Other HxCDD	84.1	0.074	99.91	48.9	0.026	99.95	74.7	[0.032]	99.99	99.95
1234678-HpCDD	46.4	0.160	99.65	35.8	0.091	99.75	62.6	[0.147]	99.99	99.80
Other Hepta-CDD	38.0	0.350	99.08	28.3	0.091	99.68	48.2	[0.147]	99.99	99.58
Octa-CDD	46.7	[0.220]	99.99	48.1	[0.160]	99.99	74.4	[0.566]	99.99	99.99
TOTAL PCDD[d]	366	0.605	99.83	239	0.207	99.91	378	0.000	99.99	99.92
FURANS										
Mono-CDF	[0.059]	NR	NR	[0.039]	NR	NR	[0.079]	NR	NR	NR
Di-CDF	7.42	NR	NR	[0.168]	NR	NR	[0.434]	NR	NR	NR
Tri-CDF	117	NR	NR	170	NR	NR	50.9	NR	NR	NR
2378 TCDF	16.0	0.028	99.83	11.2	[0.014]	99.99	10.8	[0.003]	99.99	99.94
Other TCDF	313	0.359	99.89	172	0.119	99.93	206	[0.009]	99.99	99.94
12378 PCDF	24.1	[0.010]	99.99	12.2	[0.004]	99.99	12.3	[0.018]	99.99	99.99
23478 PCDF	27.2	[0.059]	99.99	15.9	[0.004]	99.99	22.0	[0.018]	99.99	99.99
Other PCDF	219	0.190	99.91	116	0.050	99.96	175	[0.018]	99.99	99.95
123478 HxCDF	36.0	0.060	99.83	28.8	0.033	99.89	[32.2]	[0.015]	ND[e]	99.86
123678 HxDCF	18.2	[0.007]	99.99	15.0	[0.002]	99.99	[17.7]	[0.015]	ND	99.99
234678 HxCDF	24.7	[0.015]	99.99	18.8	[0.002]	99.99	[28.3]	[0.018]	ND	99.99
123789 HxCDF	1.48	[0.019]	99.99	1.43	[0.004]	99.99	0.869	[0.024]	99.99	99.99
Other HxCDF	113	0.132	99.88	65.5	0.036	99.94	11.8	[0.018]	99.99	99.94
1234678-HpCDF	52.9	[0.088]	99.99	47.5	0.055	99.88	63.7	[0.047]	99.99	99.95
1234789-HpCDF	6.29	[0.042]	99.99	5.26	[0.006]	99.99	9.22	[0.069]	99.99	99.99
Other Hepta-CDF	27.7	[0.105]	99.99	23.5	0.065	99.72	38.7	[0.055]	99.99	99.90
Octa-CDF	14.0	[0.144]	99.99	11.4	[0.015]	99.99	17.6	[0.368]	99.99	99.99
TOTAL PCDF[d]	893	0.769	99.91	544	0.357	99.93	568	0.000	99.99	99.95
TOTAL PCDD+PCDF[d]	1259	1.37	99.89	783	0.564	99.93	946	0.000	99.99	99.94

[a]Standard conditions are 68°F and 1 atm.

[b][] indicates minimum detection limit (MDL). MDLs are considered zeros for calculational purposes.

[c]NR = Not reported by TRC, Inc.

[d]Totals are for tetra- through octa-homologues.

[e]ND = Not detected.

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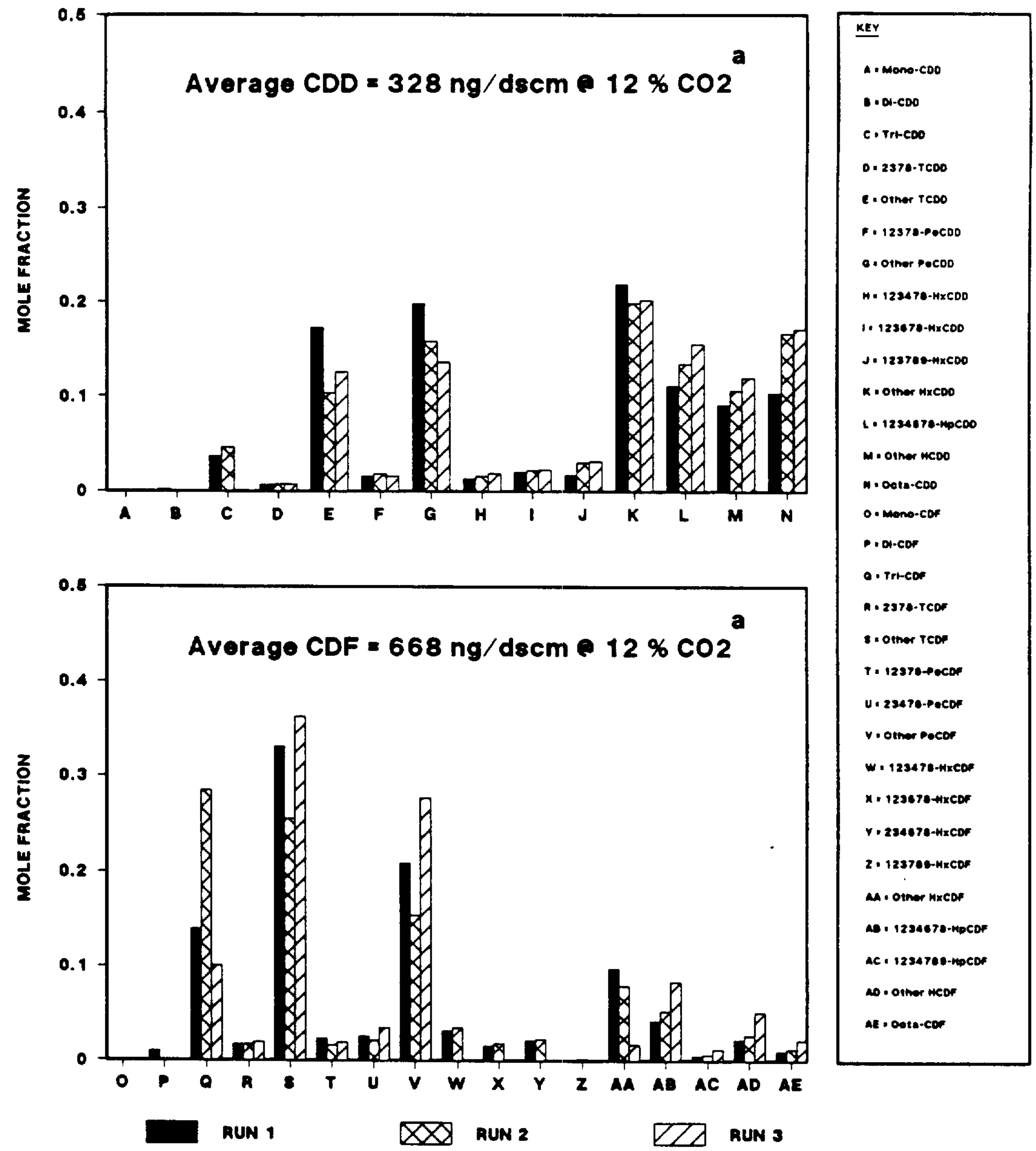

[a] Averages include only tetra- through octa- homologues.

Figure 2-1. Distribution of uncontrolled CDD/CDF congeners for the Mid-Connecticut MWC

TABLE 2-8. UNCONTROLLED EMSL METALS CONCENTRATIONS IN THE FLUE GAS ADJUSTED TO 12 PERCENT CO_2 FOR THE MID-CONNECTICUT MWC

	RUN 1	RUN 2	RUN 3	AVERAGE
DATE	7-15-88	7-15-88	7-15-88	
TIME	10:00-11:30	12:34-14:05	15:14-16:46	
SAMPLING PARAMETERS:				
Volume of flue gas sampled (dscm)	0.890	0.877	0.886	0.884
Flue gas flow rate (dscmm)	2405	2360	2400	2390
Flue gas temperature (F)	371	373	369	371
Moisture (percent by volume)	15.1	15.8	15.7	15.5
Isokinetics (percent)	100.9	101.5	100.6	--
CO_2 (percent by volume, dry)[a]	10.6	10.3	10.3	10.4
O_2 (percent by volume, dry)[a]	9.1	9.4	9.3	9.3

	CONCENTRATION IN THE FLUE GAS (ug/dscm adjusted to 12% CO_2)			
PARAMETER	RUN 1	RUN 2	RUN 3[b]	AVERAGE[c]
Antimony	2989	2763	NR	2876
Arsenic	1234	808	NR	1021
Barium	1225	225	NR	725
Beryllium	[174]	[117]	NR	[146]
Cadmium	859	1196	NR	1027
Total Chromium	920	863	NR	892
Copper	2302	2630	NR	2466
Lead	41694	30254	NR	35974
Manganese	3052	4662	NR	3857
Mercury (d)	802	1138	NR	970
Nickel	560	481	NR	520
Phosphorus	25048	29486	NR	27267
Selenium	[13.5]	[14.3]	NR	[13.9]
Silver	17.2	20.8	NR	19.0
Thallium	[14.0]	[14.6]	NR	[14.3]
Zinc	43458	51423	NR	47441

[a] CO_2 and O_2 analysis by EPA Method 3 (Orsat) was performed by TRC, Inc.

[b] NR= not reported.
Run 3 included a sootblowing cycle. The Run 3-Front half sample was lost during analysis due to analyst error.

[c] In calculating averages not detected compounds are considered zero. The average is for Runs 1 and 2 only.

[d] Mercury results are for the EMSL metals train.

TABLE 2-9. UNCONTROLLED EMSL METALS CONCENTRATIONS IN THE FLUE GAS FOR THE MID-CONNECTICUT MWC

	RUN 1	RUN 2	RUN 3	AVERAGE
DATE	7/15/88	7/15/88	7/15/88	
TIME	10:00-11:30	12:34-14:05	15:14-16:46	
SAMPLING PARAMETERS:				
Volume of flue gas sampled (dscm)	0.890	0.877	0.886	0.884
Flue gas flow rate (dscmm)	2405	2360	2400	2390
Flue gas temperature (F)	371	373	369	371
Moisture (percent by volume)	15.1	15.8	15.7	15.5
Isokinetics (percent)	100.9	101.5	100.6	--
CO_2 (percent by volume, dry)[a]	10.6	10.3	10.3	10.4
O_2 (percent by volume, dry)[a]	9.1	9.4	9.3	9.3

	CONCENTRATION IN FLUE GAS (ug/dscm, dry basis, as measured)												
	RUN 1				RUN 2				RUN 3[c]				AVERAGE[b,d]
PARAMETER	FRONT HALF	IMPINGERS 1, 2, & 3	IMPINGER 4	TOTAL[b]	FRONT HALF	IMPINGERS 1, 2, & 3	IMPINGER 4	TOTAL[b]	FRONT HALF	IMPINGERS 1, 2, & 3	IMPINGER 4	TOTAL[b]	TOTAL (Runs 1&2)
Antimony	2640	[12.1]	NA	2640	2372	[12.4]	NA	2372	NA	[12.2]	NA	NC	2506
Arsenic	1090	[0.367]	NA	1090	693	0.662	NA	694	NA	[0.368]	NA	NC	892
Barium	1079	3.16	NA	1082	187	5.86	NA	193	NA	2.79	NA	NC	637
Beryllium	[154]	[0.364]	NA	[154]	[100]	[0.374]	NA	[100]	NA	[0.365]	NA	NC	0.00
Cadmium	755	3.39	NA	758	1026	[0.748]	NA	1026	NA	[0.728]	NA	NC	892
Total Chromium	809	3.52	NA	813	741	[0.997]	NA	741	NA	[0.971]	NA	NC	777
Copper	2034	[11.7]	NA	2034	2258	[12.0]	NA	2258	NA	[11.6]	NA	NC	2146
Lead	36823	6.83	NA	36830	25966	1.53	NA	25968	NA	2.95	NA	NC	31399
Manganese	2694	1.21	NA	2696	3943	58.6	NA	4002	NA	0.607	NA	NC	3349
Mercury	584	120	4.25	709	789	185	2.83	977	NA	129	4.27	NC	843
Nickel	494	[2.67]	NA	494	413	[2.74]	NA	413	NA	[2.68]	NA	NC	454
Phosphorus	22022	103	NA	22126	25200	109	NA	25309	NA	108	NA	NC	23717
Selenium	[2.70]	[11.9]	NA	[11.9]	[2.74]	[12.3]	NA	[12.3]	NA	[12.0]	NA	NC	0.00
Silver	15	[0.016]	NA	15.2	17.8	0.027	NA	17.8	NA	[0.016]	NA	NC	16.5
Thallium	[12.4]	[5.71]	NA	[12.4]	[12.5]	[5.86]	NA	[12.5]	NA	[5.70]	NA	NC	0
Zinc	38377	11.2	NA	38388	39858	4280	NA	44138	NA	6.35	NA	NC	41263

[a] CO_2 and O_2 analysis by EPA Method 3 (Orsat) was performed by TRC, Inc.

[b] In calculating totals and averages not detected compounds are considered zero. Not detected compounds are indicated by brackets.

[c] Run 3 included a sootblowing cycle. The Run 3-Front half sample was lost during analysis due to analyst error.

[d] Average is for Runs 1 and 2 only.

NA = fraction not analyzed for this metal.

NC = total not calculated since values for the front half were not available.

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during the uncontrolled toxic metals sampling. The relatively constant velocity profile of the inlet duct indicated that the emission concentrations measured are representative.

The controlled toxic metals results are presented in Table 2-10. The controlled flue gas samples which were collected by TRC using EPA Method 12/108, were analyzed for arsenic, chromium, lead and nickel only. Nickel was found in the highest concentration with arsenic, chromium, and lead at or below minimum detection limits.

2.3 MERCURY RESULTS BY EPA METHOD 101A

The uncontrolled mercury results by EPA Method 101A are presented in Table 2-11. The concentration measured during Run 1 was about 30 percent of Runs 2 and 3. Although not measured simultaneously, the uncontrolled mercury results measured using the EMSL method and EPA Method 101A agree within about 10 percent, confirming that the EMSL metals results are valid.

The controlled mercury results determined by EPA Method 101A are summarized in Table 2-12. The mercury concentration for Run 1 was higher than Runs 2 and 3, which is not consistent with the uncontrolled mercury concentrations.

2.4 TOXIC METALS MASS RATES AND CONTROL EFFICIENCIES

The mass rates and control efficiencies for arsenic, chromium, lead, mercury and nickel are summarized in Table 2-13. Arsenic, chromium, lead and nickel were measured simultaneously at the spray dryer inlet and baghouse outlet on 7/15/88. The uncontrolled flue gas was sampled using the EPA draft EMSL protocol, while the controlled flue gas was sampled using EPA Method 12/108. Mercury was sampled at both locations using EPA Method 101A on 7/14/88.

The average control efficiencies ranged from 99.97 percent for lead to 4.14 percent for nickel. The average control efficiencies for arsenic, chromium and mercury were 99.36, 86.36 and 93.45 percent, respectively.

TABLE 2-10. CONTROLLED METHOD 12/108 METALS CONCENTRATIONS IN THE FLUE GAS FOR THE MID-CONNECTICUT MWC[a]

Run: Date: Time:	1 7/15/88 10:02-11:16		2 7/15/88 12:33-13:48		3 7/15/88 15:13-16:29		Average	
Sampling Parameters:								
Volume of flue gas sampled (dscm)	1.83		1.78		1.78		--	
Flue gas flow rate (dscmm)	2,809		2,727		2,767		2,768	
Flue gas temperature (F)	245		246		247		246	
Moisture (percent by volume)	17.0		17.7		17.7		17.5	
Isokinetics (percent)	103.6		103.9		102.5		--	
CO_2 (percent by volume, dry)	10.6		10.3		10.3		10.4	
O_2 (percent by volume, dry)	9.1		9.4		9.3		9.3	
Metals:	ug/dscm	ug/dscm @ 12% CO_2	ug/dscm	ug/dscm @ 12% CO_2	ug/dscm	ug/dscm @ 12% CO_2	ug/dscm	ug/dscm @ 12% CO_2
Arsenic	[4.4]	[4.9]	[5.0]	[5.9]	[0.56]	[0.65]	[3.3]	[3.8]
Total Chromium	98	111	[84]	[98]	[42]	[49]	[75]	[86]
Lead	[8.7]	[9.9]	[7.9]	[9.1]	[12]	[14]	[9.5]	[11]
Nickel	388	439	390	454	[287]	[335]	355	409

[a]Standard conditions are 68°F and 1 atm. Values in brackets are minimum detection limits for compounds that were not detected. Not detected compounds are considered zeros for calculational purposes.

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TABLE 2-11. SUMMARY OF UNCONTROLLED MERCURY RESULTS BY EPA METHOD 101A FOR THE MID-CONNECTICUT MWC[a]

SAMPLING PARAMETERS	Run: Date: Time:	RUN 1 7/14/89 9:44-11:57	RUN 2 7/14/89 13:34-15:48	RUN 3 7/14/89 16:49-19:04	AVERAGE
Volume of flue gas sampled (dscm)		1.365	1.328	1.323	--
Flue gas flowrate (dscmm)		2451	2372	2363	2395
Flue gas temperature (F)		369	376	382	376
Moisture (percent by volume)		14.9	14.8	15.2	15.0
Isokinetics (percent)		101.2	101.7	101.7	--
CO_2 (percent by volume, dry)[b]		10.0	10.1	10.1	10.1
O_2 (percent by volume, dry)[b]		9.7	9.7	9.8	9.7

PARAMETER	TEST RUN NUMBER	MEASURED CONCENTRATIONS (ug/dscm)	(ug/dscm @12% CO_2)	(gr/dscf)	(gr/dscf @12% CO_2)	EMISSION RATE (ppmv)[c]	(ppmv[c] @12% CO_2)	(g/hr)	(lb/hr)
MERCURY	01	267	320	0.000117	0.000140	0.0319	0.0383	39.2	0.0865
	02	979	1163	0.000428	0.000508	0.117	0.139	139	0.307
	03	884	1051	0.000386	0.000459	0.106	0.126	125	0.276
	AVERAGE	710	845	0.000310	0.000369	0.0849	0.101	101	0.223

[a]Standard conditions are 1 atm and 68°F.

[b]CO_2 and O_2 analysis by EPA Method 3 (Orsat) was performed by TRC, Inc.

[c]ppmv = parts per million by volume, dry basis.

TABLE 2-12. CONTROLLED MERCURY RESULTS BY METHOD 101A FOR THE MID-CONNECTICUT MWC (7/14/88)[a]

Run Date Time	RUN 1 7/14/88 9:44-11:49	RUN 2 7/14/88 13:33-15:39	RUN 3 7/14/88 16:43-18:48	AVERAGE
SAMPLING PARAMETERS:				
Volume of flue gas sampled (dscm)	1.93	1.92	1.95	--
Flue gas flowrate (dscmm)	2,724	2,733	2,775	2,744
Flue gas temperature (F)	259	251	259	256
Moisture (percent by volume)	16.2	14.4	14.6	15.1
Isokinetics (percent)	102.9	102.1	101.9	--
CO_2 (percent by volume, dry)	10.0	10.1	10.1	10.1
O_2 (percent by volume, dry)	9.7	9.7	9.8	9.7

Mercury	TEST RUN NUMBER	MEASURED CONCENTRATIONS				EMISSION RATE			
		(ug/dscm)	(ug/dscm @12% CO_2)	(gr/dscf)	(gr/dscf @12% CO_2)	(ppmv)[b]	(ppmv @12% CO_2)[b]	(g/hr)	(lb/hr)
	1	105	126	0.0000459	0.0000551	0.0126	0.0151	1.72	0.0378
	2	2.98	3.54	0.00000130	0.00000154	0.000356	0.000424	0.488	0.0011
	3	13.7	16.2	0.00000597	0.00000709	0.00163	0.00194	2.28	0.0050
	Average	40.6	48.6	0.0000177	0.0000212	0.00486	0.00582	1.50	0.015

[a]Standard conditions are 1 atm and 68°F.

[b]Parts per millions, by volume, dry basis.

TABLE 2-13. TOXIC METALS MASS RATES AND CONTROL EFFICIENCIES

Metal	MASS RATE (lb/hr)											
	Run 1			Run 2			Run 3			Average		
	Uncontrolled	Controlled	Efficiency (percent)[a]	Uncontrolled	Controlled	Efficiency (percent)[a]	Uncontrolled	Controlled	Efficiency (percent)[a]	Uncontrolled	Controlled	Efficiency (percent)[a]
Arsenic	0.347	<0.0016[b]	99.54	0.217	<0.0018	99.17	NR[c]	<0.0018	--	0.282	<0.0018	99.36
Chromium	0.259	0.037	85.71	0.231	<0.030	87.01	NR	<0.016	--	0.245	<0.028	86.36
Lead	11.7	<0.0032	99.97	8.11	<0.0028	99.97	NR	<0.0045	--	9.91	<0.0035	99.97
Mercury[d]	0.0865	0.0378	56.35	0.307	0.0011	99.64	0.276	0.0050	98.19	0.223	0.0146	93.45
Nickel	0.157	0.144	8.28	0.129	0.141	0	NR	<0.105	--	0.143	<0.130	4.14

[a] Where appropriate, minimum detection limits were used to calculate control efficiencies.

[b] "<" indicates a minimum detection limit.

[c] NR = Not reported.

[d] Mercury samples, were collected by EPA Method 101A on 7/14/88. All other metals were collected on 7/15/88. Uncontrolled metals other than mercury were collected using the draft EMSL method. Controlled metals other than mercury were collected using EPA Method 12/108.

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2.5 PARTICULATE LOADING

The particulate loading results are presented in Table 2-14. The uncontrolled particulate samples were collected in the same train as the EMSL metals samples, thus a sootblowing cycle was sampled during Run 3. The uncontrolled particulate loading for Run 3 is about twice that of Runs 1 and 2.

The controlled particulate was collected concurrently in the EPA Method 12/108 train. The controlled particulate loading for Run 3 which included a sootblowing cycle was somewhat higher compared to Runs 1 and 2. The control efficiencies ranged from 99.79 percent to 99.90 percent with an average efficiency of 99.85 percent.

2.6 RATIO OF TOXIC METALS TO PARTICULATE LOADING

The ratio of the metals concentration to the corresponding particulate loading concentration was calculated for each metal and is presented in Table 2-15. The ratio was calculated using the total train metals results and the front half fraction particulate results.

For the uncontrolled flue gas, zinc had the highest average ratio at 8.68 mg/g followed by lead at 6.49 mg/g. Phosphorus was the only other metal above 1 mg/g at 5.0 mg/g.

For the controlled flue gas, nickel had the highest average ratio at 71.5 mg/g. The average uncontrolled ratio for nickel was 0.094 mg/g.

2.7 CEM MONITORING OF O_2, CO_2, CO AND NO_x AT THE OUTLET STACK

Carbon monoxide, nitrogen oxides, oxygen, and carbon dioxide were continuously monitored during the test periods on July 12 and 13. The parameters were monitored by TRC, Inc., and the data were recorded as five-minute averages. The five-minute averages were averaged for each test period. The results are presented in Table 2-16.

TABLE 2-14. PARTICULATE EMISSIONS FOR THE MID-CONNECTICUT MWC[a]

Run No. ---> / Date --->	Run 1 7/15/88		Run 2 7/15/88		Run 3[b] 7/15/88		Average[c]	
	Uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled	Controlled
Sampling Parameters[a]								
Volume gas sampled (dscf)	31.4	64.6	31.0	63.0	31.3	63.0	--	--
Flue gas flow rate (dscfm)	85,000	99,200	83,200	96,300	84,700	97,700	84,300	97,700
Flue gas temperature (°F)	371	245	373	246	369	247	372	246
Moisture (percent by volume)	15.1	17.0	15.8	17.7	15.7	17.7	15.5	17.5
Isokinetics (percent)	100.9	103.6	101.4	103.9	100.6	102.5	--	--
CO_2 (percent by volume, dry)[d]	10.6	10.6	10.3	10.3	10.3	10.3	10.4	10.4
O_2 (percent by volume, dry)[d]	9.1	9.1	9.4	9.4	9.3	9.3	9.3	9.3
Process operations								
Steam load (10^3 lb/hr)	222		207		202		215	
Particulate Results[e]								
Front Half Catch (Probe, cyclone, and filter)								
mg - mass	4616.41	7.62	3880.04	14.3	8308.87	20.7	--	--
gr/dscf	2.266	0.0018	1.933	0.0035	4.101	0.0050	2.100	0.0034
gr/dscf (corrected to 12% CO_2)	2.565	0.0021	2.252	0.0041	4.778	0.0059	2.409	0.0040
mg/dscm	5,187	4.12	4,424	8.01	9,378	11.4	4,806	7.84
mg/dscm (corrected to 12% CO_2)	5,872	4.66	5,154	9.33	10,926	13.3	5,513	9.10
lb/hr	1,652	1.6	1,380	2.9	2,980	4.3	1,516	2.9
kg/hr	749	0.726	626	1.32	1,352	1.95	688	1.32
Control Efficiency (%)	99.90		99.79		99.86		99.85	

[a]Standard conditions are 68°F (20°C) and 1 atm (1.01325 x 10^5 Pa).

[b]Run 3 included a sootblowing cycle.

[c]Uncontrolled average is for Runs 1 and 2 only.

[d]CO_2 and O_2 sampling and analysis by EPA Method 3 (Orsat) was conducted by TRC, Inc.

[e]Results are adjusted for blanks.

TABLE 2-15. RATIO OF METALS TO PARTICULATE LOADING FOR THE MID-CONNECTICUT MWC

	Ratio (mg metal per gram of particulate)[a]							
	Run 1		Run 2		Run 3[b]		Average[c]	
Parameter	Uncon-trolled	Con-trolled	Uncon-trolled	Con-trolled	Uncon-trolled	Con-trolled	Uncon-trolled	Con-trolled
Antimony	0.509	--	0.536	--	--	--	0.523	--
Arsenic	0.210	[1.07]	0.157	[0.624]	--	[0.049]	0.184	[0.847]
Barium	0.209	--	0.044	--	--	--	0.127	--
Beryllium	[0.030][d]	--	[0.023]	--	--	--	[0.027]	--
Cadmium	0.146	--	0.232	--	--	--	0.189	--
Chromium	0.157	23.8	0.167	[10.5]	--	[3.68]	0.162	[17.2]
Copper	0.392	--	0.510	--	--	--	0.451	--
Lead	7.10	[2.11]	5.87	[0.986]	--	[1.05]	6.49	[1.55]
Manganese	0.520	--	0.905	--	--	--	0.713	--
Mercury	0.137	--	0.221	--	--	--	0.179	--
Nickel	0.095	94.2	0.093	48.7	--	[25.2]	0.094	71.5
Phosphorus	4.27	--	5.72	--	--	--	5.00	--
Selenium	[0.0005]	--	[0.0006]	--	--	--	[0.0006]	--
Silver	0.003	--	0.004	--	--	--	0.004	--
Thallium	[0.002]	--	[0.0037]	--	--	--	[0.003]	--
Zinc	7.38	--	9.98	--	--	--	8.68	--

[a] The ratio is calculated using the total train metals results and the front half particulate results. Ratio (mg/g) = concentration of metal (ug/dscm) ÷ concentration of particulate (mg/dscm).

[b] The front half portion of the Run 3 was lost during analysis due to analyst error. Therefore, ratios are not calculated for this run.

[c] Uncontrolled average is for Runs 1 and 2, only.

[d] Brackets indicate that metal was not detected. Ratio was calculated using minimum detection limit.

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TABLE 2-16. SUMMARY OF CEM RESULTS AT THE BAGHOUSE OUTLET, MID-CONNECTICUT MWC, UNIT #11

Parameter[a]	Run: Date: Time:	1 7/12/88 10:05-14:05	2 7/13/88 9:15-12:30	3 7/13/88 14:20-17:30	Average
Carbon monoxide (ppmv)		141.8	198.4	130.1	156.6
Maximum value (ppmv)		384.0	1286	396	--
Minimum value (ppmv)		80.1	89.0	84.2	--
(ppmv adjusted to 7% O_2)		179.2	244.0	170.6	197.7
(ppmv adjusted to 12% CO_2)		175.4	233.4	166.1	191.4
Nitrogen oxides (ppmv as NO_2)		150.1	156.9	154.5	153.4
Maximum value (ppmv)		176.7	182.6	192.0	--
Minimum value (ppmv)		112.8	115.6	108.5	--
(ppmv adjusted to 7% O_2)		189.7	193.0	202.6	194.6
(ppmv adjusted to 12% CO_2)		185.7	184.6	197.2	188.7
Oxygen (percent)		9.9	9.6	10.3	9.9
Maximum value (ppmv)		12.4	13.2	13.1	--
Minimum value (ppmv)		6.8	4.7	7.0	--
Carbon dioxide (percent)		9.7	10.2	9.4	9.8
Maximum value (ppmv)		12.3	14.4	12.1	--
Minimum value (ppmv)		7.3	7.0	7.0	--

[a]All results are on a dry basis. CEM data were collected by TRC, Inc. Results are an average of five-minute averages.

To illustrate the variability during each run and between runs, the five-minute averages were plotted against time and are presented in Figure 2-2. Carbon monoxide normally varied between 100 to 200 ppm, except for occasional excursions. Oxygen correspondingly decreased during these CO excursions. The highest CO excursions occurred during Run 2 at 9:45 when the CO was measured at 1286 ppmv.

The emission of low levels of CO from municipal waste combustors is associated with the implementation of efficient combustion which is related to the destruction of potentially toxic organic pollutants, including CDD/CDF. In general, it is known that high CDD/CDF emissions are associated with high CO emissions and low CDD/CDF emissions are associated with low CO emissions. However, available data indicate that CO and CDD/CDF emissions do not correlate as well below 100 to 200 ppm of CO.

The CO emissions from the Mid-Connecticut MWC during the test program were moderately high, averaging 191.4 ppmv (adjusted to 12% CO_2), with occasional excursions. Based on CO and CDD/CDF relationships for MWC, this level of CO emissions would suggest the high uncontrolled CDD/CDF emissions which were observed (996 ng/dscm adjusted to 12% CO_2). However, the test data also indicate the effectiveness of the application of the SD/FF for post combustion control of CDD/CDF. The SD/FF, operated at low SD outlet temperatures (270°F) and achieving high acid gas removal efficiencies, was able to remove 99.9 percent of the CDD/CDF from the flue gas.

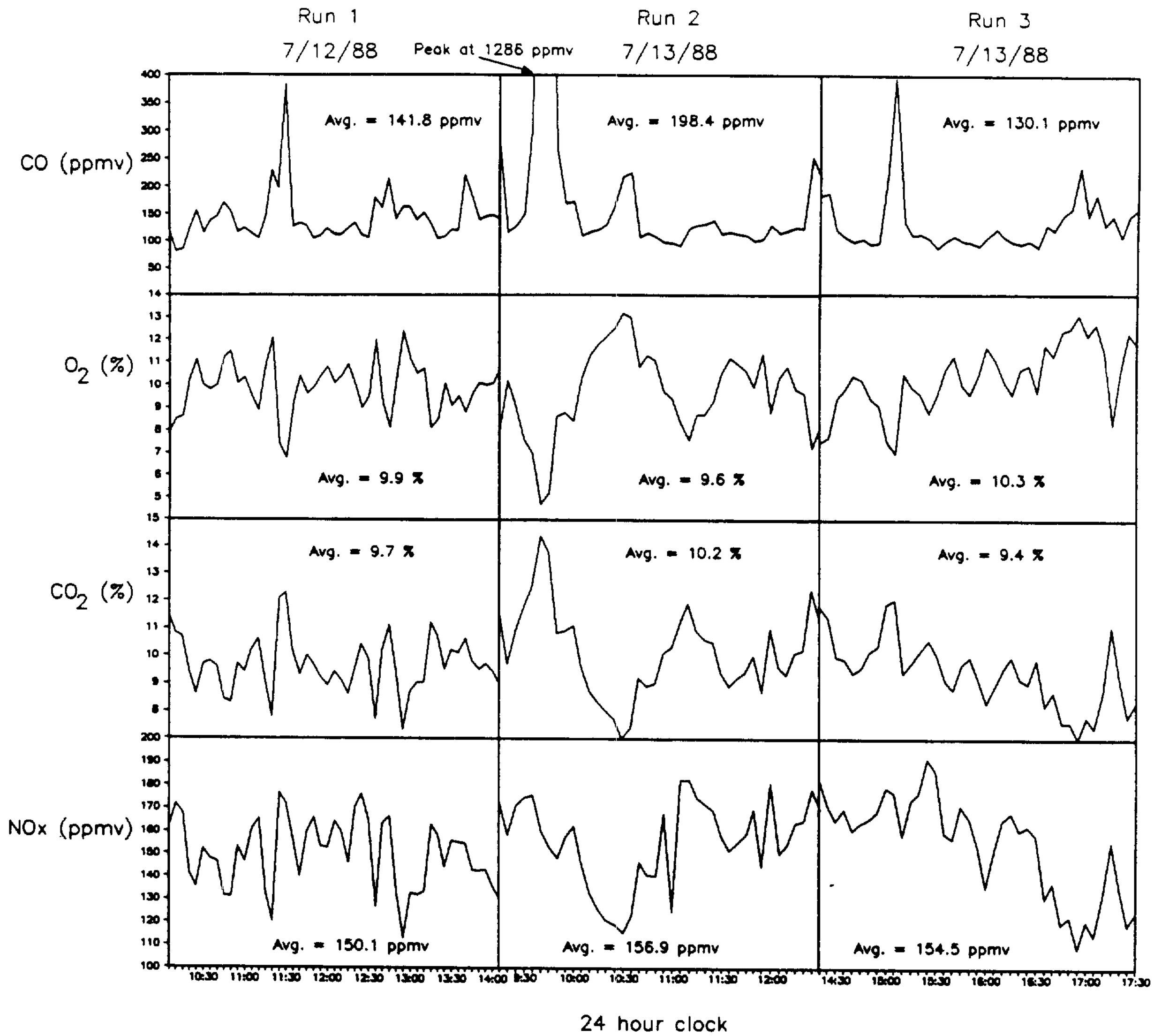

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Figure 2-2. CEM concentration histories at the fabric filter outlet during the test periods for the Mid-Connecticut MWC (Unit 11)

3.0 PROCESS DESCRIPTION AND OPERATION

3.1 COMBUSTOR DESCRIPTION

The Mid-Connecticut Resource Recovery Facility was designed and built by Combustion Engineering, Inc. The facility startup occurred in late fall of 1987 and commercial operation began in October 1988. The facility consists of three spreader stoker-fired boilers each designed to fire a maximum of 675 TPD RDF or 236 TPD coal. Each RDF combustor is designed to produce 231,000 lb/hr of steam at 880 psig and 825°F while firing 100% RDF. A total of 68.5 MW of electricity is produced by two turbine generators. A schematic of the process is shown in Figure 3-1.

Municipal solid waste (MSW) is received from trucks and is deposited onto the tipping floor. After inspection to remove bulky items and hazardous material, the MSW is directed to a flail mill. Iron and steel are then removed by drum-type magnetic separators and the rest of the waste is conveyed to large rotary trommel screens. The trommel screens allow non-combustible residue such as glass and sand to be removed. The second stage of the trommel screens separates the combustible fractions and oversized material is conveyed to a hammermill shredder for final size reduction.

RDF is conveyed from the storage area to surge bins located in front of the combustors. Vibrating pan feeders are used to feed the RDF uniformly to each combustor, where four pneumatic distributors spread the RDF across the grate. The grate is specially designed to allow self-cleaning of fused or clinkered ash during normal grate operations.

Multiple undergrate air zones provide controlled air flow to ten areas of the grate. The overfire air system is separate for coal and RDF firing. Four tangential overfire air windbox assemblies located at the furnace corners are used during RDF firing. Overfire air ports (O.F.A.) for coal

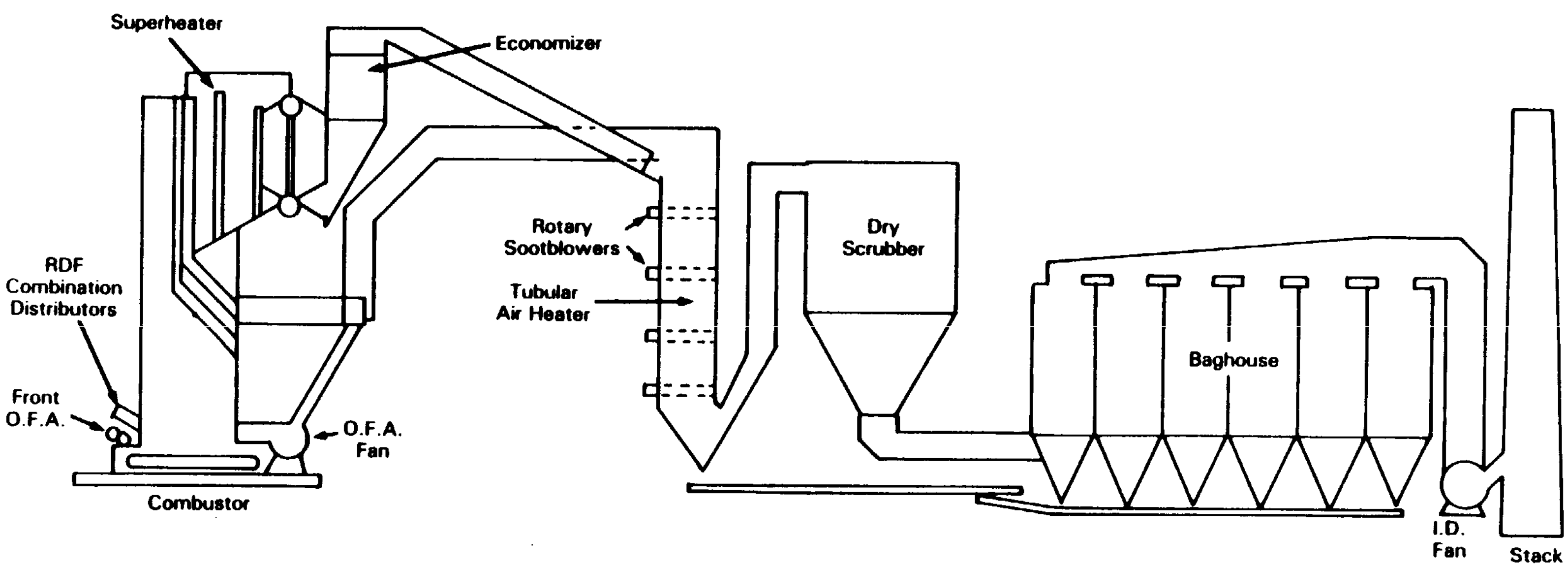

Figure 3-1. Schematic of the Process Line at Mid-Connecticut

combustion are located on the front wall (one row) and rear wall (two rows). combination of the two overfire air modes is possible. The combustion air is preheated in a preheater located downstream of the economizer.

The spreader stokers are equipped with natural circulation waterwall boilers. The furnace dimensions are 20 feet wide by 19 feet deep by 77 feet high. The upper furnace contains widely spaced water-cooled screen panels which cool the combustion panels to approximately 1600^{o}F. The cooled gases then enter the superheater, generator, and economizer sections. The superheater has two stages and operates with parallel steam and gas flow. Steam sootblowers are located between the two stages.

The generating bank is a two-drum design. Two-inch diameter tubing is arranged between a 48-inch lower water drum and a 60-inch upper steam drum. Steam sootblowers are located at the generating bank inlet and in the center cavity between the steam drums. The economizer consists of two horizontal banks of tubing with rotary sootblowers located between the banks and at the economizer outlet.

Bottom ash, economizer ash, and stoker grate siftings are combined into one stream. Baghouse ash and air heater ash are combined, conditioned in a pug mill and then combined with the first stream. The ash mixture is then transported to a three-sided storage bin. Design data for the combustor system are shown in Table 3-1.

3.2 AIR POLLUTION CONTROL SYSTEM

The flue gas cleaning system consists of a spray dryer absorber followed by a fabric filter. Lime slurry is prepared for the spray dryer by slaking pebble lime and partially diluting the slaked lime with water. Water of high quality (potable) is used for slaking. However, ponded water from coal pile runoff, lime slaker cleaning, and slurry lime flushing is used to dilute the concentrated slurry in the atomizer feed tanks. Grit is removed from the concentrated slurry and the slurry is stored in a separate

TABLE 3-1 DESIGN OPERATING CONDITIONS FOR SINGLE RDF COMBUSTOR

Parameter	Design Value
RDF firing rate (lb/hr)	56,300
Steam generation rate (lb/hr)	231,000
Steam temperature at superheater outlet (^{o}F)	825
Steam pressure at superheater outlet (psig)	880
Superheater pressure drop (psi)	102
Feedwater temperature (^{o}F)	384
Feedwater temperature leaving economizer (^{o}F)	476
Economizer pressure drop (psi)	5
Gas temperature leaving boiler (^{o}F)	776
Gas temperature leaving economizer (^{o}F)	603
Gas temperature leaving air heater (^{o}F)	333
Gas flow leaving boiler (lb/hr)	412,000
Air flow entering furnace (lb/hr)	364,000
Excess air (percent)	50

tank. The concentrated slurry is delivered to the spray dryer feed tanks where it is diluted with water. The diluted slurry is atomized into the spray dryer absorber vessel. The slurry rate and dilution water rate are controlled according to the required flue gas temperature and SO_2 concentration at the spray dryer outlet.

The flue gas flowrate through the spray dryer is controlled to maintain near design flue gas velocity in the spray dryer vessel. This is accomplished through use of a multi-louvered damper.

The fabric filter following the spray dryer is reverse-air and has 12 compartments. Each compartment contains 168 teflon-coated fiber glass filter bags arranged in 12 rows of 14 bags. The filter bags are automatically cleaned using a pressure and/or timed cycle. The compartments are cleaned sequentially, with one compartment off-line while the others remain on-line.

3.3 OPERATING DATA DURING THE TEST PROGRAM

Combustor and air pollution control process operating data were monitored during the testing periods. The data were recorded every 15 minutes. The collected data are summarized in Table 3-2. Both the average and relative standard deviation over each test run are presented.

Combustor operation remained fairly consistent across the various runs. The total combustion air flow entering the furnace averaged 397,000 pounds per hour (lb/hr) and ranged from 372,000 to 429,000 lb/hr. The overfire air flow for coal remained zero during all the tests. The boiler oxygen content remained fairly consistent, averaging 8.0 percent. During the EMSL metals/particulate-Run 1, the oxygen concentration did fall to the minimum observed, 6.5 percent, and in Method 101A-Run 1, the highest oxygen concentration was observed, 9.2 percent. The steam flow ranged from 197,900 lb/hr for CDD/CDF-Run 2 to 221,500 lb/hr for EMSL metals/particulate-Run 1 and averaged 204,400 lb/hr. For each of the test runs, the flue gas temperature at the boiler convective pass was

TABLE 3-2. SUMMARY OF OPERATING DATA DURING THE TEST PERIODS FOR THE MID-CONNECTICUT MWC (UNIT 11)[a]

Parameters	CDD/CDF			MERCURY-METHOD 101A			PARTICULATE/EMSL METALS			Total Average
	Run 1 7/12/88 11:50-14:48	Run 2 7/13/88 9:44-12:53	Run 3 7/13/88 15:12-18:08	Run 1 7/14/88 9:44-11:57	Run 2 7/14/88 13:34-15:48	Run 3 7/14/88 16:49-19:04	Run 1 7/15/88 10:00-11:30	Run 2 7/15/88 12:34-14:05	Run 3 7/15/88 15:14-16:46	
Main steam flow (10^3 lb/hr)	203.6 (7.3)	197.9 (15.6)	198.6 (17.8)	202.5 (20.3)	195.0 (19.9)	211.2 (9.6)	221.5 (12.0)	207.3 (8.1)	202.1 (26.8)	204.4 (3.9)
Main steam temperature (^oF)	830.1 (0.9)	826.7 (1.8)	837.4 (2.3)	822.8 (1.0)	818.1 (0.9)	821.0 (0.4)	826.1 (1.4)	820.7 (1.8)	806.3 (2.5)	823.3 (1.0)
Main steam pressure (psig)	833.5 (3.1)	799.0 (1.1)	796.1 (1.1)	803.0 (1.3)	793.5 (1.3)	802.1 (1.3)	858.2 (4.5)	834.8 (4.8)	793.9 (2.4)	812.7 (2.9)
Feed water flow (10^3 lb/hr)	215.6 (12.2)	208.2 (15.0)	208.1 (20.9)	201.8 (22.2)	199.5 (13.7)	213.0 (11.1)	224.0 (10.0)	191.5 (6.0)	225.6 (13.1)	209.7 (5.3)
Total air flow (10^3 lb/hr)	240.8 (2.2)	229.1 (2.8)	228.1 (1.5)	239.7 (2.6)	233.4 (2.5)	233.0 (1.5)	248.3 (1.5)	254.8 (2.3)	261.9 (1.6)	241.0 (4.9)
Left side underfire air										
Flow (10^3 lb/hr)	71.8 (1.6)	66.2 (5.6)	63.6 (1.2)	71.0 (2.4)	72.2 (1.4)	73.1 (1.7)	79.7 (1.3)	80.7 (1.2)	80.2 (0.9)	73.2 (8.3)
Temperature (^oF)	469.3 (0.3)	463.9 (0.8)	471.6 (0.8)	458.5 (0.6)	464.7 (0.5)	473.7 (0.4)	466.4 (0.7)	468.2 (0.3)	464.6 (1.2)	466.8 (0.97)
Pressure (in. WG)	2.3 (6.8)	2.8 (16.8)	2.4 (10.6)	3.7 (24.6)	3.3 (7.5)	3.0 (20.8)	2.7 (6.5)	3.0 (7.5)	2.9 (11.4)	2.9 (14.7)
Right side underfire air										
Flow (10^3 lb/hr)	69.1 (1.9)	69.1 (1.9)	69.6 (2.2)	78.7 (2.9)	69.5 (1.6)	69.6 (1.3)	71.3 (1.8)	73.5 (2.4)	76.3 (2.5)	71.9 (5.0)
Temperature (^oF)	465.3 (0.3)	461.1 (0.9)	468.9 (0.8)	457.7 (0.6)	461.6 (0.5)	470.2 (0.4)	461.0 (0.7)	463.0 (0.3)	459.8 (1.1)	463.2 (0.90)
Pressure (in. WG)	1.1 (15.2)	1.2 (23.6)	1.1 (21.4)	2.1 (6.0)	1.3 (14.8)	1.4 (12.6)	1.8 (10.9)	2.2 (8.9)	2.2 (14.5)	1.6 (30.4)
RDF injection air flow (lb/hr)	10639 (1.2)	10698 (1.8)	10675 (0.5)	10736 (0.4)	11307 (0.7)	11310 (0.5)	10139 (0.4)	10369 (0.9)	10467 (0.9)	10704 (3.7)
Overfire air flow (lb/hr)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

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TABLE 3-2. SUMMARY OF OPERATING DATA DURING THE TEST PERIODS FOR THE MID-CONNECTICUT MWC (UNIT 11)[a] (Continued)

Parameters	CDD/CDF			MERCURY-METHOD 101A			PARTICULATE/EMSL METALS			Total Average
	Run 1 7/12/88 11:50-14:48	Run 2 7/13/88 9:44-12:53	Run 3 7/13/88 15:12-18:08	Run 1 7/14/88 9:44-11:57	Run 2 7/14/88 13:34-15:48	Run 3 7/14/88 16:49-19:04	Run 1 7/15/88 10:00-11:30	Run 2 7/15/88 12:34-14:05	Run 3 7/15/88 15:14-16:46	
Boiler oxygen	7.9	8.7	9.1	9.2	8.6	8.0	6.5	6.7	6.9	8.0
(percent)	(9.1)	(18.7)	(15.2)	(15.3)	(20.1)	(11.4)	(28.4)	(15.3)	(47.3)	(12.9)
Boiler convective pass gas temp.										
Upper left	1073.3	1098.4	1101.9	1116.1	1101.6	1130.0	1105.0	1071.3	1069.1	1096.3
(°F)	(2.9)	(4.2)	(4.1)	(3.8)	(3.3)	(1.7)	(4.4)	(3.3)	(4.0)	(1.9)
Upper center	1149.8	1144.6	1145.4	1151.1	1150.1	1158.2	1157.6	1153.3	1146.6	1150.8
(°F)	(1.4)	(2.7)	(2.5)	(1.6)	(1.9)	(0.0)	(0.0)	(1.0)	(2.4)	(0.43)
Upper right	1137.8	1097.7	1106.7	1117.1	1126.0	1146.9	1157.7	1154.9	1145.4	1132.3
(°F)	(1.7)	(4.5)	(3.7)	(3.4)	(3.0)	(1.3)	(0.0)	(0.6)	(2.7)	(1.9)
Middle left	1143.8	1139.2	1140.2	1142.1	1144.8	1158.2	1155.2	1139.3	1133.4	1144.0
(°F)	(2.2)	(3.1)	(3.3)	(2.6)	(2.7)	(0.0)	(0.4)	(2.8)	(4.7)	(0.7)
Middle center	1147.1	1129.5	1134.0	1132.0	1135.1	1156.2	1157.6	1144.3	1135.0	1141.2
(°F)	(1.8)	(3.6)	(3.5)	(3.2)	(3.3)	(0.6)	(0.0)	(2.2)	(4.9)	(0.9)
Middle right	1060.1	1025.2	1035.3	1037.9	1040.6	1058.2	1115.3	1091.7	1086.3	1061.2
(°F)	(2.1)	(4.5)	(4.4)	(4.4)	(4.5)	(2.0)	(3.1)	(3.5)	(5.9)	(2.9)
Lower left	1021.9	1010.1	1021.6	1001.3	1004.7	1029.8	1040.4	1016.2	981.9	1014.2
(°F)	(2.3)	(4.1)	(5.1)	(4.5)	(4.1)	(1.9)	(3.1)	(3.7)	(6.0)	(1.7)
Lower center	998.2	966.5	978.0	967.3	969.1	987.7	1005.6	991.5	978.1	982.4
(°F)	(1.8)	(3.5)	(4.1)	(3.7)	(3.4)	(1.7)	(1.8)	(3.0)	(4.6)	(1.4)
Lower right	905.7	892.2	903.2	892.6	894.7	908.3	934.3	911.0	889.4	903.5
(°F)	(2.0)	(3.3)	(3.7)	(3.6)	(3.1)	(1.6)	(2.7)	(3.0)	(4.2)	(1.5)
Feed water to economizer temp.	360.3	352.8	350.3	342.9	352.1	357.5	356.3	351.8	365.5	354.4
(°F)	(1.3)	(1.9)	(2.4)	(3.3)	(1.8)	(0.6)	(2.0)	(1.7)	(3.2)	(1.8)
Economizer outlet gas temperature	643.0	635.0	644.6	635.0	643.2	656.0	646.9	642.5	633.8	642.2
(°F)	(1.2)	(1.7)	(1.8)	(1.8)	(1.7)	(0.7)	(1.8)	(1.5)	(1.8)	(1.1)
Airheater air outlet pressure	10.7	9.1	9.1	9.1	9.1	9.2	10.2	11.0	11.6	9.9
(in. WG)	(2.9)	(4.6)	(3.4)	(3.8)	(2.5)	(2.7)	(1.6)	(2.1)	(5.2)	(10.0)

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TABLE 3-2. SUMMARY OF OPERATING DATA DURING THE TEST PERIODS FOR THE MID-CONNECTICUT MWC (UNIT 11)[a] (Continued)

Parameters	CDD/CDF			MERCURY-METHOD 101A			PARTICULATE/EMSL METALS			Total Average
	Run 1 7/12/88 11:50-14:48	Run 2 7/13/88 9:44-12:53	Run 3 7/13/88 15:12-18:08	Run 1 7/14/88 9:44-11:57	Run 2 7/14/88 13:34-15:48	Run 3 7/14/88 16:49-19:04	Run 1 7/15/88 10:00-11:30	Run 2 7/15/88 12:34-14:05	Run 3 7/15/88 15:14-16:46	
Airheater air outlet temperature (°F)	487.6 (0.4)	483.5 (1.0)	491.1 (0.9)	477.2 (0.8)	483.8 (0.7)	492.0 (0.6)	483.1 (0.9)	484.2 (0.4)	479.2 (1.3)	484.6 (1.0)
Airheater gas outlet temperature (°F)	378.7 (0.5)	374.6 (2.3)	384.4 (1.0)	368.2 (0.8)	374.4 (0.8)	381.3 (0.7)	369.6 (1.0)	371.2 (0.4)	369.1 (1.6)	374.6 (1.5)
Airheater gas side ΔP (in. WG)	2.2 (11.7)	2.1 (6.2)	2.0 (3.3)	2.0 (3.4)	1.9 (3.5)	2.1 (6.2)	2.0 (6.5)	1.9 (2.3)	1.9 (5.4)	2.0 (5.5)
Spray dryer ΔP (in. WG)	1.7 (11.0)	1.5 (9.9)	1.6 (11.0)	1.5 (9.5)	1.5 (7.7)	1.5 (5.5)	1.4 (9.5)	1.4 (6.3)	1.5 (11.3)	1.5 (5.5)
Spray dryer outlet temperature (°F)	269.7 (0.6)	265.5 (1.3)	276.7 (0.9)	288.5 (8.8)	277.6 (1.5)	284.8 (0.8)	273.5 (0.8)	275.9 (0.4)	277.8 (0.3)	276.7 (2.5)
Slurry rate to feed tank (gpm)	3.4 (10.5)	4.9 (13.4)	5.4 (2.2)	5.0 (5.9)	5.6 (7.4)	2.8 (8.6)	4.5 (67.6)	3.5 (14.5)	3.5 (11.8)	4.3 (23.8)
Atomizer slurry flow (gpm)	30.3 (0.2)	30.2 (0.2)	30.1 (0.3)	25.1 (19.8)	27.0 (1.0)	26.4 (0.4)	26.6 (0.1)	26.9 (0.6)	27.1 (0.6)	27.7 (7.0)
Lime slurry density (lb/gal)	11.6 (0.2)	11.5 (0.2)	11.6 (0.2)	11.6 (0.1)	11.6 (0.2)	11.6 (0.1)	11.6 (0.1)	11.6 (0.1)	11.6 (0.4)	11.6 (0.3)
Baghouse outlet temperature (°F)	240.6 (0.8)	234.0 (1.0)	250.3 (10.4)	254.1 (4.3)	244.1 (1.7)	253.9 (1.1)	240.0 (0.7)	242.7 (0.3)	241.9 (2.0)	244.6 (2.8)
Baghouse total ΔP (in. WG)	2.3 (14.3)	3.8 (8.0)	3.8 (3.8)	3.7 (4.7)	3.9 (7.5)	3.8 (4.3)	3.9 (13.0)	3.7 (5.7)	3.6 (7.7)	3.6 (14.3)
Air pollution control system total ΔP (in. WG)	9.8 (3.6)	11.3 (2.9)	10.9 (2.5)	11.1 (1.9)	11.5 (3.1)	10.9 (2.5)	11.5 (3.6)	12.0 (1.7)	11.4 (8.2)	11.2 (5.4)

[a]Average value presented with relative standard deviation given in parentheses below the average value.

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consistently near 1,000°F for the nine monitoring thermocouples located left, center and right of the upper, middle and lower portions of the boiler convective section.

The air pollution control system also operated consistently. The spray dryer outlet temperature ranged from 265.5 to 288.5°F and averaged 276.7°F. The lime slurry feed rate to the spray dryer atomizer averaged 27.7 gal/min. During CDD/CDF-Runs 1 to 3, the slurry feed rate ranged from 30.1 to 30.3 gallons/minute, while during the rest of the runs the rate ranged from 25.1 to 27.7 gallons/minute. The lime slurry density averaged 11.6 pounds/gallon for each run.

4.0 SAMPLING LOCATIONS

Sampling was conducted at two locations, the inlet to the spray dryer and the baghouse outlet. These locations are discussed below.

4.1 SPRAY DRYER INLET

Sampling was conducted by Radian at the inlet to the spray dryer. The inlet sampling location is shown on the process line schematic in Figure 4-1. The parameters that were measured at the spray dryer inlet sampling location included CDD/CDF, metals, particulate loading, volumetric flowrate, moisture, O_2 and CO_2.

A side view of the spray dryer inlet sampling location is shown in Figure 4-2. The inlet sampling location has five four-inch I.D. ports arranged horizontally across the face of the rectangular duct between the exit to the air heater and the entrance to the spray dryer (dry scrubber). The internal duct dimensions are 7'5" wide by 6'5" deep. The insulation is 4" deep.

EPA Method 1 was used to select the number and location of the traverse points in the duct. The ports are located approximately 5.7 equivalent duct diameters (39') downstream of a narrowing of the duct and approximately 1.7 equivalent duct diameters (12') upstream of a 90^{o} bend in the duct. Following EPA Method 1 procedures, 20 traverse points are required. However, a 5 x 5 matrix was used for a more balanced traverse point layout. The traverse point location diagram is presented in Figure 4-3.

During metals/PM sampling, the use of teflon transfer line between the heated box and the impinger bucket was discontinued due to the significant time delays caused by its use. However with the heated box and impinger bucket as one unit, the safety rail prevented the traversing of Port A, and

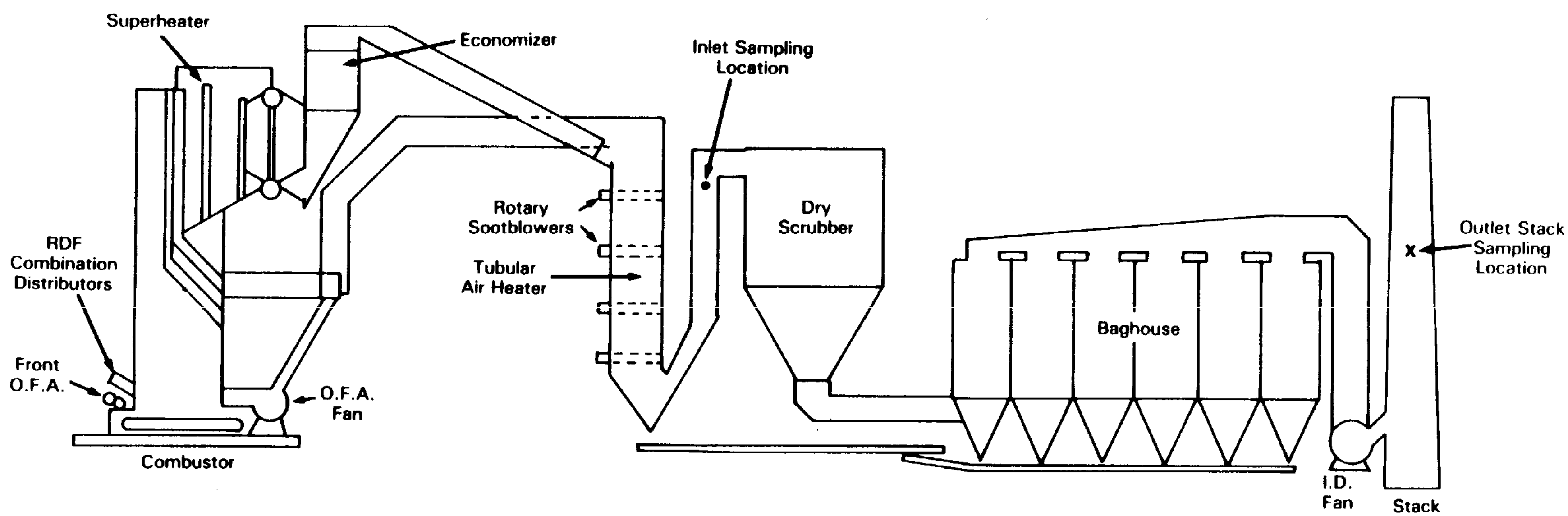

Figure 4-1. Mid-Connecticut MWC Process Line with Sampling Locations

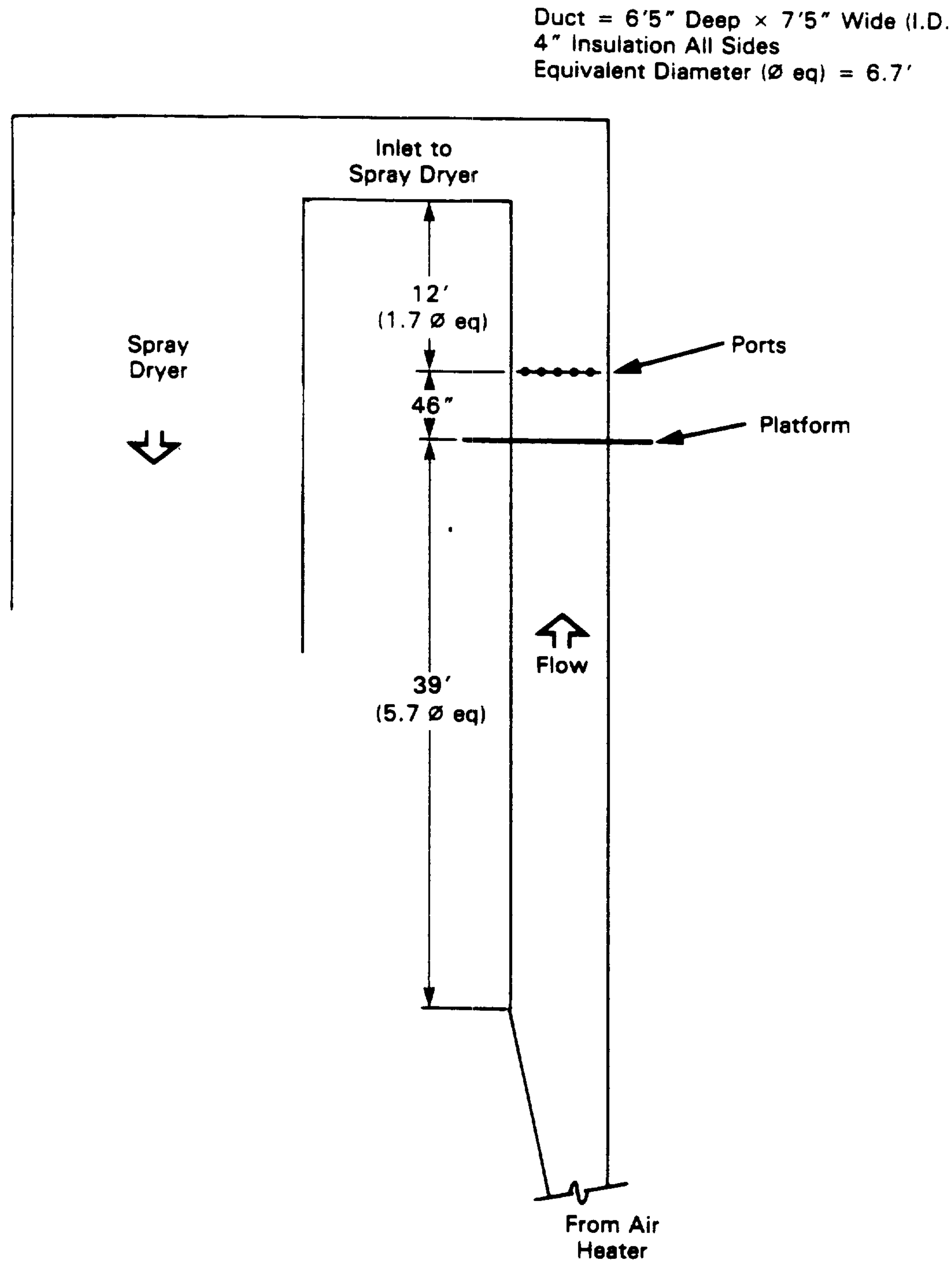

Figure 4-2. Side View of Spray Dryer Inlet Sampling Location at Mid-Connecticut MWC

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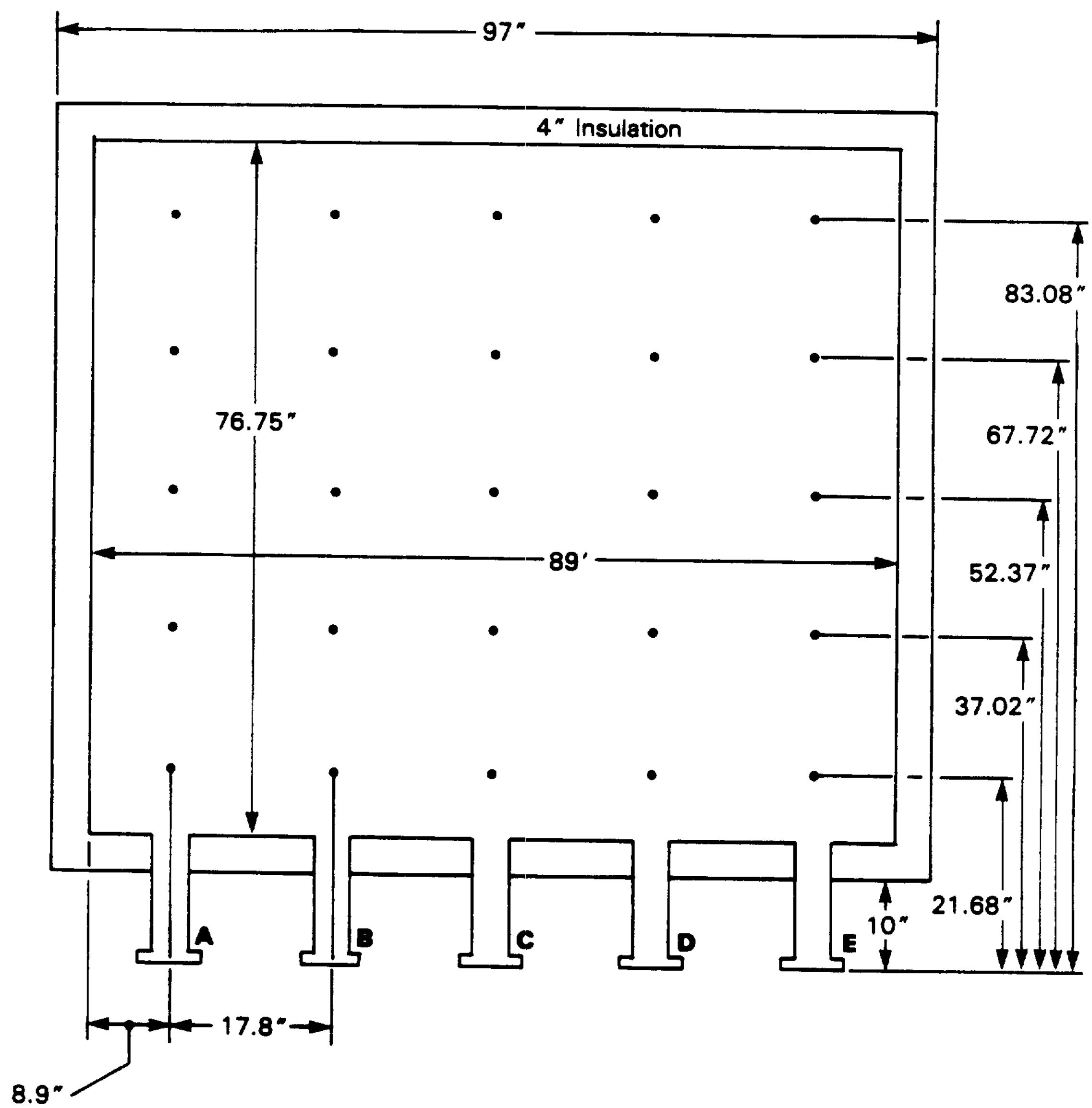

Figure 4-3. Traverse Point Location Diagram for the Spray Dryer Inlet Sampling Location at Mid-Connecticut MWC

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the first point for the remaining ports was moved in to 27.68 inches (referring to Figure 4-3).

A cyclonic flow check was conducted according to EPA Method 1 which requires that the average degree of rotation should be equal to or less than 10 degrees. The results of the cyclonic flow check determined that the average degree of rotation at the inlet to the spray dryer was 0.15 degrees. Thus, the location meets the EPA Method 1 criteria.

The volumetric flowrate during the test program averaged 84,800 dscfm at 370°F. Moisture was an average of 15.5 percent by volume. The static pressure at this point was -5.0 inches of water.

4.2 BAGHOUSE OUTLET

The baghouse outlet sampling ports are located in the exhaust stack approximately 3 equivalent duct diameters downstream from the last flow disturbance. The duct is rectangular and the five sampling ports are located on the 72-inch-wide vertical face of the duct that is 70 inches deep (equivalent diameters 71 inches). The ports are 2.7 equivalent diameters (192 inches) downstream and 1.8 equivalent diameters (132 inches) upstream from the nearest flow disturbances. In accordance with EPA Method 1, 25 traverse points (five per port) were used at this location. The traverse point location diagram is presented in Figure 4-4.

TRC Environmental Consultants, Inc

EPA Method 1 Sample and Velocity Traverses for Stationary Sources

Firm Mid Connecticut RRF

Location Baghouse Outlet 11/12

Diameters Upstream 1.8

Diameters Downstream 2.7

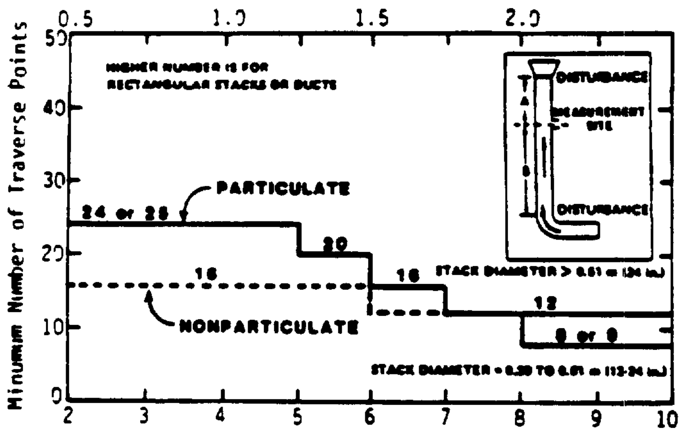
Total Traverse Points Required 25

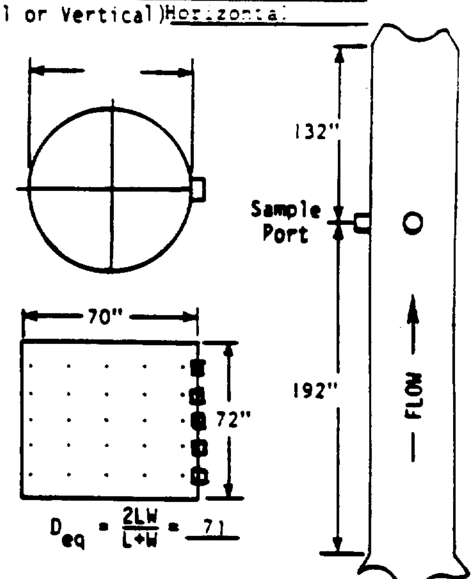
Number of Ports 5

Points Per Port 5

Traverse (Horizontal or Vertical) Horizontal

MINIMUM NUMBER OF TRAVERSE POINTS FOR PARTICULATE AND NONPARTICULATE TRAVERSES





LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

Point Number On A Diameter	(Percent of stack diameter from inside wall to traverse point) Number Of Traverse Points On A Diameter 4	6	8	10	12
1	6.7	4.4	3.2	2.6	2.1
2	25.0	14.6	10.5	8.2	6.7
3	75.0	29.6	19.4	14.6	11.8
4	93.3	70.4	32.3	22.6	17.7
5		85.4	67.7	34.2	25.0
6		95.6	80.6	65.8	35.6
7			89.5	77.4	64.4
8			96.8	85.4	75.0
9				91.8	82.3
10				97.4	88.2
11					93.3
12					97.9

CROSS-SECTIONAL LAYOUT FOR RECTANGULAR STACKS

Total Traverse Points	Matrix
9	3x3
12	4x3
16	4x4
20	5x4
25	5x5

TRAVERSE POINT LOCATIONS

No.	Distance From Wall	Nipple Size	Total Distance
1	7		
2	21		
3	35		
4	49		
5	63		
6			
7			
8			
9			
10			
11			
12			

Figure 4-4. Traverse Point Location Diagram for the Baghouse Outlet Sampling Location at Mid-Connecticut MWC

5.0 SAMPLING AND ANALYTICAL PROCEDURES

The sampling at the spray dryer inlet was performed by Radian Corporation and the sampling at the outlet stack was performed by TRC, Inc. There were some differences in the sampling protocols used by Radian and TRC. These differences are discussed in this section.

The sampling and analytical methods used for Mid-Connecticut MWC were based on accepted EPA protocols. Modifications were made to suit the needs of the test program. The sampling methods and pertinent modifications are discussed below. Additional details of the sampling and analytical procedures are included in the emission test reports.[6,7]

5.1 CDD/CDF DETERMINATION

CDD/CDF sampling followed the December 1984 draft protocol for the determination of chlorinated organic compounds in stack emissions. The protocol was developed by the Environmental Standards Workshop sponsored by the American Society of Mechanical Engineers (ASME) and EPA. The method is based on EPA Reference Method 5. Modifications made by Radian to the sampling protocol were:

1) Inlet samples were analyzed as separate front half and back half fractions.

2) Due to limited clearances at the sampling location, a flexible, heated Teflon transfer line was used between the filter and coil condenser for the CDD/CDF runs at the inlet and the outlet. The Teflon line was recovered as part of the back half filter housing/coil rinse fraction.

3) The laboratory proof blank was archived pending the analytical results from the field blank. Since the field blank results were acceptable (see Section 6), the proof blank was not analyzed.

4) The XAD traps were spiked with the surrogate compounds: ^{37}Cl-TCDD and $^{13}C_{12}$-HxCDF prior to sampling.

5) 2378-TCDF confirmation analyses were performed for both the inlet and outlet CDD/CDF samples.

There were some differences between the CDD/CDF protocols followed by Radian and TRC. These differences were:

1) To clean the glassware prior to sampling, TRC soaked the glassware in a chromic acid cleaning solution. Radian bakes the glassware for 2 hours at 450°F because chromic acid soaks are suspected of leaving residuals which may react with the native CDD/CDF in the samples.

2) TRC used a stainless steel nozzle in their CDD/CDF sampling train. Radian used a glass nozzle.

3) TRC recovered the samples from the sampling train using a 1:1 mixture of methylene chloride and methanol. Radian used acetone followed by methylene chloride to recover the CDD/CDF samples.

4) TRC analyzed for the tetra- through octa- CDD/CDF congeners. EPA also included the mono- through tri-CDD/CDF congeners as their target compounds.

5.2 TOXIC METALS AND PARTICULATE DETERMINATION

Different protocols were used to sample the uncontrolled and controlled flue gas for toxic metals. For the uncontrolled flue gas, Radian followed a draft EPA/EMSL method which was not a validated EPA Method. This method is applicable for the determination of mercury, arsenic, cadmium, chromium, lead, zinc, phosphorus, copper, nickel, manganese, selenium, beryllium, thallium, silver, antimony and barium emissions as well as particulate loading. The method is based on EPA Reference Method 5.

For the controlled flue gas, TRC combined EPA Method 12 and EPA Method 108 into a single train and analyzed for lead, arsenic, nickel, and total chromium, only. Both the uncontrolled and controlled protocols were a modification of EPA Method 5 with the difference being the collection media in the impingers. The draft EPA/EMSL method used a mixture of HNO_3 and H_2O_2 in the first two impingers and acidic $KMnO_4$ in the third impinger. The EPA Method 12/108 train used distilled water in the first two impingers followed by HNO_3 in the third impinger.

Sampling of the uncontrolled flue gas was conducted as described in the Radian test plan except that only twenty of the twenty-five traverse points were sampled. As discovered during CDD/CDF sampling, the flexible, heated, transfer line caused considerable delays during setup. Thus for the metals sampling, the transfer line was eliminated and the sampling location was re-configured. However, the handrail could not be removed due to safety considerations. Thus, Port A could not be traversed at all, and Point 1 of the other ports was moved in six inches. However, the emission concentrations were not expected to be affected, since the velocity profile was relatively uniform.

5.3 MERCURY DETERMINATION BY EPA METHOD 101A

Mercury concentratation in the flue gas was determined by EPA Method 101A. Mercury was also measured using this method since data based in a validated method were desired by EPA. The method is based on EPA Reference Method 5 except acidic potassium permanganate is used as the impinger solution. No modifications were made to this method.

5.4 VOLUMETRIC FLOWRATE, FIXED GAS, AND MOISTURE DETERMINATIONS BY EPA METHODS 2, 3 AND 4

Volumetric flowrate and moisture determinations were made according to EPA Methods 2 and 4, respectively. These samples were collected concurrently with the flue gas sampling trains.

Integrated bag samples were collected for fixed gas determinations by EPA Method 3. The samples were analyzed by ORSAT. The ORSAT analyses were performed by TRC personnel.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Completeness and data quality were emphasized during the test program by both Radian Corporation and TRC Environmental Consultants, Inc. at the Mid-Connecticut MWC. The QA/QC measures were incorporated into each sampling or analytical task. For manual methods, these included equipment and sampling preparation, sampling operations, sample recovery, sample analysis, and data reduction. The QA/QC measures were incorporated into CEM sampling as well. This section briefly summarizes the procedures and results for QA/QC performed by both Radian and TRC during the test program. The detailed procedures and results are include in the emission test reports.[8,9]

6.1 EQUIPMENT AND SAMPLING PREPARATION

Sampling equipment was cleaned, checked out, and calibrated before each use in the field. Table 6-1 summarizes the equipment that was calibrated for each method. Calibration data were recorded on data sheets included in the appendices of the emission test reports.

Following the cleaning procedure specified by each method, the sampling train and recovery glassware were cleaned and capped prior to shipment to the field. Once the equipment arrived in the field, a laboratory proof blank was collected for each set of sampling glassware. The purpose of the laboratory proof blank is to quantify background contamination in the cleaned glassware. Sets of sampling glassware were dedicated to each method and sampling location to prevent cross-contamination.

In addition, field blanks were collected for each method. A field blank was collected from a train which had been used to collect a flue gas sample and then recovered. Then, the train was reloaded, left at the sampling location for the duration of the sampling period and recovered. The field blank quantifies contamination from the combined effect of sampling location, handling, reagents and recovery efficiency. One field blank was analyzed for each method.

TABLE 6-1. SUMMARY OF EQUIPMENT CALIBRATED IN PERFORMING SOURCE SAMPLING AT THE MID-CONNECTICUT MWC

		Calibrated Equipment Used to Measure Parameters						
Parameter	Method	Type "S" Pitot Tube	Manometer	Temperature Measuring Device	Orsat	Nozzles	Balances	Dry Gas Meter
Volumetric Flue Gas Flow Rate	EPA 1 & 2	X	X	X				
Gas Phase Composition								
Moisture	EPA 4	X	X	X			X	X
Molecular Weight	EPA 3				X			
CDD/CDF	ASME/EPA Protocol	X	X	X	X	X	X	X
PM/Toxic Metals	Draft EMSL EPA Methods 12 and 108	X	X	X	X	X	X	X
Mercury	EPA 101A	X	X	X	X	X	X	X

lmo/057

For CDD/CDF sampling, additional preparation QC steps included cleaning and blanking the XAD® resin and filters. The final rinse of the solvents used for cleaning the XAD® and filters were analyzed for total chromatographable organics by gas chromatography/flame ionization detection.

6.2 SAMPLING OPERATIONS

The QA/QC procedures for sampling operations included performing leakchecks before and after each port change, following detailed checklists during sampling to ensure each step was properly completed, and requiring qualified personnel to perform the sampling operations.

The sampling operations met all leakcheck and isokinetics QC criteria except for one run. Only in the Run 2 CDD/CDF train at the spray dryer inlet, was a leak rate correction required, as specified by the sampling method.

6.3 SAMPLE RECOVERY

Reagent blanks were collected and archived for a potential check for background contamination. Sample recovery procedures were carried out in a controlled-atmosphere, enclosed trailer to minimize contamination.

Each sample bottle was assigned a unique alphanumeric identification code that was recorded in a logbook and on the sample label. Chain-of-custody sheets were filled out and packed with the samples.

6.4 SAMPLE ANALYSIS

The sample analyses were performed by laboratories familiar with the analytical procedures. The accuracy of the analyses was evaluated by submitting blind audit samples prepared by independent laboratories along with the field samples. Precision was evaluated by performing duplicate analyses of selected samples in each batch. For the CDD/CDF analyses, internal standard and surrogate recoveries were also determined.

For the CDD/CDF samples, the internal standards and surrogate recoveries were within the QC criteria of 100 ± 50 percent. The reagent and method blanks contained CDD/CDF at or below minimum detection limits which was considered acceptable. The CDD/CDF results were not adjusted. The duplicate analyses agreed closely.

For the uncontrolled mercury (Method 101A) samples, the reagent blanks contained mercury at less than minimum detection limits. The matrix spikes were recovered at 96.1 and 94.4 percent.

The toxic metal and particulate results were adjusted for reagent blanks. The reagent blanks contained low levels of silver, barium, lead, manganese and zinc.

6.5 DATA REDUCTION

The QA/QC procedures for data reduction included using computer programs to generate tables of results. Data input files and equations were double checked by a second person and tables of results were spot checked by hand. In addition, any data points that appeared to be outliers were double checked.

7.0 REFERENCES

1. Anderson, C.L., D.J. Holder and M.A. Vancil (Radian Corporation) Uncontrolled CDD/CDF, Metals, and Particulate Emissions Test Report: Mid-Connecticut Resource Recovery Facility, Hartford, Connecticut. Volumes I and II. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. January 1989.

2. TRC Environmental Consultants. Mid-Connecticut Resource Recovery Facility Air Emissions Compliance Report. Volumes I and II. Prepared for Combustion Engineering, Windsor, Connecticut. August 19, 1988.

3. Reference 1.

4. Reference 2.

5. Procedures for Estimating Risks Associated with Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (CDD and CDF). Prepared by the U.S. Environmental Protection Agency, Washington, D.C. April 1986.

6. Reference 1.

7. Reference 2.

8. Reference 1.

9. Reference 2.

8.0 METRIC-TO-ENGLISH CONVERSION TABLE

Metric		English
2.8317×10^{-2} dscm	=	1 dscf
2.8317×10^{-2} dscmm	=	1 dscfm
4.5359×10^{-1} kg/hr	=	1 lb/hr
1 ng/dscm	=	4.3699×10^{-10} grains/dscf
1 mg/dscm	=	4.3699×10^{-4} grains/dscf
^{o}C	=	$(^{o}F - 32^{o}F)\ 5/9$
1.01325×10^{5}	=	1 atm
1 ng/kg	=	6.9998×10^{-9} grains/lb
1 ng/g	=	6.9998×10^{-6} grains/lb
1 mg/g	=	6.9998×10^{-3} grains/lb