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Air



Integrated Iron and Steel Industry Final Report Manual Testing

Volume I of III

Youngstown Sinter Company
Youngstown, Ohio



Integrated Iron and Steel Industry

Final Report Volume I of III

**Contract No. 68-D7-0068
Work Assignment 2-13**

**Youngstown Sinter Company
Youngstown, Ohio**

Prepared for:

**Michael K. Ciolek
Emission Measurement Center
Emission, Monitoring, and Analysis Division
Office of Air Quality Planning and Standards
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E A S T E R N R E S E A R C H G R O U P , I N C .

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1.0 INTRODUCTION

Integrated iron and steel manufacturing is among the categories of major sources for which national emission standards for hazardous air pollutants (NESHAPS) are to be issued by November 2000 pursuant to Section 112 of the Clean Air Act. The integrated iron and steel manufacturing category includes mills that produce steel from iron ore. Key processes and unit operations include sinter production, iron production, steel making, continuous casting, and the preparation of semi-finished and finished products.

Source tests are required to quantify and characterize the particulate matter (PM), hazardous air pollutant (HAP) emissions, and the performance of a sintering plant equipped with baghouse control devices.

1.1 Objective

The objective of the testing at the Youngstown Sinter Company (YSC) plant in Youngstown, Ohio, was to perform all activities necessary to characterize the baghouse sintering plant windbox (Strand Baghouse) for the following emission components:

- Particulate mass (PM) and metal HAPs using EPA Method 29; and
- Dioxins/furans (D/F) and polynuclear aromatic hydrocarbons (PAH) using EPA Method 23.

The discharge end baghouse (Baghouse A) was tested for the following emission components:

- Particulate mass (PM) and metal HAPs using EPA Method 29.

In addition, the determination of total hydrocarbons using Method 25A and preliminary screening for organic HAPs using a Fourier Transform Infrared (FTIR) monitoring instrument

were conducted by Midwest Research Institute (MRI) under a separate work assignment. Testing by ERG and MRI occurred simultaneously. The FTIR element is not included within this final report.

Testing at the Strand Baghouse was performed at the inlet and outlet simultaneously. Testing at Baghouse A was performed at the outlet only. ERG coordinated all field test activities with MRI personnel.

1.2 Brief Site Description

The sintering process is used to agglomerate fine raw materials into a product suitable for charging into a blast furnace. Raw materials processed include ore, fines, limestone, coke, flue dust, basic oxygen furnace (BOF) slag, pellet chips, filter cake and mill scale. The principal emission point at a sinter plant is the exhaust from the sintering machine windbox. Emissions were controlled by baghouses.

The plant has a rated capacity of 2,900 tons per day (tpd) of sinter. The plant operates 24 hours per day, 6 days per week, with 1 day scheduled for routine maintenance. In operation, 150-170 truckloads per day of raw materials are brought into the plant and 140-160 truckloads per day of finished sinter are shipped from the plant. Raw materials are stored at the site. Two feeder tables blend mill scale, BOF slag, and crushed ore pellets by volume and the mixture is transferred by conveyor to the sinter plant. The mixture is referred to as pre-blend. YSC used 200,000 tons of their own material and 500,000 tons of material that are purchased from other sources each year. Their specification on the oil content of the mill scale is a maximum of 0.2 percent.

1.3 Emissions Measurements Program

This section provides an overview of the emissions measurements program conducted at Youngstown Sinter Company. Included in this section are summaries of the test matrix,

sampling locations, sampling methods, and laboratory analysis. Additional detail on these topics is provided in the sections that follow.

1.3.1 Test Matrix

The sampling and analytical matrix is presented in Table 1-1. Manual emissions tests were employed; detailed descriptions of these sampling and analytical procedures are provided in Section 5.0.

1.3.2 Test Schedule

The daily test schedule is presented in Figure 1-1. The test required one day of set-up and five test days. Each test day was approximately 12 hours in length with a typical working period being between 6:00 am and 8:00 pm.

The test schedule was based on the test duration assumed in Table 1-1.

1.3.3 Sampling Locations

The stack gas sampling was conducted at the inlet and outlet of the sintering plant Strand Baghouse and Baghouse A outlet. The inlet location was a rectangular duct with four new 4" ports (installed by the plant) positioned on the long vertical side. Access to this location required the use of a man lift which was provided by the plant.

The test ports and their locations met the requirements of EPA Method 1. The Strand baghouse inlet location was a rectangular duct with dimensions of 11' by 10' with four 4" ports installed on the vertical 10' side. The Strand baghouse outlet location was a circular stack with an inside diameter (I.D.) of 9 feet. The Baghouse A outlet was a circular stack with an I.D. of 6'.

Table 1-1. Test Matrix, Youngstown Sinter Company, Youngstown, Ohio

Sample Location	Number of Runs	Sample Type	Reference Method	Sample Duration	Analysis Method	Laboratory
Strand BH ¹ Inlet	3	Gas Velocity/ Volume/Moisture	EPA Methods 1-4	4 Hrs	Volumetric/Gravimetric	ERG
Strand BH Inlet	3	Total Particulates/Metals (Pb, Cr, Cd, Be, Ni, Co, As, Sb, Mn, Se, Hg)	EPA Method 29	4 Hrs	Gravimetric/Atomic Absorption/ICAP	ERG and Triangle Labs
Strand BH & Baghouse A Outlet	3	Gas Velocity/ Volume/Moisture	EPA Methods 1-4	4 Hrs (2 Hrs for Baghouse A)	Volumetric/Gravimetric	ERG
Strand BH & Baghouse A Outlet	3	Total Particulates/ Metals (Pb, Cr, Cd, Be, Ni, As, Sb, Co, Mn, Se, Hg)	EPA Method 29	4 Hrs (2 Hrs for Baghouse A)	Gravimetric/Atomic Absorption/ICAP	ERG and Triangle Labs
Strand BH Outlet	5	D/F/PAHs	EPA Method 23	4 Hrs	GC/HRMS ² 8290/8270	Triangle Labs

¹BH = Baghouse

²PAHs analyzed by low resolution mass spectrometry (LRMS)

1997

August

1997

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
3	4	5	6	7	8	9
10 Travel	11 Coordination Meeting with plant and setup	12 Test Day #1	13 Test Day #2	14 Test Day #3	15 Set-up BHA and Test Day #4	16 Test Day #5 and Tear Down
17 Travel	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Figure 1-1. Test Schedule

The position and number of traverse points for each location are shown in Section 4 of this report. A new sampling port for the FTIR sampling was installed at the outlet of the Strand baghouse. Existing ports on top of the Strand baghouse inlet duct were used for FTIR sampling.

1.3.4 Sampling and Analysis Methods

Total particulate matter emissions along with 11 metal HAPs (Pb, Ni, Cr, Mn, Se, Be, Sb, Co, Cd, As, and Hg) were determined using a single sampling train following the protocol provided in EPA Method 29. Particulate loading on the filter and the front half rinse (nozzle/probe, front half of the filter holder) was determined gravimetrically. Metals analyses were then performed on the residue from this front half rinse, the filter and the contents of the first two impinger catches using inductively coupled argon plasma spectroscopy (ICAPS) for all metals except Hg. Cold vapor atomic absorption (CVAA) was used for the analysis of all fractions for Hg. Flue gas samples for D/F and PAHs were collected using EPA Method 23. Flue gas was extracted isokinetically and any D/F/PAH was collected on the filter, the XAD-2® resin trap and in the impingers. The analysis was performed using high resolution gas chromatography (HRGC) coupled with high resolution mass spectrometry (HRMS) for D/F, and gas chromatography/low resolution mass spectrometry (GC/LRMS) for the PAHs.

1.4 Quality Assurance/Quality Control (QA/QC)

All flue gas testing procedures followed comprehensive QA/QC procedures as outlined in the Site Specific Test Plan (SSTP) and the Quality Assurance Project Plan (QAPP). A full description of the resulting QA parameters is given in Section 6.

All post-test and port change leak checks met the criteria prescribed in the manual methods procedure. The allowable isokinetic QC range of $\pm 10\%$ was met for all D/F/PAH and metals/PM sampling runs. All post-test dry gas meter calibration checks were within 5% of the full calibration factor. Field blanks (FB) for the D/F/PAH tests showed virtually no contamination. However, the metals FB for the Strand baghouse inlet location did indicate the

possibility of some carry over for Mn and Pb, due most likely to high levels encountered during sampling. The metals FB is discussed in detail in Sections 6.1.2 and 6.2.2.

All analyses were completed under a strict QA/QC regimen. For the D/F/PAH results, percent recoveries of all isotopically labeled compounds were within the lower and upper limits of recovery as specified in the method. For the metals results, all matrix spike recoveries were within the acceptable range.

1.5 Test Report

This final report, presenting all data collected and the results of the analyses, has been prepared in six sections and three volumes as described below:

- Section 1 provides an introduction to the testing effort and includes a brief description of the test site, an overview of the emissions measurements program and a brief overview of the QC results;
- Section 2 gives a summary of the test results for the D/F/PAH, metals and PM tests;
- Section 3 provides a description of the process and plant operation during the field test. These data are to be supplied by EPA;
- Section 4 gives a discussion of the sampling locations;
- Section 5 presents detailed descriptions of the sampling and analysis procedures; and
- Section 6 provides details of the quality assurance/quality control procedures used on this program and the QC results.

The appendices containing copies of the actual field data sheets and the results of the laboratory analyses are contained in two separate volumes.

2.0 SUMMARY OF RESULTS

This section provides the results of the emissions test program conducted at the Youngstown Sinter Company operation from August 11 to August 16, 1997. Included in this section are results of manual tests conducted for D/F/PAH, metal HAPs and PM.

2.1 Emissions Test Log

Fourteen tests were conducted over a five day period (5 D/F/PAH and 9 Metals/PM). Table 2-1 presents the emissions test log which shows the test date, location, run number, test type, run times and port change times for each test method.

Table 2-2 shows the volume of stack gas sampled for each run in dry standard cubic meters (dscm) and Table 2-3 shows the stack gas volumetric flow rate during each run in dry standard cubic meters per minute (dscmm). The percent relative standard deviation (%RSD) calculated for the number of runs for each test method (shown in Table 2-3) was less than 6%, indicating that the process flow was very constant over the five test days. All related field data sheets are given in Appendix E.

2.2 D/F/PAH RESULTS

2.2.1 Overview

Five 4-hour D/F/PAH emission test runs were completed at the Youngstown Sinter Company during the week of August 11, 1997. Five test runs were completed at the outlet of the Strand baghouse associated with the sintering plant windbox. The sample collection protocol followed EPA Method 23 while the analysis protocol was modified to also allow for the analysis of the sample extracts for PAHs. This modification to the sample preparation procedure and subsequent analysis is discussed in Section 5 of this report. A total of five D/F/PAH tests were performed at the Strand baghouse outlet where only three were scheduled. For Run 1 and Run 2

Table 2-1. Emissions Test Log, Youngstown Sinter Company

Date	Location ¹	Run Number	Test Type	Run Time
8/12/97	SBH, Outlet, Port B	1	D/F/PAH	1355-1608 ²
	SBH, Outlet, Port A	1	D/F/PAH	1800-2007
	SBH, Outlet, Port A	1	Metals/PM	1355-1608 ²
	SBH, Outlet, Port B	1	Metals/PM	1800-2007
	SBH, Inlet, Port A	1	Metals/PM	1335-1435
	SBH, Inlet, Port B	1	Metals/PM	1445-1618 ²
	SBH, Inlet, Port C	1	Metals/PM	1754-1854
	SBH, Inlet, Port D	1	Metals/PM	1906-2001
8/13/97	SBH, Outlet, Port A	2	D/F/PAH	1055-1255 ³
	SBH, Outlet, Port B	3	D/F/PAH	1530-1812 ⁴
	SBH, Outlet, Port A	3	D/F/PAH	0800-1000 ⁵
	SBH, Outlet, Port B	2	Metals/PM	1055-1255
	SBH, Outlet, Port A	2	Metals/PM	1530-1812 ⁴
	SBH, Inlet, Port A	2	Metals/PM	1103-1203
	SBH, Inlet, Port B	2	Metals/PM	1210-1310
	SBH, Inlet, Port C	2	Metals/PM	1530-1713 ⁴
	SBH, Inlet, Port D	2	Metals/PM	1830-2035
8/14/97	SBH, Outlet, Port B	4	D/F/PAH	1245-1445
	SBH, Outlet, Port A	4	D/F/PAH	1610-1810
	SBH, Outlet, Port A	3	Metals/PM	1245-1445
	SBH, Outlet, Port B	3	Metals/PM	1610-1810
	SBH, Inlet, Port A	3	Metals/PM	1250-1350
	SBH, Inlet, Port B	3	Metals/PM	1400-1500
	SBH, Inlet, Port C	3	Metals/PM	1610-1710
	SBH, Inlet, Port D	3	Metals/PM	1725-1850
8/15/97	SBH, Outlet, Port A	5	D/F/PAH	0830-1030
	SBH, Outlet, Port B	5	D/F/PAH	1055-1255
	BHA, Outlet, Port A	1	Metals/PM	1100-1200
	BHA Outlet, Port B	1	Metals/PM	1211-1311
	BHA, Outlet, Port A	2	Metals/PM	1538-1638
	BHA, Outlet, Port B	2	Metals/PM	1649-1749
8/16/97	BHA, Outlet, Port A	3	Metals/PM	0823-0923
	BHA, Outlet, Port B	3	Metals/PM	0930-1030

¹SBH = Strand baghouse; BHA = Baghouse A

²Plant down for approximately 33 minutes during this period.

³Run 2 terminated after first port due to bad leak check.

⁴Plant down for approximately 30 minutes during this period.

⁵Second port sampling continued on 8/14/97.

Table 2-2. Sample Volume Collected, dscm¹

Location ²	Parameter	Run 1	Run 2	Run 3	Run 4	Run 5	Average Runs 1-5	Average Runs 1-3 ³	Runs 1-3 %RSD ³
SBH, Outlet	D/F/PAH	5.97	2.90	6.02	5.90	5.91	5.34	5.94	1.12
SBH, Outlet	Metals/PM	5.85	5.74	5.54	NA ⁴	NA	NA	5.71	2.75
SBH, Inlet	Metals/PM	2.82	2.77	2.92	NA	NA	NA	2.84	2.69
BHA, Outlet	Metals/PM	2.33	2.32	2.13	NA	NA	NA	2.26	4.98

¹dscm, dry standard cubic meters. Standard conditions are defined as 1 atm and 68°F.

²SBH = Strand baghouse, BHA = Baghouse A.

³Used Runs 3 through 5 for D/F/PAHs.

⁴NA = not applicable.

2-3

Table 2-3. Flue Gas Volumetric Flow Rates, dscmm¹

Location ²	Parameter	Run 1	Run 2	Run 3	Run 4	Run 5	Average Runs 1-5	Average Runs 1-3 ³	Runs 1-3 %RSD ³
SBH, Outlet	D/F/PAH	7851	7585	7706	7754	7631	7705	7697	0.81
SBH, Outlet	Metals/PM	7858	7748	7797	NA ⁴	NA	NA	7801	0.71
SBH, Inlet	Metals/PM	9488	9021	9456	NA	NA	NA	9322	2.80
BHA, Outlet	Metals/PM	2312	2338	2098	NA	NA	NA	2249	5.84

¹dscmm, dry standard cubic meters per minute. Standard conditions are defined as 1 atm and 68°F.

²SBH = Strand baghouse, BHA = Baghouse A.

³Used Runs 3 through 5 for D/F/PAHs.

⁴NA = not applicable.

unacceptable leak checks were observed after the completion of the first port traverse sampling. The long (15') probe, coupled with stack vibrations caused the glass cyclone by-pass to crack, thus creating a small leak. The cyclone by-pass was replaced and Run 1 was continued. At the end of Run 1, a successful leak check was observed. The same problem occurred for Run 2. However, Run 2 was aborted after the first port traverse sampling. The sampling equipment was then modified to provide extra support for the probe. Runs 1 and 2 should be considered as questionable.

2.2.2 D/F Emission Results

Table 2-4 presents the concentration, in nanograms per dry standard cubic meter (ng/dscm), for the selected D/F congeners by run number, the average concentration over the three runs (Runs 3, 4, and 5) and the %RSD. All results except for the 2,3,7,8-tetrachloro dibenzofuran (2,3,7,8-TCDF) were determined by high resolution gas chromatography (HRGC)/high resolution mass spectrometry (HRMS) using a DB-5 capillary gas chromatographic column. The 2,3,7,8-TCDF was determined by HRGC/HRMS using a DB-225 column which gives improved chromatographic resolution for this compound over the DB-5 and thus a more accurate quantitation.

As noted in Table 2-4, the reported concentration of several congeners may be over-estimated due to the presence of an associated diphenyl ether (DPE) that coelutes with the peak of interest. However, these values are at or very near the detection limit for that compound or they are very consistent with the value(s) from the other test runs that do not have this DPE interferent and should be considered as estimated maximum possible concentrations (EMPC). These values are included in all calculations. Any compound that was not detected is reported as a "less than" value with this value being the reported instrumental detection limit. A "less than" value rather than a "0" is used in all appropriate calculations. These data have not been blank corrected. The %RSDs reported in Table 2-4 for the three runs (Runs 3, 4, and 5) by compound are generally less than 20% indicating excellent reproducibility. In a few cases, the %RSDs are

Table 2-4. Dioxin/Furan Stack Gas Concentrations, Strand Baghouse Outlet, Runs 3 through 5

Congener	ng/dscm				
	Run 3	Run 4	Run 5	Average	%RSD
2,3,7,8 -TCDD	0.0731	0.0915	0.0728	0.079	13.6
1,2,3,7,8-PeCDD	0.158	0.187	0.203	0.182	12.5
1,2,3,4,7,8-HxCDD	0.0316	0.0237	0.0237 ¹	0.026 ¹	17.2
1,2,3,6,7,8-HxCDD	0.266	0.288	0.305	0.286	6.8
1,2,3,7,8,9-HxCDD	0.118	0.114	0.124	0.118	4.2
1,2,3,4,6,7,8--HpCDD	0.141	0.137	0.130	0.136	4.1
1,2,3,4,6,7,8,9-OCDD	0.0781	0.271 ¹	0.0558	0.135 ¹	87.7
2,3,7,8-TCDF ²	1.91	2.17	1.90	1.99	7.7
1,2,3,7,8-PeCDF	0.582	0.797	0.677	0.685	15.7
2,3,4,7,8-PeCDF	0.532	0.712	0.643	0.629	14.5
1,2,3,4,7,8-HxCDF	0.249	0.288	0.271	0.269	7.2
1,2,3,6,7,8-HxCDF	0.0881	0.103	0.0982	0.097	8.1
2,3,4,6,7,8-HxCDF	0.0581	0.0542	0.0542	0.056	4.1
1,2,3,7,8,9-HxCDF	<0.0332	0.0068 ³	0.0102 ³	0.017 ³	86.1
1,2,3,4,6,7,8-HpCDF	0.0631	0.0644	0.0575	0.062	5.9
1,2,3,4,7,8,9-HpCDF	<0.0665	<0.0339	<0.0338	<0.045	42.0
1,2,3,4,6,7,8,9-OCDF	<0.0997	0.0288	<0.0677	<0.065	54.3

¹ Maximum value, may include interference from a diphenyl ether.

² Determined from DB-225 GC column.

³ Amount detected is less than 5 times the detection limit and should be considered only an estimate.

higher where the concentrations are near the detection limit or the presence of a DPE is indicated. Increased variability is not unusual in these cases. The %RSDs reported in Table 2-5 for Runs 1-5 are generally higher (mostly under 50%) for all compounds as compared to those in Table 2-4, but include Runs 1 and 2 which resulted in questionable data.

Table 2-6 shows the D/F average stack emission rates from the Strand baghouse outlet using Runs 3 through 5. This value was calculated from the average concentration from Table 2-4 and the average stack flow rate from Table 2-3.

Table 2-7 shows the congener concentrations in ng/dscm converted to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin toxicity equivalents as well as a summation of the values presented as total chlorinated dioxins and total chlorinated furans. All D/F analytical raw data can be found in Appendix A.

2.2.3 PAH Emission Results

Table 2-8 presents the concentration, in micrograms per dry standard cubic meter ($\mu\text{g/dscm}$), for the selected PAH compounds by run number, the average concentration over the last three runs (Runs 3, 4, and 5) and the %RSD. Due to the levels of PAHs encountered, the extracts were analyzed on a low resolution mass spectrometer (LRMS) after dilution of the sample extracts. The %RSDs reported in Table 2-8 for the three runs by compound are generally less than 20% indicating excellent reproducibility. In a few cases, the %RSDs are higher where the concentrations are near the detection limit. Increased variability would not be unusual in this case. Table 2-9 presents the concentrations and %RSDs for Runs 1 through 5. For these five runs, the compound %RSDs are generally less than 40%. This higher variability is most likely due to the limited value of the data from Runs 1 and 2. Any compound that was not detected is reported as a "less than" value with this value being the reported instrument detection limit. A "less than" value rather than a "0" is used in all appropriate calculations. These data have not been blank corrected.

Table 2-5. Dioxin/Furan Stack Gas Concentrations, Strand Baghouse Outlet, Runs 1 through 5

Congener	ng/dscm						
	Run 1	Run 2	Run 3	Run 4	Run 5	Average	%RSD
2,3,7,8 -TCDD	0.104	0.0827	0.0731	0.0915	0.0728	0.085	15.5
1,2,3,7,8-PeCDD	0.285	0.214	0.158	0.187	0.203	0.209	22.6
1,2,3,4,7,8-HxCDD	0.064	0.0517	0.0316	0.0237	0.0237 ¹	0.039 ¹	46.2
1,2,3,6,7,8-HxCDD	0.637	0.482	0.266	0.288	0.305	0.395	40.4
1,2,3,7,8,9-HxCDD	0.268	0.196	0.118	0.114	0.124	0.164	41.1
1,2,3,4,6,7,8--HpCDD	0.302	0.234	0.141	0.137	0.130	0.189	40.2
1,2,3,4,6,7,8,9-OCDD	0.161	0.128	0.0781	0.271 ¹	0.0558	0.139 ¹	61.1
2,3,7,8-TCDF ²	2.58	2.03	1.91	2.17	1.90	2.12	13.2
1,2,3,7,8-PeCDF	1.12	0.827	0.582	0.797	0.677	0.801	25.6
2,3,4,7,8-PeCDF	1.16	0.827	0.532	0.712	0.643	0.774	30.9
1,2,3,4,7,8-HxCDF	0.653	0.413	0.249	0.288	0.271	0.375	44.9
1,2,3,6,7,8-HxCDF	0.235	0.145	0.0881	0.103	0.0982	0.134	45.1
2,3,4,6,7,8-HxCDF	0.147	0.0861 ¹	0.0581	0.0542	0.0542	0.080	49.9
1,2,3,7,8,9-HxCDF	0.017 ³	0.0103	<0.0332	0.0068 ³	0.0102 ³	<0.015	68.4
1,2,3,4,6,7,8-HpCDF	0.147	0.103 ¹	0.0631	0.0644	0.0575	0.087	43.9
1,2,3,4,7,8,9-HpCDF	<0.034	<0.069	<0.0665	<0.0339	<0.0338	<0.047	39.3
1,2,3,4,6,7,8,9-OCDF	<0.067	<0.103	<0.0997	0.0288 ³	<0.0677	<0.0732	41.2

¹ Maximum value, may include interference from a diphenyl ether.

² Determined from DB-225 GC column.

³ Amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-6. Dioxin/Furan Stack Emission Rate, Strand Baghouse Outlet

Congener	Average Concentration Runs 3 - 5 ng/dscm	Average Emission Rate µg/Hr
2,3,7,8 -TCDD	0.079	36.5
1,2,3,7,8-PeCDD	0.182	84.1
1,2,3,4,7,8-HxCDD	0.026 ¹	12.0 ¹
1,2,3,6,7,8-HxCDD	0.286	132
1,2,3,7,8,9-HxCDD	0.118	54.7
1,2,3,4,6,7,8-HpCDD	0.136	62.9
1,2,3,4,6,7,8,9-OCDD	0.135 ¹	62.4 ¹
2,3,7,8-TCDF ²	1.99	919
1,2,3,7,8-PeCDF	0.685	316
2,3,4,7,8-PeCDF	0.629	290
1,2,3,4,7,8-HxCDF	0.269	124
1,2,3,6,7,8-HxCDF	0.097	44.6
2,3,4,6,7,8-HxCDF	0.056	25.9
1,2,3,7,8,9-HxCDF	0.017 ³	7.72 ³
1,2,3,4,6,7,8-HpCDF	0.062	28.5
1,2,3,4,7,8,9-HpCDF	<0.045	<20.7
1,2,3,4,6,7,8,9-OCDF	<0.065	<30.2

¹ Maximum value, may include interference from a diphenyl ether.

² Determined from DB-225 GC column.

³ Amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-7. Dioxin/Furan 2,3,7,8-TCDD Toxicity Equivalent Stack Gas Concentrations, Strand Baghouse Outlet

Congener	2,3,7,8-TCDD TEF ¹	ng/dscm			
		Run 3	Run 4	Run 5	Average
2,3,7,8 -TCDD	1	0.0731	0.0915	0.0728	0.0791
1,2,3,7,8-PeCDD	0.5	0.0789	0.093	0.102	0.0912
1,2,3,4,7,8-HxCDD	0.1	0.00316	0.00237	0.00237 ²	0.00263 ²
1,2,3,6,7,8-HxCDD	0.1	0.0266	0.0288	0.0305	0.0286
1,2,3,7,8,9-HxCDD	0.1	0.0118	0.0114	0.0124	0.0118
1,2,3,4,6,7,8-HpCDD	0.01	0.00141	0.00137	0.00130	0.00136
1,2,3,4,6,7,8,9-OCDD	0.001	0.000078	0.000271 ²	0.000056	0.000135 ²
Total PCDD					0.215
2,3,7,8-TCDF ³	0.1	0.191	0.217	0.190	0.199
1,2,3,7,8-PeCDF	0.05	0.0291	0.0398	0.0338	0.0342
2,3,4,7,8-PeCDF	0.5	0.266	0.356	0.321	0.314
1,2,3,4,7,8-HxCDF	0.1	0.0249	0.0288	0.0271	0.0269
1,2,3,6,7,8-HxCDF	0.1	0.00880	0.0103	0.00981	0.0097
2,3,4,6,7,8-HxCDF	0.1	0.00581	0.00542	0.00541	0.00555
1,2,3,7,8,9-HxCDF	0.1	<0.00332	0.00068 ⁴	0.00102 ⁴	0.00167 ⁴
1,2,3,4,6,7,8-HpCDF	0.01	0.000631	0.000644	0.000575	0.000617
1,2,3,4,7,8,9-HpCDF	0.01	<0.000664	<0.000339	<0.000338	<0.000447
1,2,3,4,6,7,8,9-OCDF	0.001	<0.0000997	0.0000288	<0.000677	<0.0000654
Total PCDF					0.592

¹TEF, Toxicity Equivalent Factor

²Maximum value, may include interference from a diphenyl ether

³Determined from DB-225 GC column

⁴The amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-8. PAH Concentration, Strand Baghouse Outlet, Runs 3 through 5

PAHs	Concentration, µg/dscm				
	Runs			Average	%RSD
	3	4	5		
Naphthalene	486	446	502	478	6.0
2-Methylnaphthalene	386	373	387	382	2.0
2-Chloronaphthalene	<0.920	3.03 ¹	<1.27	1.74 ¹	64.9
Acenaphthylene	31.4 ¹	31.8 ¹	40.4	34.5 ¹	14.8
Acenaphthene	18.3 ¹	17.2 ¹	21.6 ¹	19.0 ¹	11.9
Fluorene	36.9	35.0	49.1	40.3	18.9
Phenanthrene	245	205	299	250	18.8
Anthracene	42.7	31.5 ¹	58.5	44.2 ¹	30.7
Fluoranthene	128	88.7	150	122	25.5
Pyrene	52.5	51.4	60.3	54.8	8.9
Benzo(a)anthracene	19.8 ¹	20.0 ¹	23.7 ¹	21.2 ¹	10.5
Chrysene	29.4 ¹	38.8	35.5	34.6 ¹	13.8
Benzo(b)fluoranthene	7.71 ¹	9.05 ¹	9.66 ¹	8.81 ¹	11.3
Benzo(k)fluoranthene	3.17 ¹	3.90 ¹	1.31 ¹	2.79 ¹	47.7
Benzo(e)pyrene	3.70 ¹	4.90 ¹	4.22 ¹	4.28 ¹	14.1
Benzo(a)pyrene	1.48 ¹	1.97 ¹	2.76 ¹	2.07 ¹	31.2
Perylene	<0.488	<0.539	<0.645	<0.557	14.3
Ideno(1,2,3-cd)pyrene	<0.390	<0.431	<0.479	<0.433	10.2
Dibenzo(a,h)anthracene	<0.538	<0.595	<0.638	<0.590	8.5
Benzo(g,h,i)perylene	0.286 ¹	<0.475	<0.496	<0.419	27.6

¹ Amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-9. PAH Concentration, Strand Baghouse Outlet, Runs 1 through 5

PAHs	Concentration, µg/dscm						
	Runs					Average	%RSD
	1	2	3	4	5		
Naphthalene	506	481	486	446	502	484	4.9
2-Methylnaphthalene	419	394	386	373	387	392	4.3
2-Chloronaphthalene	2.93 ¹	2.06 ¹	<0.920	3.03 ¹	<1.27	2.04 ¹	46.5
Acenaphthylene	35.9	31.2 ¹	31.4 ¹	31.8 ¹	40.4	34.1 ¹	11.7
Acenaphthene	21.6 ¹	17.3 ¹	18.3 ¹	17.2 ¹	21.6 ¹	19.2 ¹	11.5
Fluorene	44.0	38.7 ¹	36.9	35.0	49.1	40.7 ¹	14.0
Phenanthrene	248	234	245	205	299	246	13.8
Anthracene	44.3	39.4 ¹	42.7	31.5 ¹	58.5	43.3 ¹	22.8
Fluoranthene	131	98.4	128	88.7	150	119	21.2
Pyrene	58.7	60.3 ¹	52.5	51.4	60.3	56.6 ¹	7.7
Benzo(a)anthracene	29.3 ¹	23.6 ¹	19.8 ¹	20.0 ¹	23.7 ¹	23.3 ¹	16.6
Chrysene	47.4	38.8 ¹	29.4 ¹	38.8	35.5	38.0 ¹	17.2
Benzo(b)fluoranthene	15.4 ¹	12.0 ¹	7.71 ¹	9.05 ¹	9.66 ¹	10.8 ¹	27.9
Benzo(k)fluoranthene	4.37 ¹	4.04 ¹	3.17 ¹	3.90 ¹	1.31 ¹	3.36 ¹	36.5
Benzo(e)pyrene	7.27 ¹	5.58 ¹	3.70 ¹	4.90 ¹	4.22 ¹	5.14 ¹	27.0
Benzo(a)pyrene	3.61 ¹	2.82 ¹	1.48 ¹	1.97 ¹	2.76 ¹	2.53 ¹	32.6
Perylene	0.894 ¹	<1.75	<0.488	<0.539	<0.645	<0.864	60.3
Ideno(1,2,3-cd)pyrene	<0.394	<1.40	<0.390	<0.431	<0.479	<0.618	70.8
Dibenzo(a,h)anthracene	<0.544	<1.94	<0.538	<0.595	<0.638	<0.850	71.5
Benzo(g,h,i)perylene	0.575 ¹	<1.55	0.286 ¹	<0.475	<0.496	<0.675	73.8

¹Amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-10 shows the average PAH stack emission rate from the Strand baghouse outlet using data from Runs 3 through 5. These values were calculated from the average concentrations from Table 2-8 and the average stack flow rate from Table 2-3. All PAH analytical raw data can be found in Appendix B.

2.3 Metals HAPs Results

2.3.1 Overview

Nine metals emission test runs were completed at Youngstown Sinter Company during the week of August 11, 1997. Three test runs were completed at the Strand baghouse inlet, three at the Strand baghouse outlet, and three at the outlet of Baghouse A. The sample collection protocol followed EPA Method 29 using a single sampling train to determine emission rates of 11 metal HAPs. A total of five (5) fractions for each test run were presented to the laboratory for analysis (see Section 5 of this report for details).

2.3.2 Metal HAPs Emission Results

Tables 2-11 through 2-19 show the results of the analysis, by fraction by analyte, for each of the three samples collected at the outlet and at the inlet of the Strand baghouse and the three Baghouse A outlet samples along with a total amount detected. Any metal that was not detected is reported as a "less than" value with this value being the instrument detection limit. A "less than" value rather than a "0" is used in all appropriate calculations. These data have not been blank corrected (see Section 6 for further discussion). Using the results shown in Tables 2-11 through 2-19 and the sample volume collected in the corresponding train given in Table 2-2, the concentration of each metal in the stack gas was calculated. The concentration ($\mu\text{g/dscm}$) of each metal by run number, the average concentration and %RSD for the Strand baghouse inlet and outlet tests are given in Tables 2-20 and 2-21, respectively, and given in Table 2-22 for the Baghouse A outlet. The %RSDs reported in Table 2-20 by metal are generally less than 15% indicating excellent reproducibility. Tables 2-21 and 2-22 present a higher overall

Table 2-10. PAH Stack Emission Rate, Strand Baghouse Outlet

PAHs	Average Concentration Runs 3 - 5 (µg/dscm)	Average Emission Rate (g/hr)
Naphthalene	478	221
2-Methylnaphthalene	382	176
2-Chloronaphthalene	1.74 ¹	0.804 ¹
Acenaphthylene	34.5 ¹	16.0 ¹
Acenaphthene	19.0 ¹	8.80 ¹
Fluorene	40.3	18.8
Phenanthrene	250	115
Anthracene	44.2 ¹	20.4 ¹
Fluoranthene	122	56.3
Pyrene	54.8	25.3
Benzo(a)anthracene	21.2 ¹	9.79 ¹
Chrysene	34.6 ¹	16.0 ¹
Benzo(b)fluoranthene	8.81 ¹	4.07 ¹
Benzo(k)fluoranthene	2.79 ¹	1.29 ¹
Benzo(e)pyrene	4.28 ¹	1.98 ¹
Benzo(a)pyrene	2.07 ¹	0.956 ¹
Perylene	<0.557	<0.257
Ideno(1,2,3-cd)pyrene	<0.433	<0.200
Dibenzo(a,h)anthracene	<0.590	<0.273
Benzo(g,h,i)perylene	<0.419	<0.194

¹ Amount detected is less than 5 times the detection limit and should be considered only an estimate.

Table 2-11. Metals Results: Strand Baghouse Inlet, Run 1 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	1.32	3.25	<0.280	10.4	<1.10	<16.3
As	21.9	4.13				26.0
Be	<0.100	<0.115				<0.215
Cd	74.5	20.4				94.9
Co	29.7	11.2				40.9
Cr	242	40.9				283
Mn	6270	859				7129
Ni	43.2	10.2				53.4
Pb	14800	3830				18630
Sb	5.2	<0.462				5.66
Se	31.2	27.3				58.5

Table 2-12. Metals Results: Strand Baghouse Inlet, Run 2 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	0.422	4.03	<0.392	10.6	<1.20	<16.6
As	16.7	5.48				22.2
Be	<0.100	<0.114				<0.214
Cd	66.5	27.0				93.5
Co	16.5	1.32				17.8
Cr	203	35.0				238
Mn	4900	824				5724
Ni	37.2	11.0				48.2
Pb	16700	4700				21400
Sb	7.79	<0.456				8.25
Se	18.3	42.8				61.1

Table 2-13. Metals Results: Strand Baghouse Inlet, Run 3 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	8.16	<0.504	10.5	<0.600	<20.2
As	16.7	5.39				22.1
Be	<0.100	<0.113				<0.213
Cd	63.2	21.9				85.1
Co	18.6	2.18				20.8
Cr	207	39.3				246
Mn	5240	877				6117
Ni	41.2	13.2				54.4
Pb	16000	4810				20810
Sb	6.96	<0.450				7.14
Se	23.8	53.4				77.2

Table 2-14. Metals Results: Strand Baghouse Outlet, Run 1 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	14.4	<0.360	10.7	<1.18	<27.04
As	1.51	1.6				3.11
Be	<0.100	<0.116				<0.216
Cd	1.93	<0.116				<2.046
Co	0.64	0.534				1.174
Cr	10.4	12.9				23.3
Mn	17.3	27.7				45.0
Ni	6.83	2.34				9.17
Pb	120	4.48				124
Sb	4.46	<0.465				<4.93
Se	4.46	110				114

Table 2-15. Metals Results: Strand Baghouse Outlet, Run 2 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	15.0	<0.304	13.5	<1.20	<30.4
As	1.43	1.44				2.87
Be	<0.100	<0.114				<0.214
Cd	0.209	0.446				0.655
Co	0.48	<0.156				<0.636
Cr	15.8	14.2				30.0
Mn	18.1	352				370
Ni	11.5	3.31				14.8
Pb	110	6.77				117
Sb	8.56	<0.454				<9.01
Se	8.02	102				110

Table 2-16. Metals Results: Strand Baghouse Outlet, Run 3 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	16.4	<0.200	10.7	<0.800	<28.5
As	1.18	0.615				1.80
Be	<0.100	<0.114				<0.214
Cd	0.116	0.314				0.430
Co	0.41	<0.114				<0.524
Cr	12.8	10.4				23.2
Mn	18.6	66				84.6
Ni	8.51	3.01				11.5
Pb	116	7.47				123
Sb	6.37	<0.457				<6.83
Se	6.36	79				85.4

Table 2-17. Metals Results: Baghouse A Outlet, Run 1 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	<1.96	<0.200	<0.488	<0.408	<3.46
As	1.16	<0.628				<1.79
Be	<0.100	<0.126				<0.226
Cd	<0.100	<0.126				<0.226
Co	1.13	<0.126				<1.26
Cr	13.8	1.52				15.3
Mn	12.1	13.4				25.5
Ni	10.4	0.979				11.4
Pb	6.62	6.33				13.0
Sb	8.2	<0.503				8.70
Se	7.36	<0.377				7.74

Table 2-18. Metals Results: Baghouse A Outlet, Run 2 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	<2.72	<0.320	<1.22	<1.04	<5.70
As	1.12	<0.586				<1.71
Be	<0.100	<0.117				<0.217
Cd	<0.100	0.210				0.310
Co	0.270	<0.117				<0.387
Cr	14.7	7.03				21.7
Mn	12.8	259				272
Ni	9.42	8.15				17.6
Pb	8.98	4.64				13.6
Sb	7.74	<0.469				<8.21
Se	6.98	<0.352				<7.33

Table 2-19. Metals Results: Baghouse A Outlet, Run 3 (µg collected)

Metal	Fraction #					
	1	2	3	4	5	Total
Hg	<0.400	<2.52	<0.256	<1.22	<0.800	<5.20
As	1.03	<0.594				<1.62
Be	<0.100	<0.119				<0.219
Cd	<0.100	0.215				<0.315
Co	0.24	<0.119				<0.359
Cr	12.9	10.2				23.1
Mn	10.6	114				125
Ni	8.49	12.6				21.9
Pb	21.2	4.76				26.0
Sb	6.82	<0.475				<7.30
Se	6.32	<0.357				<6.68

Table 2-20. Metals Stack Gas Concentration: Strand Baghouse Inlet

Metal	µg/dscm				
	Run 1	Run 2	Run 3	Average	%RSD
Hg	5.78	5.99	6.92	6.23	9.71
As	9.22	8.01	7.57	8.27	10.3
Be	0.076	0.077	0.073	0.075	2.99
Cd	33.7	33.8	29.1	32.2	8.18
Co	14.5	6.43	7.12	9.35	47.9
Cr	100	85.9	84.2	90.2	9.82
Mn	2528	2066	2095	2230	11.6
Ni	18.9	17.4	18.6	18.3	4.44
Pb	6606	7726	7127	7153	7.83
Sb	2.01	2.98	2.45	2.48	19.6
Se	20.7	22.1	26.4	23.1	12.9

Table 2-21. Metals Stack Gas Concentration: Strand Baghouse Outlet

Metal	$\mu\text{g/dscm}$				
	Run 1	Run 2	Run 3	Average	%RSD
Hg	4.62	5.30	5.14	5.02	7.08
As	0.532	0.500	0.325	0.452	24.6
Be	0.037	0.037	0.039	0.038	2.39
Cd	0.350	0.114	0.078	0.180	81.8
Co	0.201	0.111	0.095	0.135	42.2
Cr	3.98	5.23	4.19	4.47	14.9
Mn	7.69	64.5	15.3	29.1	106
Ni	1.57	2.58	2.08	2.07	24.4
Pb	21.2	20.4	22.2	21.3	4.29
Sb	0.842	1.57	1.23	1.21	30.1
Se	19.5	19.2	15.4	18.0	12.6

Table 2-22. Metals Stack Gas Concentration: Baghouse A Outlet

Metal	$\mu\text{g/dscm}$				
	Run 1	Run 2	Run 3	Average	%RSD
Hg	1.48	2.46	2.44	2.13	26.2
As	0.768	0.737	0.761	0.755	2.15
Be	0.097	0.094	0.103	0.098	4.80
Cd	0.097	0.134	0.148	0.126	20.8
Co	0.541	0.167	0.169	0.292	73.8
Cr	6.57	9.35	10.8	8.92	24.3
Mn	10.9	117	58.7	62.3	85.5
Ni	4.89	7.59	10.3	7.59	35.5
Pb	5.58	5.86	12.2	7.88	47.5
Sb	3.73	3.54	3.43	3.57	4.35
Se	3.32	3.16	3.14	3.21	3.16

reproducibility at less than 35%. In the case where a %RSD is higher, the concentrations detected are near the detection limit. Increased variability is not unusual in this case. The value of Mn in fraction 2 of the Strand baghouse Run 2 outlet (see Table 2-15) is high and not consistent with the other two runs. The most likely cause is laboratory contamination as the other metals results are consistent over the three test runs. The same situation was encountered for Baghouse A outlet Run 2 (see Table 2-18).

Using the average concentration values listed in Tables 2-21 and 2-22 and the average stack flow rate from Table 2-3, the average emission rate from the Strand baghouse and Baghouse A outlets for each metal can be calculated. These results, in grams per hour, are given in Table 2-23 and 2-24, respectively. Using these values from Table 2-23 in conjunction with the equivalent values for the inlet (see Table 2-25), a removal efficiency for the Strand baghouse was calculated for each metal. All metal analytical raw data are given in Appendix C.

2.4 PM Results

2.4.1 PM Emissions Results

Particulate matter emissions were determined from the same sampling trains as used for the collection of metals at the Strand baghouse inlet and outlet and Baghouse A outlet. Before metals analysis, PM collected on the filter and in the front half acetone rinse (nozzle, probe, front-half filter holder) was analyzed gravimetrically. PM stack gas concentrations, in grams per dry standard cubic meter (g/dscm), the average of three test runs and %RSD for the three test runs at the inlet and outlet are presented in Table 2-26. The %RSD for the inlet of the Strand baghouse was less than 26% indicating good reproducibility for the sampling and analysis method. The %RSD for the outlet of the Strand baghouse was 56% and 38% for Baghouse A outlet. This higher variability is most likely due to the gravimetric measurements made on very low amounts of particulate matter collected.

Table 2-23. Metals Stack Emission Rate, Strand Baghouse Outlet

Metal	Average Concentration µg/dscm	Average Emission Rate g/Hr
Hg	5.02	2.35
As	0.452	0.212
Be	0.038	0.018
Cd	0.180	0.084
Co	0.135	0.063
Cr	4.47	2.09
Mn	29.1	13.6
Ni	2.07	0.969
Pb	21.3	9.97
Sb	1.21	0.566
Se	18.0	8.43

Table 2-24. Metals Stack Emission Rate, Baghouse A Outlet

Metal	Average Concentration µg/dscm	Average Emission Rate g/Hr
Hg	2.13	0.287
As	0.755	0.102
Be	0.098	0.013
Cd	0.126	0.017
Co	0.292	0.039
Cr	8.92	1.20
Mn	62.3	8.41
Ni	7.59	1.02
Pb	7.88	1.06
Sb	3.57	0.482
Se	3.21	0.433

Table 2-25. Strand Baghouse Removal Efficiency for Metals

Metal	Average Emission Rate Inlet g/Hr	Average Emission Rate Outlet g/Hr	Removal Efficiency¹ %
Hg	3.48	2.35	32.6
As	4.63	0.212	95.4
Be	0.042	0.018	57.6
Cd	18.0	0.084	99.5
Co	5.23	0.063	98.8
Cr	50.5	2.09	95.9
Mn	1247	13.6	98.9
Ni	10.2	0.969	90.5
Pb	4001	9.97	99.8
Sb	1.39	0.566	59.2
Se	12.9	8.43	34.8

1

$$\% \text{ Removal Efficiency} = \frac{\text{Inlet Rate} - \text{Outlet Rate}}{\text{Inlet Rate}} \times 100$$

Table 2-26. Particulate Matter Concentration

Location	g/dscm				
	Run 1	Run 2	Run 3	Average	%RSD
Strand Baghouse Inlet	1.56	0.935	1.19	1.23	25.7
Strand Baghouse Outlet	0.00226	0.000697	0.00126	0.0014	56.2
Baghouse A Outlet	0.00172	0.00216	0.000939	0.0016	38.4

Table 2-27 shows the average PM emission rate from the Strand baghouse to be 1.44 pounds per hour (lb/hr). This value was calculated from the average outlet concentration from Table 2-26 and the average stack flow rate from Table 2-3. Using this value in conjunction with the equivalent value for the inlet (see Table 2-27), a PM removal efficiency for the Strand baghouse was calculated to be 99.9%. The emission rate of particulate from Baghouse A is 0.48 lb/hr. The PM analytical raw data are given in Appendix D.

Table 2-27. Particulate Matter Emission Rates and Removal Efficiency

Location	Average Inlet Rate lb/Hr	Average Outlet Rate lb/Hr	Removal Efficiency¹ %
Strand Baghouse	1515	1.44	99.9
Baghouse A	NA	0.476	NA

$$\% \text{ Removal Efficiency} = \frac{\text{Inlet Rate} - \text{Outlet Rate}}{\text{Inlet Rate}} \times 100$$

3.0 Youngstown Sinter Company's Sinter Plant (Prepared by RTI)

3.1 Overview

The primary purpose of the sinter plant is to recover the iron value from waste materials generated at iron and steel plants by converting the materials to a product that can be used in the blast furnace (as burden material). Many of these wastes have little or no value otherwise and would require disposal if they could not be recycled by this process. A secondary purpose of the sinter plant is to recover lime from wastes and to convert limestone to lime, which is used as a fluxing agent in the blast furnace. The raw material feed (sinter mix) consists of iron ore fines, chips from iron ore pellets, fine limestone, slag from the steelmaking furnace, scale from the steel rolling mill, blast furnace flue dust, coke breeze (undersize coke that cannot be used in the blast furnace), and dolomite.

There are currently 10 sinter plants in operation in the U.S. A total of 6 of these plants use scrubbers to control emissions from the sinter plant windbox, and 4 use a baghouse. The sinter plant at Youngstown Sinter Plant, Youngstown, OH, a wholly owned subsidiary of WCI Steel Company, was chosen for testing to evaluate hazardous air pollutants and emission control performance associated with sinter plants that use baghouses.

3.2 Process Description

The Youngstown sinter plant is operated by Youngstown Sinter Company, a wholly owned subsidiary of WCI Steel. The plant was purchased from LTV Steel Company and was brought on line in June 1991. The sinter plant is located a few miles from the WCI Steel integrated iron and steel plant in Warren, OH. The integrated plant includes one blast furnace, a basic oxygen furnace (BOF) shop containing two BOF vessels, ladle metallurgy, continuous casting, rolling mills, and galvanizing lines. The sinter plant has a capacity of 60,000 tons per month (tpm) and operates 24 hours per day with 2 days scheduled downtime every seven days for routine maintenance. The major processing steps in the sinter plant include preparation of the

sinter mix (feed material), sintering, discharge end operations (crushing and screening), and cooling of the sinter product. Figure 1 is a simplified schematic of the sintering process.

The typical feed composition of the sinter mix during the emission tests is shown in Table 3-1.

Table 3-1. Summary of Sinter Mix (Feed) Components

Feed material	Composition (% of feed)	Feed Rate (tons/day)
Ore fines	27.70	880
Mill scale	12.79	406
Limestone	12.15	385
Flue dust	9.07	288
Coke breeze	0.63	20
BOF slag	16.51	524
Pellet chips	19.73	625
Dolomite	1.42	4.5

The raw materials are brought into the sinter plant by truck and are stored at the site. Two feeder tables blend mill scale, BOF slag, and crushed ore pellets by volume, and the mixture is transferred by conveyor to the sinter plant and fed into the sinter machine through a series of bins. Limestone, dolomite, coke fines, and cold fines recycled from the sintering process are also contained in bins and are blended into the mix. A "hearth layer" of material, which is undersize sinter material that is recycled from the screening operation, is first deposited on the grate bars of the sinter pallets so that the sinter mixture does not burn through to the grate, and then the feed mix is added to a depth of about 17 inches. The plant has found that a deeper bed results in fewer fines being generated.

The sinter feed passes through an ignition furnace, and the surface of the sinter feed is ignited with natural gas. The sinter pallets move continually through the ignition furnace at

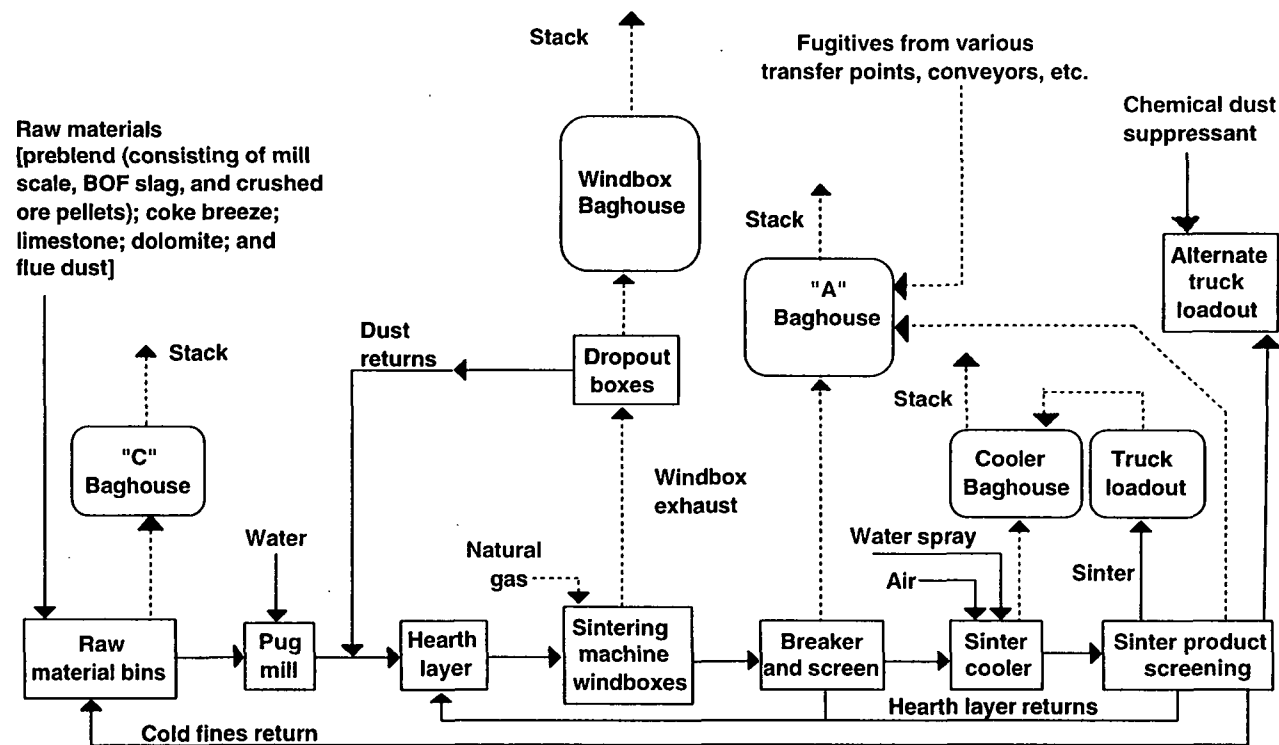


FIGURE 1. SCHEMATIC OF MATERIAL FLOW IN SINTER PLANT

about 6.3 to 7.0 feet per minute over 21 vacuum chambers called "windboxes." A vacuum is created in the windbox by a fan that draws heat through the sinter bed and creates the fused "sintered" product.

The red hot sinter from the furnace continues to be transported on the pallets to the breaker, where it is crushed, screened, and discharged to a 250-foot linear four-stack sinter cooler. The sinter is removed from the cooler and transported by covered conveyor to the truck loadout station. The sinter plant has two truck loadout stations, and all of the sinter is transported to the blast furnace by truck. The larger station is evacuated to a hood which goes to the cooler baghouse; the building is open but has a curtain over each end to contain emissions with an opening for the trucks to enter and exit.

The smaller truck loadout station is used to provide more capacity and is normally used to handle production from the midnight shift; the station utilizes chemical dust suppression. The sinter is transferred by a covered conveyor from the sinter cooler to a storage building as needed, and is then transferred by a covered conveyor to the truck loadout station. Emissions from the sinter storage building are evacuated to the A baghouse. *SoLong*, manufactured by Midwest, is used for dust suppression at the truck loadout station. The chemical acts as a polymer and binds the dust to the sinter during truck loading; *SoLong* is applied to the sinter as the product exits the covered conveyor and drops into the bed of each truck. Very little emissions from the loading process were observed to escape capture at the larger truck loadout station. Some emissions were observed from the unenclosed area at the top of the conveyor and from the truck as the sinter was being loaded. Dust emissions were minimal but were noticeable depending on the truck being loaded. Sinter material that passes through the screens ("fines") is returned to the sinter process for use as the hearth layer or for addition to the sinter mix.

Several operating parameters are monitored and controlled to ensure proper operation of the sinter machine. These parameters include the feed rate of each of the ten feed bins, the sinter furnace temperature, the temperature profile through the various windboxes, draft on the

windboxes, speed of the grate, and percent water in the feed. The percentage of oil in each of the feed materials is analyzed and the total amount of oil in the sinter feed is limited to less than 0.1 percent. To maintain the proper chemistry in the blast furnace, an important quality control parameter that is monitored is the sinter basicity:

$$(\text{CaO}+\text{MgO})/(\text{SiO}_2+\text{Al}_2\text{O}_3)$$

The sinter composition for the four tests days is summarized in Table 3-2 and shows that the sinter basicity ranged from 2.72 to 2.92.

Table 3-2. Summary of Sinter Composition

Component	Percent of total			
	Test 1 (08/12/97)	Test 2 (08/13/97)	Test 3 (08/14/97)	Test 4 (08/15/97)
Fe	53.23	52.23	52.42	52.20
SiO ₂	4.82	5.47	5.21	5.17
Al ₂ O ₃	0.90	0.98	0.91	0.89
CaO	14.69	15.30	15.03	15.40
MgO	2.09	2.16	2.23	2.28
Sinter basicity	2.90	2.72	2.84	2.92

3.4 Emission Control Equipment

Emissions are generated in the process as sinter dust and combustion products are discharged through the grates and the 21 windboxes to a common collector main and are then collected by the strand baghouse. The pulse jet baghouse is manufactured by Environmental Elements and uses Nomex® bags that are coated with an acid-resistant finish. There are fourteen modules, each containing 306 bags. The bags are 6 inches in diameter and 15 feet in length, and

the total cloth area for each module is 7,215 square feet. The gross air-to-cloth ratio is 3.96 acfm/ft² and the net air-to-cloth ratio, with one module off-line for cleaning is 4.26 acfm/ft².

The flow to the baghouse is approximately 400,000 cubic feet per minute. A preheat burner is used to minimize condensation and to bring the gas up to the desired inlet temperature. The dust is removed from the baghouse by rotary screw to bins where it is stored on the ground to gather moisture and is blended back into the sinter feed. The parameters associated with the baghouse that are monitored include the pressure drop across the baghouse, inlet temperature, stack temperature, damper percent, and fan amps.

Typical operating conditions associated with the baghouse are summarized in Table 3-3. Current State regulations limit particulate matter to 50 pounds per hour for the strand baghouse.

Table 3-3. Typical Baghouse Parameters

Parameter	Typical value
Pressure drop	10 to 13 inches of water
Gas flow rate	400,000 scfm
Inlet temperature	235 to 270 °F
Outlet temperature	120°F
Damper Percent	90%
Fan Amps	659-735

Three additional baghouses are used to control emissions from the sinter plant. The C baghouse, a pulse jet baghouse utilizing polyester bags, is used to control emissions from the material handling bins and the conveyors that transfer the sinter mix to the sinter machine. The cooler baghouse controls emissions from the sinter cooler and from the main truck loadout station. The baghouse is a shaker baghouse that utilizes Nomex® bags and contains nine compartments. Eight of the compartments are used for the cooler and one compartment is used

for the truck loadout station. There are four 200 horsepower fans on the sinter cooler. The first fan is the dirtiest fan and is directed back to hoods on the sinter machine and sent back through as preheat air. The other 3 fans are ducted to the baghouse. In addition, the truck loadout station has a 70,000 cubic feet per minute fan. These baghouses were not evaluated as part of this test program.

The A baghouse that serves the discharge end of the sinter plant was evaluated as part of this test program. A schematic of A baghouse is shown in Figure 2. This baghouse controls emissions from discharge end emission points, including the hood before the sinter machine; the hood over sinter discharge; the sinter breaker and hot screen which is enclosed by a cloth curtain; the tail end of the sinter cooler; emissions from each of the ten sinter feed bins; a variety of transfer points for the transport of sinter, dust, and fines; and emissions from sinter bins located in the sinter overflow storage area. At any point where there is hot sinter, emissions are first ducted to a cyclone before going to the baghouse.

The plant sprays the roads twice per week to minimize dust emissions, except during the winter months. All of the baghouses are monitored on a weekly basis by an outside contractor, Fastway, Inc., to check the operation and for any visible opacity. A whole compartment is dye-tested if there is more than 5 percent visible emissions observed, and the broken bags are then replaced. Every other month, a complete compartment of either the strand or cooler baghouse is replaced; each compartment is replaced approximately every 3 years.

3.5 Monitoring Results During the Tests

The operating parameters associated with the process and control device were recorded at 15-minute intervals throughout each test day. The process parameters that were monitored included the temperatures and the fan draft for the windboxes, percent water in the feed, sinter machine speed, and the temperature of each of the four cooling fans. In addition, the turn supervisor's report provided additional information, including tons per hour of pre-blend, and



tons per 8-hour turn of limestone, dolomite, coke fines, and cold fines. The emission control device parameters that were monitored included the pressure drop across the baghouse, damper percent, inlet temperature, stack temperature, fan amps, and the pressure drop of each of the 14 compartments of the baghouse. Tables 3-4 and 3-5 present a summary of the range of values for these parameters for each test period. Table 3-6 presents a summary of the pressure drops of each compartment of the baghouse for the four days of testing.

The process and control device appeared to be stable throughout the four test days; consequently, sampling was conducted under normal and representative conditions. An examination of the monitoring data showed that the average pressure drop across the baghouse was 10.8, 12.0, 12.9 and 13.5 inches of water for the 4 test days. The pressure drop across the baghouse did increase slightly during each day of testing. On the third day, the compartments were double cleaned to try to reduce the pressure drop. The temperatures and draft of the windboxes varied somewhat during the tests; plant operators stated that the temperature of windboxes 19 and 20, should generally be 475-500 °F to achieve proper burnthrough of the sinter bed.

During each run of testing performed on A baghouse, the pressure drops of each compartment and the pressure drop across the baghouse were monitored periodically, generally every 20 to 30 minutes. The plant does not monitor any other parameters on A baghouse; since the A baghouse is responsible for the capture and control of dust sources throughout the sintering process, malfunctions are readily apparent. Table 3-7 presents a summary of the pressure drops of each compartment and the pressure drop across the baghouse during each test period.

3.6 Analysis of Monitoring and Test Results

Table 3-8 summarizes the emission results for each run for key pollutants from the outlet of the control device on the sinter strand, along with selected parameters that were monitored during the test. Only a few comparisons can be made because the process operated stably and

consistently during the 3 test runs. One difference is that the pressure drop across the strand baghouse increased over the four days of testing, from an average of 10.78 on the first day of testing, to an average of 13.48 on the final day of testing. However, the results were fairly stable and did not appear to be impacted by the increased pressure drop over the course of testing. Table 3-9 presents emission results for each run for key pollutants from the A baghouse outlet.

Particulate matter and HAP metal emissions were fairly steady over three runs. One interesting factor is that while particulate matter emissions during Run 2 were three times lower than during Run 1, and two times lower than during Run 3, HAP metal emissions were steady over the course of the three runs. The major metal HAPs that were found were lead and manganese; both were effectively captured and controlled by both the Strand baghouse and A baghouse.

Another interesting result is the very low emission rate of dioxins, relative to what had been reported from testing at German sinter plants. The German study reported concentrations of 23 to 68 ng TEQ/m³ from their initial studies and a range of 5 to 10 ng TEQ/m³ for plants that optimized and improved their operation. The results for this sinter plant was much lower, with an average concentration of 0.807 ng TEQ/m³. On the basis of sinter production, the Germans reported emission levels in the range of 10 to 100 µg/Mg of sinter compared to a measured level of 0.6 µg/Mg of sinter for this plant. The WCI sinter plant had emissions of dioxins and furans that were on the order of 10 to 100 times less than that reported for German sinter plants.

The dioxin results are not unexpected because there are basic differences between the operation of WCI's sinter plant and the German plants. The German study attributed the formation of dioxin to the presence of chlorinated organics, primarily in cutting oils, that were in the waste materials fed to the sintering process. In addition, they stated that the use of electrostatic precipitators contributed to recombination and formation of dioxin. In contrast, the WCI plant, like most U.S. integrated plants, has eliminated the purchase and use of chlorinated organics in their facility. Their rolling mill oils (lubricants and hydraulic fluids) do not contain

chlorinated compounds. In addition, routine analysis of waste materials going to the sinter plant have not detected chlorinated solvent. Finally, the WCI plant does not use an electrostatic precipitator. Consequently, dioxin rates at WCI that are much lower than those reported by German sinter plants appear to be reasonable and explainable.

A surprising result is the emission rate of polycyclic aromatic hydrocarbons (PAHs) that was measured during the testing. Emissions for PAHs were slightly higher than particulate matter emissions from the outlet of the strand baghouse. These results were consistent over all test runs; even though the first two test runs resulted in questionable data, the results still are consistent with the remaining three test runs. It is not known if the higher emissions were present in the inlet stream or if the baghouse performed poorly in the capture and control of PAHs emissions, since inlet testing for PAHs was not performed. The major PAHs present in the outlet stream were naphthalene and 2-methylnaphthalene, with 3,660 and 2,920 pounds per year being emitted respectively.

Table 3-10 presents a summary of particulate matter and metal HAP results for the strand baghouse, including concentrations, efficiencies, annual emission rates, and emissions factors for each metal HAP. Table 3-11 presents similar results for polycyclic aromatic hydrocarbons and dioxins and furans. Table 3-12 presents a summary of results for the A baghouse for particulate matter and metal HAPs. The information contained in Tables 3-11 and 3-12 does not contain efficiencies since inlet testing was not performed.

Table 3-4. Process Parameter Ranges During The Tests

Parameter	Test 1 (8/12/97)	Test 2 (8/13/97)	Test 3 (8/14/97)	Test 4 (8/15/97)
Feed rate:				
Pre-blend (ore) (tons/hour)	120	120	120	120
Limestone (tons/turn)	144	114	167	
Dolomite (tons/turn)	43	39	43	
Coke fines (tons/turn)	19	17	18	
Cold fines (tons/turn)	1738	1545	1787	
Other parameters:				
Percent water	7.0 - 7.2	6.7 - 7.6	6.8 - 7.0	6.7 - 6.8
Grate speed (feet/min)	—	—	—	6.3 - 7.0
Windbox 1 temperature (°F)	177-211	150-202	157-207	166-220
Windbox 1 draft (in. H ₂ O)	18.0-22.1	20.3-23.5	19.5-22.3	19.5-21.8
Windbox 3 temperature (°F)	167-195	108-186	149-181	159-198
Windbox 3 draft (in. H ₂ O)	16.2-20.3	18.6-21.5	18.1-20.5	18.0-20.1
Windbox 13 temperature (°F)	187-266	184-233	169-231	165-342
Windbox 13 draft (in. H ₂ O)	—	—	—	—
Windbox 18 temperature (°F)	327-463	251-459	288-457	301-521
Windbox 18 draft (in. H ₂ O)	14.7-18.3	16.6-19.9	15.7-18.5	16.0-17.8
Windbox 19 temperature (°F)	396-542	357-513	350-460	363-545
Windbox 19 draft (in. H ₂ O)	16.4-21.1	18.4-21.9	18.0-20.4	17.2-20.5
Windbox 20 temperature (°F)	373-580	391-546	372-496	385-545
Windbox 20 draft (in. H ₂ O)	14.5-18.9	17.0-20.7	16.2-18.9	16.5-18.6
Windbox 21 temperature (°F)	—	360-465	332-429	355-443
Windbox 21 draft (in. H ₂ O)	14.9-17.7	15.7-19.3	15.1-17.5	15.3-17.2

Parameter	Test 1 (8/12/97)	Test 2 (8/13/97)	Test 3 (8/14/97)	Test 4 (8/15/97)
Cooling Fan Temperatures (°F)				
A	420-463	411-460	395-415	376-413
B	505-546	405-544	456-530	456-507
C	430-460	205-458	372-440	385-435
D	185-243	116-237	157-200	172-192

Table 3-5. Control Device Operating Parameters — Windbox Baghouse

Parameter	Test 1 (08/12/97)	Test 2 (08/13/97)	Test 3 (08/14/97)	Test 4 (08/15/97)
Pressure drop (in. H ₂ O)	9.30-11.87	10.60-12.59	11.61-13.57	12.09-14.12
Inlet Temp. (°F)	242 - 265	217-253	211-245	217-236
Stack Temp. (°F)	243 - 248	231-248	216-243	227-248
Fan amps	684 - 735	667-690	667-694	659-690
Damper (%)	88.9-90.1	89.5-91.2	88.8-90.9	89.0-90.8

Table 3-6. Pressure Drop Across Each Compartment of The Windbox Baghouse

Compartment Pressure Drop	Test 1 (08/12/97)	Test 2 (08/13/97)	Test 3 (08/14/97)	Test 4 (08/15/97)
1	7.0-8.6	6.8-9.3	7.0-9.6	8.6-9.9
2	8.2-9.2	6.7-9.6	6.9-9.8	8.0-10.0
3	7.1-8.6	8.6-9.8	9.4-10+	9.9-10+
4	5.6-8.0	6.8-8.8	7.4-9.8	7.9-10+
5	7.1-8.5	8.0-9.8	9.1-10+	10.0-10+
6	6.6-7.9	7.8-9.3	8.3-9.9	8.9-10+
7	6.4-8.0	7.1-9.4	8.9-10.0	9.7-10+
8	6.7-8.4	6.0-8.8	7.7-9.7	7.2-10+
9	7.6-9.4	8.6-9.9	9.4-10+	9.5-10+
10	7.1-9.0	7.8-9.7	9.3-10+	9.9-10+
11	6.8-8.9	7.3-9.4	8.5-10+	8.2-10+
12	7.6-9.4	8.8-10+	9.6-10+	10+
13	6.4-9.0	7.6-10+	9.8-10+	10.0-10+
14	6.4-9.2	7.6-10+	9.4-10+	8.5-10+
Total	9.9-11.5	10.0-11.5	11.4-12.3	12.0-13.0

Table 3-7. Pressure Drop Across Each Compartment of "A" Baghouse

Compartment	Test 1 (08/15/97)	Test 2 & 3 (08/16/97)
1	2.6-3.8	3.0-4.7
2	2.8-3.7	3.7-5.5
3	4.7-5.5	1.5-2.0
4	4.4-6.0	5.5-7.4
Total	7.7-8.1	7.9-10.9

TABLE 3-8. Strand Baghouse Summary of Results for Each Test Run

Test Day	Units	Day 1	Day 2	Day 3	Day 4	Average
Sinter production	tons/hour	110	110	110	110	110
Baghouse ΔP	in. H ₂ O	10.78	12.00	12.88	13.48	12.28
Windbox 20 Temp.	°F	474	467	446	457	461
Baghouse Inlet Temp.	°F	252	240	230	231	238
Baghouse Outlet Temp.	°F	246	240	230	238	238
Parameter	Units	Run 1	Run 2	Run 3	Runs 4 & 5	Average
PM ^a — outlet	lb/hr	2.35	0.71	1.30	Not necessary to do more than 3 runs	1.45
Pb — outlet	lb/hr	0.0220	0.0209	0.0229		0.0219
Mn — outlet	lb/hr	0.0080	0.0661	0.0158		0.0300
HAP metals — outlet	lb/hr	0.0628	0.1224	0.0681		0.0845
		Runs 1 & 2	Run 3	Run 4	Run 5	Average
Dioxin/furan congeners ^b	μg/hr	Questionable data; unacceptable leak checks	2,142	2,444	2,186	2,257
Dioxin/furan TEQ ^c	μg/hr		342	404	375	374
7 PAHs ^d	g/hr		28.90	34.75	33.88	32.51
16 PAHs	g/hr		510	457	575	514
Total PAHs	g/hr		691	634	755	693

^a PM = particulate matter^b D/F congeners are those dioxins and furans that have a toxicity equivalent factor relative to 2,3,7,8-TCDD^c D/F TEQ is the toxicity equivalent expressed relative to 2,3,7,8-TCDD^d PAH = polycyclic aromatic hydrocarbons**Table 3-9. A Baghouse Summary of Results for Each Test Run**

Parameter	Units	Run 1	Run 2	Run 3	Average
PM ^a — outlet	lb/hour	0.53	0.67	0.26	0.48
Mn — outlet	lb/hour	0.0033	0.036	0.016	0.019
HAP metals — outlet	lb/hour	0.012	0.046	0.028	0.029

^a PM = particulate matter

Table 3-10. Strand Baghouse Summary of Results for Particulate Matter and Metal HAPs

Pollutant — Particulate Matter	Inlet		Outlet		Efficiency	Annual Rate, ^b tpy		Emission Factor (lb/ton of sinter)	
	lb/hr	g/dscm	lb/hr	g/dscm	%	Inlet	Outlet	Inlet	Outlet
	1,520	1.23	1.45	0.0014	99.9	5,700	5.36	13.8	0.013
Pollutant — HAP Metals	Concentration ($\mu\text{g/dscm}$)		Emission rate (g/hr)		Efficiency (%)	Annual rate (tpy)		Emission factor (lb/t sinter)	
	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	Inlet	Outlet
Mercury	6.23	5.02	3.5	2.35	32.5	0.03	0.02	7.0×10^{-5}	4.7×10^{-5}
Arsenic	8.27	0.452	4.6	0.21	95.4	0.04	0.00	9.3×10^{-5}	4.2×10^{-6}
Beryllium	0.075	0.038	0.04	0.02	57.7	0.00	0.00	8.4×10^{-7}	3.6×10^{-7}
Cadmium	32.2	0.180	18.0	0.08	99.5	0.15	0.00	3.6×10^{-4}	1.7×10^{-6}
Cobalt	9.35	0.135	5.2	0.06	98.8	0.04	0.00	1.0×10^{-4}	1.3×10^{-6}
Chromium	90.2	4.47	50.5	2.09	95.9	0.41	0.02	1.0×10^{-3}	4.2×10^{-5}
Manganese	2230	29.1	1,247	13.62	98.9	10.16	0.11	2.5×10^{-2}	2.7×10^{-4}
Nickel	18.3	2.07	10.2	0.97	90.5	0.08	0.01	2.0×10^{-4}	1.9×10^{-5}
Lead	7153	21.3	4,001	9.97	99.8	32.61	0.08	8.0×10^{-2}	2.0×10^{-4}
Antimony	2.48	1.21	1.4	0.57	59.3	0.01	0.00	2.8×10^{-5}	1.1×10^{-5}
Selenium	23.1	18.0	12.9	8.42	34.7	0.11	0.07	2.6×10^{-4}	1.7×10^{-4}
HAP metals	9,573	82	5,354	38	99.3	44	0.31	1.1×10^{-1}	7.7×10^{-4}

^a PM = particulate matter

^b Based on operation for 24 hours per day, 6 days per week, 52 weeks per year (7400 hours/year).

Table 3-11. Strand Baghouse Summary of Results for PAHs and Dioxin/Furans

Pollutant — Polycyclic Aromatic Hydrocarbons (PAHs)	Outlet		Annual Emissions, Outlet of Control Device ^a	Emission Factor, Sinter Basis Outlet of Control Device
	g/hr	µg/dscm	tpy	lb/ton
Benzo(a)anthracene	9.79	21.2	0.0799	1.96x10 ⁻⁴
Benzo(a)pyrene	0.956	2.07	0.0078	1.92x10 ⁻⁵
Benzo(b)fluoranthene	4.07	8.81	0.0332	8.16x10 ⁻⁵
Benzo(k)fluoranthene	1.29	2.79	0.0105	2.58x10 ⁻⁵
Chrysene	16.0	34.6	0.1305	3.21x10 ⁻⁴
Dibenzo(a,h)anthracene	<0.273	0.590	0.0022	5.47x10 ⁻⁶
Ideno(1,2,3-cd)pyrene	<0.200	0.433	0.0016	4.01x10 ⁻⁶
7 PAHs (Total)	32.6	70.7	0.266	6.53x10 ⁻⁴
Acenaphthene	8.80	19.0	0.072	1.76x10 ⁻⁴
Acenaphthylene	16.0	34.5	0.1305	3.21x10 ⁻⁴
Anthracene	20.4	44.2	0.1664	4.09x10 ⁻⁴
Benzo(g,h,i)perylene	<0.194	0.419	0.0016	3.89x10 ⁻⁶
Fluoranthene	56.3	122	0.459	1.13x10 ⁻³
Fluorene	18.8	40.3	0.1534	3.77x10 ⁻⁴
Naphthalene	221	478	1.80	4.43x10 ⁻³
Phenanthrene	115	250	0.938	2.30x10 ⁻³
Pyrene	25.3	54.8	0.206	5.07x10 ⁻⁴

Pollutant — Polycyclic Aromatic Hydrocarbons (PAHs)	Outlet		Annual Emissions, Outlet of Control Device ^a	Emission Factor, Sinter Basis Outlet of Control Device
	g/hr	μg/dscm	tpy	lb/ton
16 PAHs (Total)	514	1114	4.19	1.03x10 ⁻²
2-methylnaphthalene	176	382	1.44	3.53x10 ⁻³
2-chloronaphthalene	0.804	1.74	0.0066	1.61x10 ⁻⁵
Benzo(e)pyrene	1.98	4.27	0.0162	3.97x10 ⁻⁵
Perylene	<0.257	0.557	0.0021	5.15x10 ⁻⁶
Total PAHs	693	1503	5.65	1.39x10 ⁻²
Pollutant — Dioxin/Furans	Outlet		Annual Emissions, Outlet of Control Device ^a	Emission Factor, Sinter Basis Outlet of Control Device
	μg/hr	ng/dscm	grams/year	lb/ton
D/F congeners ^b	2,257	4.877	16.70	5.11x10 ⁻⁸
D/F TEQ ^c	374	0.807	2.77	8.48x10 ⁻⁹

^a Based on operation for 24 hours per day, 6 days per week, 52 weeks per year (7400 hours/year).

^b D/F congeners are those dioxins and furans that have a toxicity equivalent factor relative to 2,3,7,8-TCDD.

^c D/F TEQ is the toxicity equivalent expressed relative to 2,3,7,8-TCDD.

Table 3-12. Discharge End Baghouse ("A") -- Results for Particulate Matter and Metal Haps

Pollutant — Particulate Matter	Outlet		Emissions ^b	Emission Factor
	lb/hr	gr/dscf	tpy	lb/ton sinter
PM ^a	0.48	0.0007	1.8	0.0044
Pollutant — Metal HAPs	Outlet		Emissions ^b	Emission Factor
	g/hr	μg/dscm	tpy	lb/ton sinter
Arsenic	0.10	0.755	0.0008	2.4 x 10 ⁻⁶
Beryllium	0.013	0.098	0.0001	2.6 x 10 ⁻⁷
Cadmium	0.017	0.126	0.0001	3.4 x 10 ⁻⁷
Cobalt	0.039	0.292	0.0003	7.8 x 10 ⁻⁷
Chromium	1.2	8.92	0.0099	2.4 x 10 ⁻⁵
Mercury	0.29	2.13	0.0024	5.8 x 10 ⁻⁶
Manganese	8.4	62.3	0.070	1.7 x 10 ⁻⁴
Nickel	1.0	7.59	0.0084	2.0 x 10 ⁻⁵
Lead	1.1	7.88	0.0086	2.2 x 10 ⁻⁵
Antimony	0.48	3.57	0.0040	9.6 x 10 ⁻⁶
Selenium	0.43	3.21	0.0036	8.6 x 10 ⁻⁶
HAP metals	13.1	96.9	0.11	2.6 x 10 ⁻⁴

^a PM = particulate matter

^b Based on operation for 24 hours per day, 6 days per week, 52 weeks per year (7400 hours/year)

4.0 SAMPLING LOCATIONS

The sampling locations used during the emission testing program at the Youngstown Sinter Company are described in this section. Flue gas samples were collected at the inlet and outlet of the sintering plant Strand baghouse and Baghouse A outlet using four ports for the inlet and two ports for the outlets. The configurations of the sampling locations are shown in Figures 4-1, 4-2, and 4-3.

The test ports and their locations met the requirements of EPA Method 1. The Strand baghouse inlet location was a rectangular duct with dimensions of 11' by 10' with four 4" ports installed on the vertical 10' side. The Strand baghouse outlet location was a circular stack with an inside diameter (I.D.) of 9 feet. The Baghouse A outlet was a circular stack with an I.D. of 6'. The position and number of traverse points for each location are shown in Figures 4-4, 4-5, and 4-6, respectively.

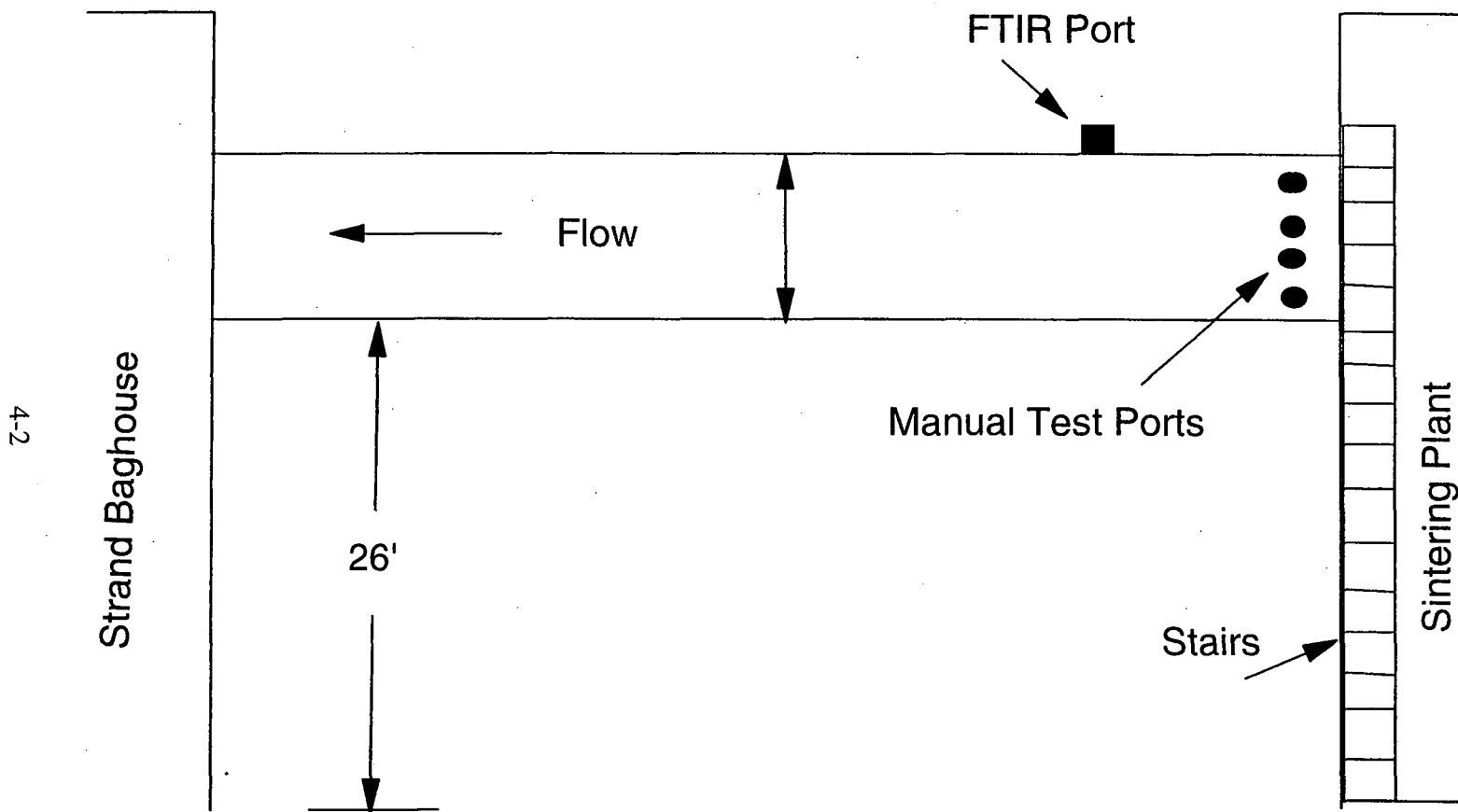


Figure 4-1. Strand Baghouse Inlet Sampling Location

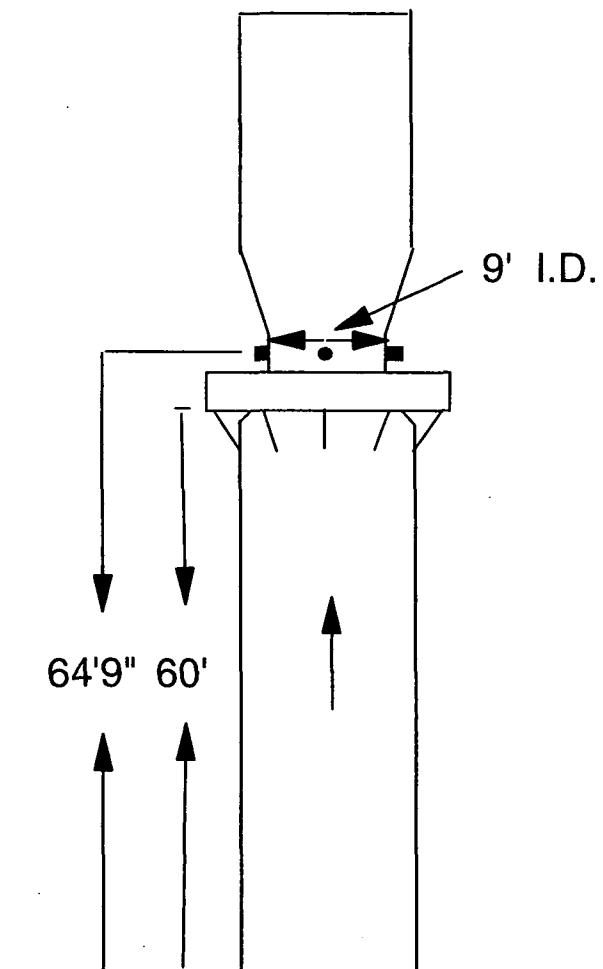


Figure 4-2. Strand Baghouse Outlet Sampling Location

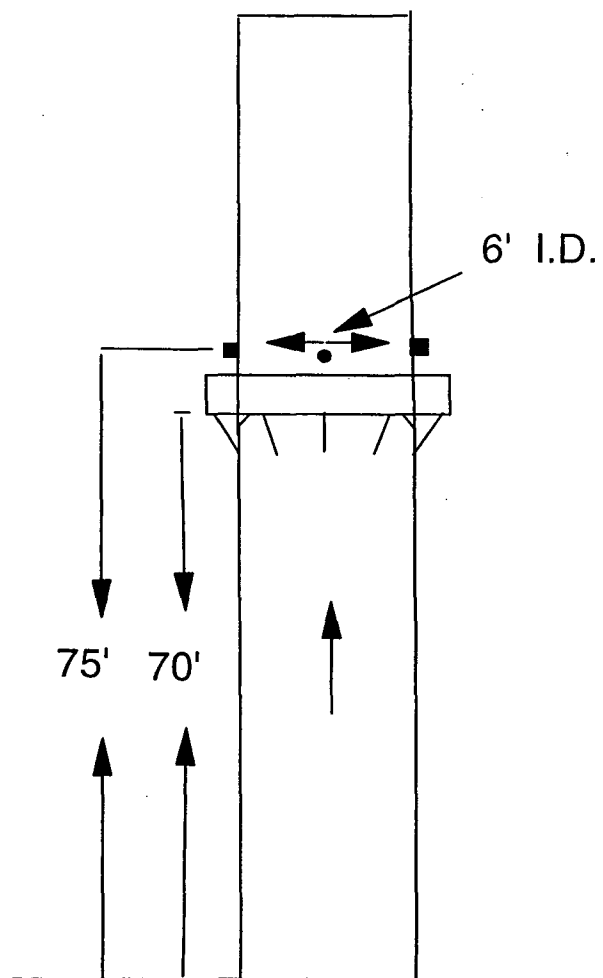


Figure 4-3. Baghouse A Outlet Sampling Location

4-5

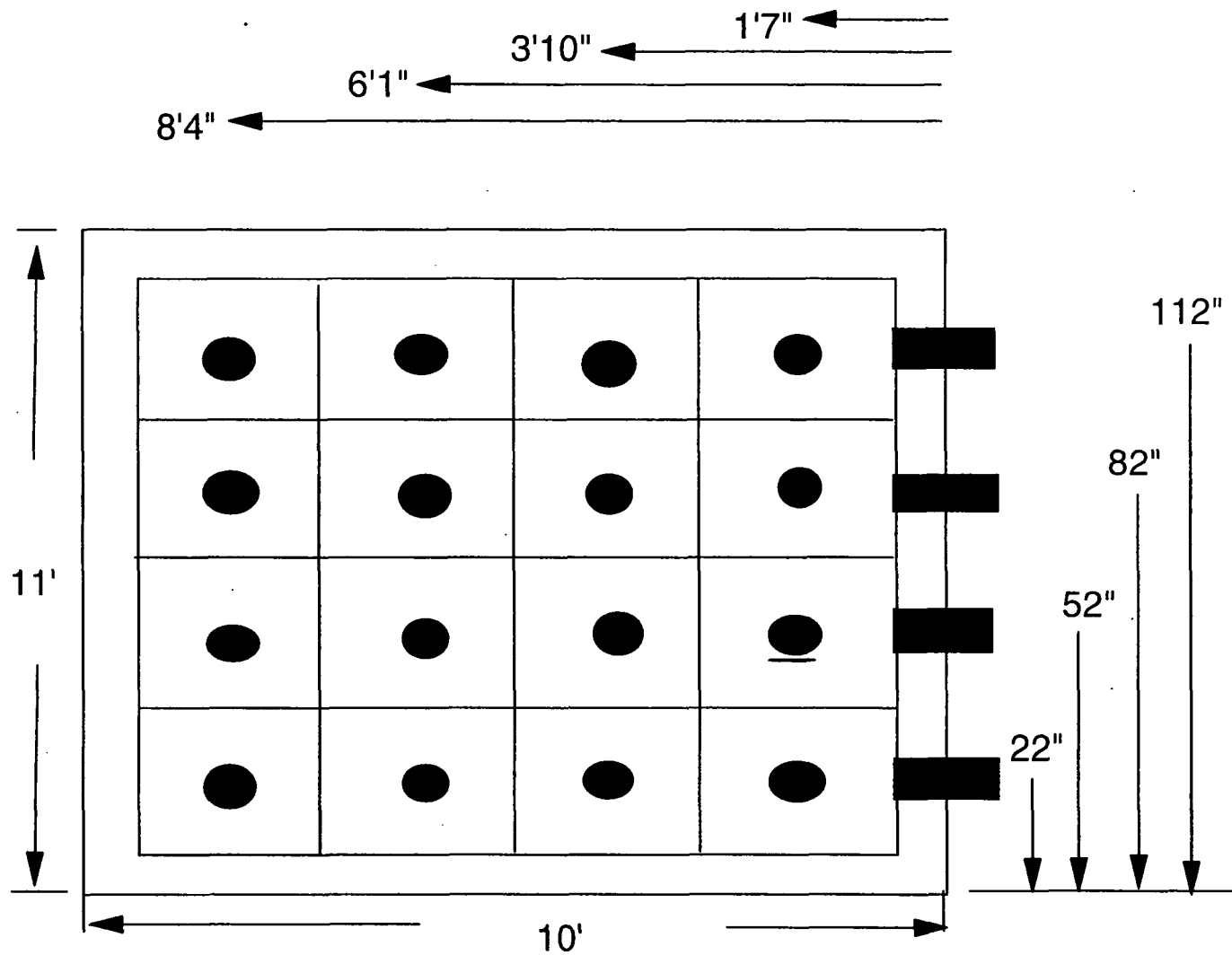


Figure 4-4. Strand Baghouse Inlet Traverse Point Layout

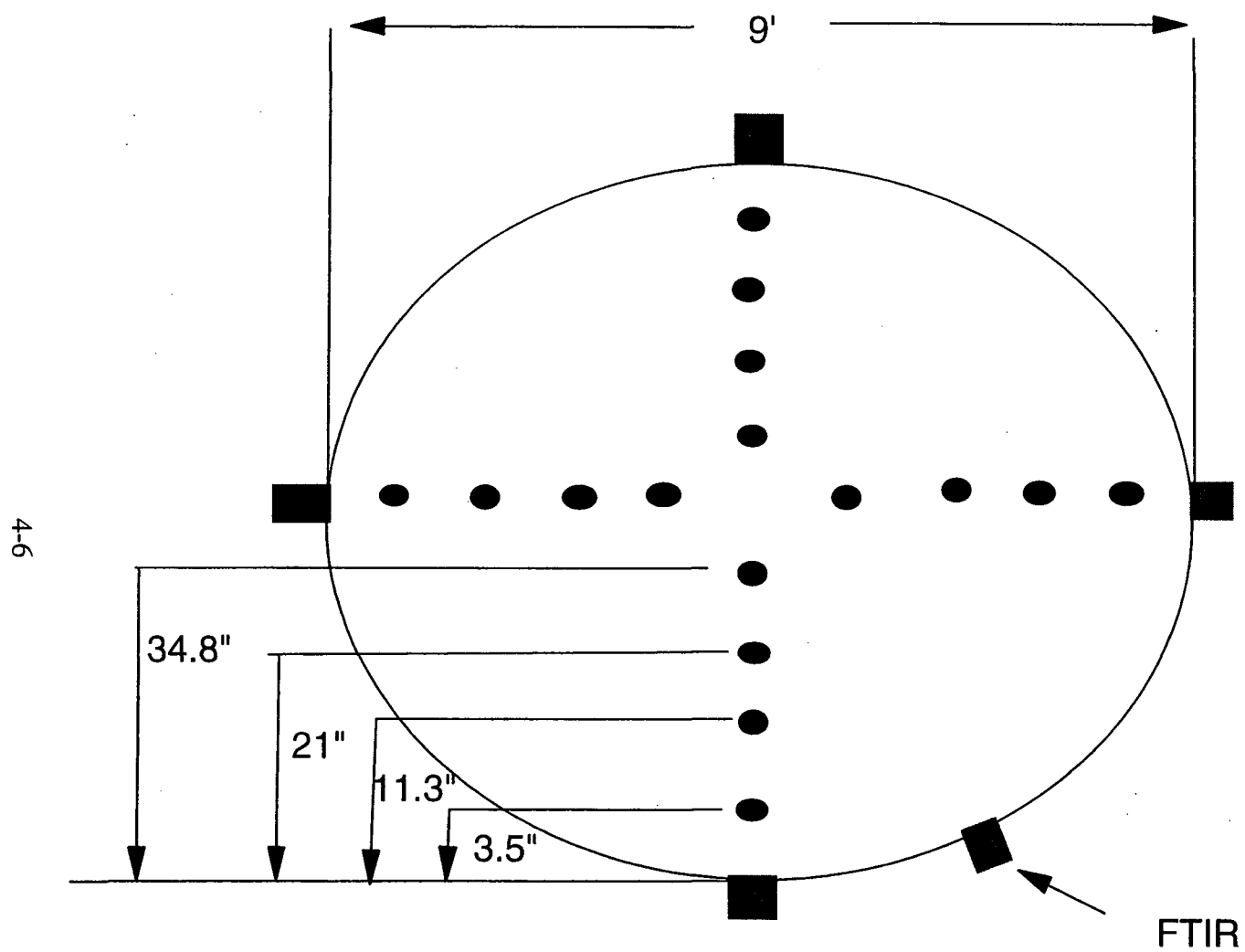


Figure 4-5. Strand Baghouse Outlet Traverse Point Layout

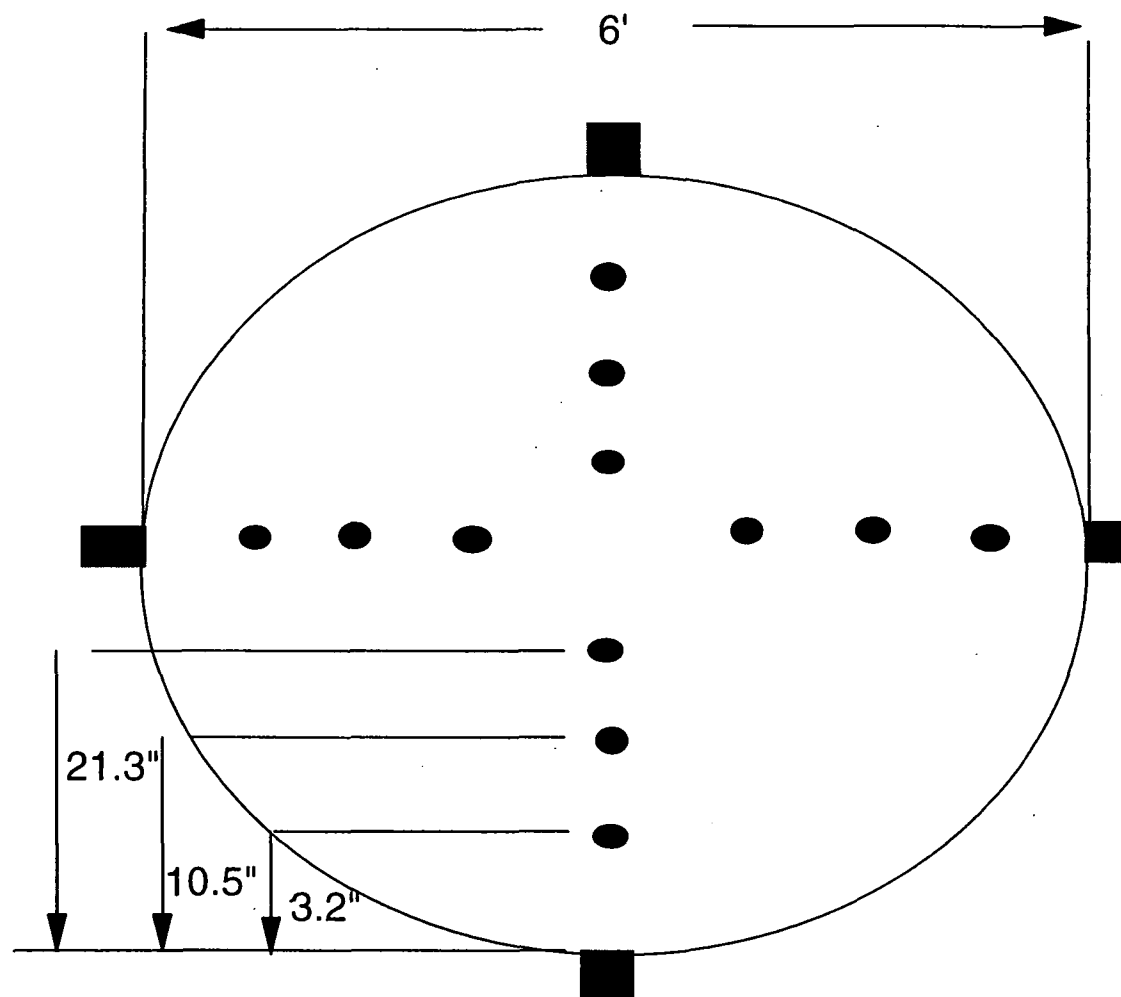


Figure 4-6. Baghouse A Traverse Point Layout

5.0 SAMPLING AND ANALYTICAL PROCEDURES BY ANALYTE

The sampling and analytical procedures used for the sintering plant test program are the most recent revisions of the published EPA methods. In this section, descriptions of each sampling and analytical method by analyte are provided.

5.1 Particulate Matter and Metals Emissions Testing Using EPA Method 29

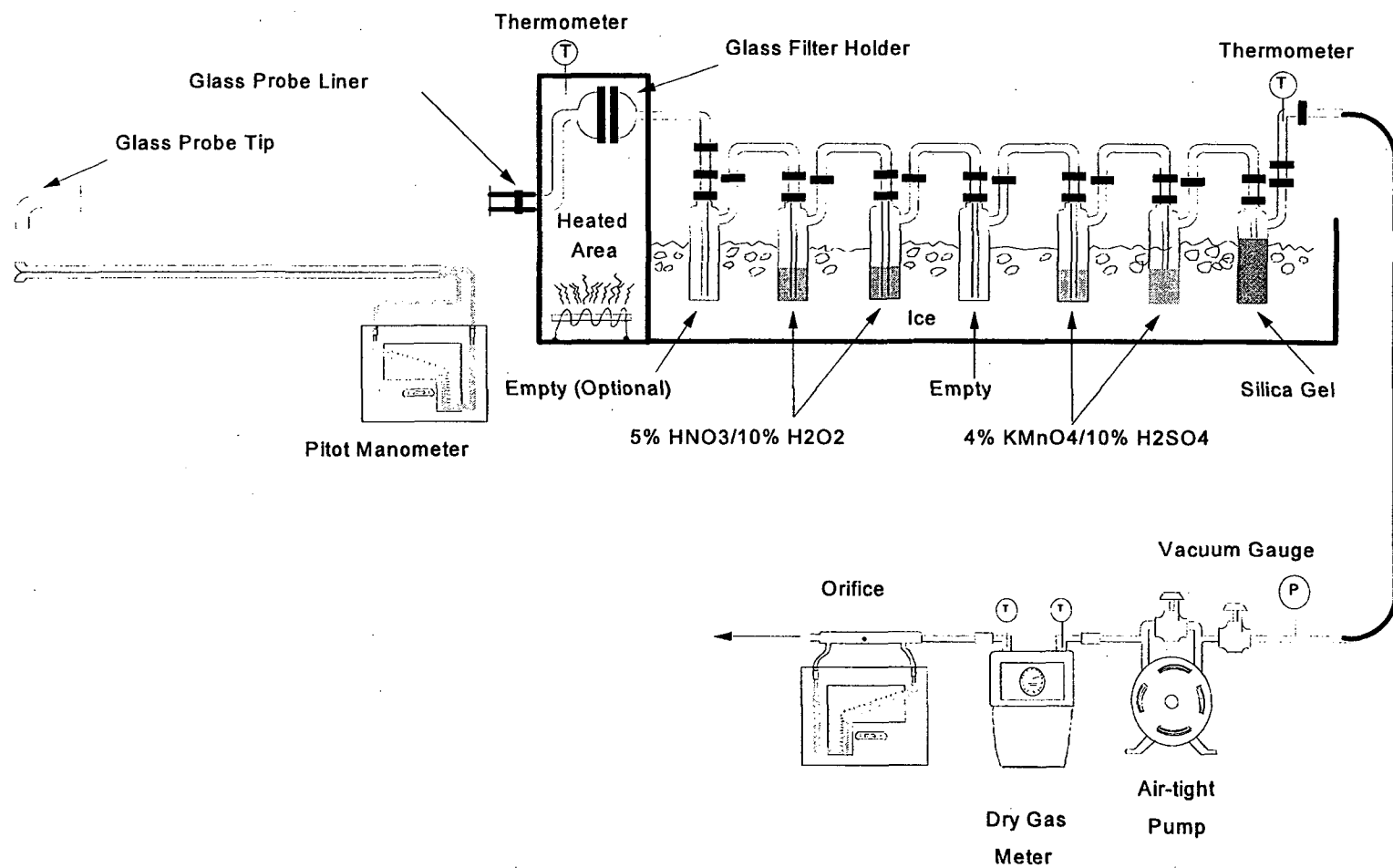
Sampling for Particulate Matter (PM) and metals was performed according to the EPA Method 29 protocol. This method is applicable to the determination of particulate mass and Pb, Ni, Cr, Mn, Se, Be, Sb, Co, Cd, As, and Hg emissions from various types of process controls and combustion sources. Analyses of the test samples were performed for the metals listed employing inductively-coupled argon plasma spectroscopy (ICAPS) and cold vapor atomic absorption (CVAA) for mercury instrumental measurements. Mercury was analyzed using EPA Method 7470A.

PM emissions were also determined from this sampling train. Particulate concentrations are based on the weight gain of the filter and the front half acetone rinses (probe, nozzle, and front half of the filter holder). The procedures which were used to determine particulate concentrations from the Method 29 samples may have resulted in some mercury losses due to volatilization during sample workup for PM determination. After the gravimetric analyses were completed, the sample fractions were then analyzed for the target metals as discussed in Section 5.1.6.

5.1.1 Method 29 Sampling Equipment

The Method 29 methodology uses the sampling train shown in Figure 5-1. The 7-impinger train consists of a borosilicate glass nozzle/probe liner followed by a heated filter

Figure 5-1. EPA Method 29 Sampling Train



assembly with a Teflon® filter support, a series of impingers and a standard EPA Method 5 meterbox and vacuum pump. The sample was not exposed to any metal surfaces in this train.

The contents of the sequential impingers were:

- An empty knockout impinger is the first impinger;
- Two impingers with a 5% nitric acid (HNO_3)/10% hydrogen peroxide (H_2O_2) solution;
- An empty knockout impinger;
- Two impingers with a 4% potassium permanganate (KMnO_4)/10% sulfuric acid (H_2SO_4) solution; and
- An impinger containing indicating silica gel.

5.1.2 Method 29 Sampling Equipment Preparation

5.1.2.1 Glassware Preparation

Glassware was washed in soapy water, rinsed with hot tap water, soaked in 10% HNO_3 for 12 hours, rinsed with Type II water, and then rinsed with acetone. This procedure included all the glass components of the sampling train including the glass nozzles plus any bottles, erlenmeyer flasks, petri dishes, graduated cylinders or stirring rods that are used during recovery. Non-glass components (such as the Teflon®-coated filter screens and seals, tweezers, Teflon® squeeze bottles, Nylon® probe and nozzle brushes) were cleaned following the same procedure. The specifics of the cleaning procedure are presented in Table 5-1.

Table 5-1. Glassware Cleaning Procedure (Train Components)

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox®).
2. Tap water rinse to remove soap.
3. Distilled/deionized H₂O rinse (X3).^a
4. Soak in 10% HNO₃ solution for 12 hours.
5. Distilled/Deionized H₂O rinse (X3).
6. Acetone (X3).
7. Cap glassware with clean glass plugs or Parafilm®.
8. Mark cleaned glassware with color-coded identification sticker.

^a(X3) = Three Times.

5.1.2.2 Reagent Preparation

The sample train filters were Pallflex Tissuequartz 2500 QAS filters. The acids and hydrogen peroxide were Baker “Instra-analyzed” grade or equivalent. The peroxide was purchased specifically for this test site.

The reagent water was Baker “Analyzed” low metals grade or equivalent. The lot number, manufacturer and grade of each reagent that was used was recorded.

The HNO₃/H₂O₂ and KMnO₄/H₂SO₄ solutions were prepared daily immediately prior to sampling according to Section 4.2.1 of the reference method. The analyst wears both safety glasses and protective gloves when the reagents are mixed and handled. Each reagent has its own designated transfer and dilution glassware. This glassware was marked for identification with a felt tip glass marking pen and used only for the reagent for which it was designated.

5.1.2.3 Equipment Preparation

The remaining preparation included calibration and leak checking of the all the train equipment, including meterboxes, thermocouples, nozzles, pitot tubes, and umbilicals. Referenced calibration procedures were followed when available, and the results properly documented and retained. A discussion of the techniques used to calibrate this equipment is presented below.

Type-S Pitot Tube Calibration. The EPA has specified guidelines concerning the construction and geometry of an acceptable Type-S pitot tube. If the specified design and construction guidelines are met, a pitot tube coefficient of 0.84 is used. Information pertaining to the design and construction of the Type-S pitot tube is presented in detail in Section 3.1.1 of EPA Document 600/4-77-027b. Only Type-S pitot tubes meeting the required EPA specifications were used. Pitot tubes were inspected and documented as meeting EPA specifications prior to field sampling.

Sampling Nozzle Calibration. Glass nozzles were used for isokinetic sampling. Calculation of the isokinetic sampling rate requires that the cross sectional area of the sampling nozzle be accurately and precisely known. All nozzles were thoroughly cleaned, visually inspected and calibrated according to the procedure outlined in Section 3.4.2 of EPA Document 600/4-77-027b.

Temperature Measuring Device Calibration. Accurate temperature measurements are required during source sampling. Bimetallic stem thermometers and thermocouple temperature sensors were calibrated using the procedure described in Section 3.4.2 of EPA document 600/4-77-027b. Each temperature sensor was calibrated at a minimum of two points over the anticipated range of use against a NBS-traceable mercury-in-glass thermometer. All sensors were calibrated prior to field sampling.

Dry Gas Meter Device Calibration. Dry gas meters (DGMs) are used in the Method 29 sampling trains to monitor the sampling rate and to measure the sample volume. All DGMs were calibrated to document the volume correction factor just prior to shipping of the equipment to the field. Post-test calibration checks were performed as soon as possible after the equipment was returned to the ERG Laboratory. Pre- and post-test calibrations should agree to within 5%.

Prior to calibration, a positive pressure leak check of the system was performed using the procedure outlined in Section 3.3.2 of EPA document 600/4-77-237b. The system was placed under approximately 10 inches of water pressure and a gauge oil manometer is used to determine if a pressure decrease could be detected over a one-minute period. If leaks were detected, they were eliminated before actual calibrations were performed.

After the sampling console was assembled and leak checked, the pump was run for 15 minutes, to allow the pump and DGM to warm up. The valve was then adjusted to obtain the desired flow rate. For the pre-test calibrations, data were collected at orifice manometer settings (ΔH) of 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 in H_2O . Gas volumes of 5 ft^3 were used for the two lower orifice settings, and volumes of 10 ft^3 are used for the higher settings. The individual gas meter correction factors (Y_i) were calculated for each orifice setting and averaged. The method requires that each of the individual correction factors fall within $\pm 2\%$ of the average correction factor or the meter is cleaned, adjusted, and recalibrated. In addition, ERG requires that the average correction factor be within $1.00 \pm 1\%$. For the post-test calibration, the meter was calibrated three times at the average orifice setting and vacuum which were used during the actual test.

5.1.3 Method 29 Sampling Operations

5.1.3.1 Preliminary Measurements

Prior to sampling, preliminary measurements are required to ensure isokinetic sampling. These preliminary measurements include determining the traverse point locations and performing a preliminary velocity traverse and a cyclonic flow check. These measurements were used to calculate a "K factor." The K factor was used to determine an isokinetic sampling rate from stack gas flow readings taken during sampling.

Measurements were then made of the duct inside diameter, port nipple length, and the distances to the nearest upstream and downstream flow disturbances. These measurements were then used to determine sampling point locations by following EPA Reference Method 1 guidelines. The distances were then marked on the sampling probe using an indelible marker.

5.1.3.2 Assembling the Train

The assembly of the Method 29 sampling train components was completed in the recovery trailer and final train assembly was performed at the stack location. First, the empty, clean impingers were assembled and laid out in the proper order in the recovery trailer. Each ground glass joint was carefully inspected for hairline cracks. After the impingers were loaded, each impinger was weighed, and the initial weight and contents of each impinger were recorded on a recovery data sheet. The impingers were connected using clean glass U-tube connectors and arranged in the impinger bucket. The height of all the impingers was approximately the same to aid in obtaining a leak free seal. The open ends of the train were sealed with Parafilm®.

The filter was loaded into the filter holder in the recovery trailer. The filter holder was then capped off and placed in the impinger bucket. To avoid contamination of the sample, sealing greases were not used. The train components were transferred to the sampling location and assembled as previously shown in Figure 5-1.

5.1.3.3 Sampling Procedures

After the train was assembled, the heaters for the probe liner and heated filter box were turned on. When the system reached the appropriate temperatures, the sampling train was ready for pre-test leak checking. The filter temperature was maintained at $120 \pm 14^{\circ}\text{C}$ ($248 \pm 25^{\circ}\text{F}$). The probe temperature was maintained above 100°C (212°F).

The sampling trains were leak checked at the start and finish of sampling. (Method 5 protocol requires post-test leak checks and recommends pre-test leak checks.) ERG protocol also incorporates leak checks before and after every port change. An acceptable pre-test leak rate is less than 0.02 acfm (ft^3/min) at approximately 15 inches of mercury (in. Hg). If during testing, a piece of glassware needed to be emptied or replaced, a leak check was performed before the glassware piece was removed, and after the train was re-assembled.

To leak check the assembled train, the nozzle end was capped off and a vacuum of 15 in. Hg was pulled in the system. When the system was evacuated, the volume of gas flowing through the system was timed for 60 seconds. After the leak rate was determined, the cap was slowly removed from the nozzle end until the vacuum dropped off, and then the pump was turned off. If the leak rate requirement was not met, the train was systematically checked by first capping the train at the filter, at the first impinger, etc., until the leak was located and corrected.

After a successful pre-test leak check was conducted, all train components were at their specified temperatures and initial data were recorded [dry gas meter (DGM) reading], the test was initiated. Sampling train data were recorded every five minutes on standard data forms. A checklist for sampling is included as Table 5-2.

Table 5-2. Sampling Checklist

Before Test Starts:

1. Check impinger set (right order and number). Verify probe markings, and re-mark if necessary.
 2. Check that you have all the correct pieces of glassware, and in correct order.
 3. Check for data sheets and barometric pressure.
 4. Sampling equipment needs to be ready for Method 3 analysis.
 5. Leak check pitot tubes.
 6. Examine meter box - level it and confirm that the pump is operational.
 7. Assemble train to the filter and leak check at 15 in. Hg. Attach probe to train and do final leak check; record leak rate and pressure on sampling log.
 8. Check out thermocouples - make sure they are reading correctly.
 9. Turn on heaters and check to see that their temperatures are increasing.
 10. Add ice to impinger buckets.
 11. Check isokinetic K-factor - make sure it is correct. (Refer to previous results to confirm assumptions. Two people should calculate the K-factor independently to double check it).
 12. Have a spare probe liner, probe sheath, meter box and filter ready to go at location.
-

Table 5-2. Continued

During Test:

1. Notify crew chief of any sampling problems ASAP. Train operator should fill in sampling log.
2. Perform simultaneous/concurrent testing with other locations (if applicable). Maintain filter temperature between $248^{\circ}\text{F} \pm 25^{\circ}\text{F}$. Keep temperature as steady as possible. Maintain impinger temperatures below 68°F . Maintain probe temperature above 212°F .
3. Leak check between ports and record on sampling log.
4. Record sampling rate times and location for the fixed gas (CO , CO_2 , O_2) sample (if applicable).
5. Blow back pitot tubes every 15 minutes.
6. Change filter if pressure drop exceeds 20 in. Hg.
7. Check permanganate impinger solutions every 1/2 hr for reagent depletion.
8. Check impinger silica gel every 1/2 hr; if indicator disappears request a pre-weighed impinger from the lab and replace.
9. Check manometer fluid levels and zero every hour.

After Test is Completed:

1. Record final meter reading.
 2. Check completeness of data sheet.
 3. Do final leak check of sampling train at maximum vacuum during test.
 4. Leak check each leg of pitot tubes.
-

Table 5-2. Continued

-
5. Disassemble train. Cap sections. Take sections to recovery trailer.
 6. Nozzle probe/cyclone recovery (use 500 mL bottles)
 - a) For acetone rinses (all trains)
 - Attach flask to end of probe
 - Add 50 mL of acetone
 - Put a brush down probe, and brush back and forth
 - Rinse back and forth in probe
 - Empty out acetone in sample jar
 - Do this 3 times so that the final combined acetone rinse volume is ≤ 150 mL.
 - b)
 - Rinse nozzle and probe 3X with 0.1N HNO₃
 - Collect approximately 100 mL of rinse into sampling jar.
 7. Reattach nozzle and cap for next day, store in dry safe place.
 8. Make sure data sheets are completely filled out and give to location leader.
-

The leak rates and sampling start and stop times were recorded on the sampling task log. Also, any other events that occur during sampling were recorded on the task log, such as pitot cleaning, thermocouple malfunctions, heater malfunctions, or any other unusual occurrences.

At the conclusion of the test run, the sample pump (or flow) was turned off, the probe was removed from the duct, a final DGM reading was taken, and a post-test leak check was completed. The procedure was identical to the pre-test procedure; however, the vacuum should be at least one inch Hg higher than the highest vacuum attained during sampling. An acceptable leak rate is less than 4% of the average sample rate or 0.02 acfm (whichever is lower). If a final leak rate on-site did not meet the acceptance criterion, the test run may still be accepted upon

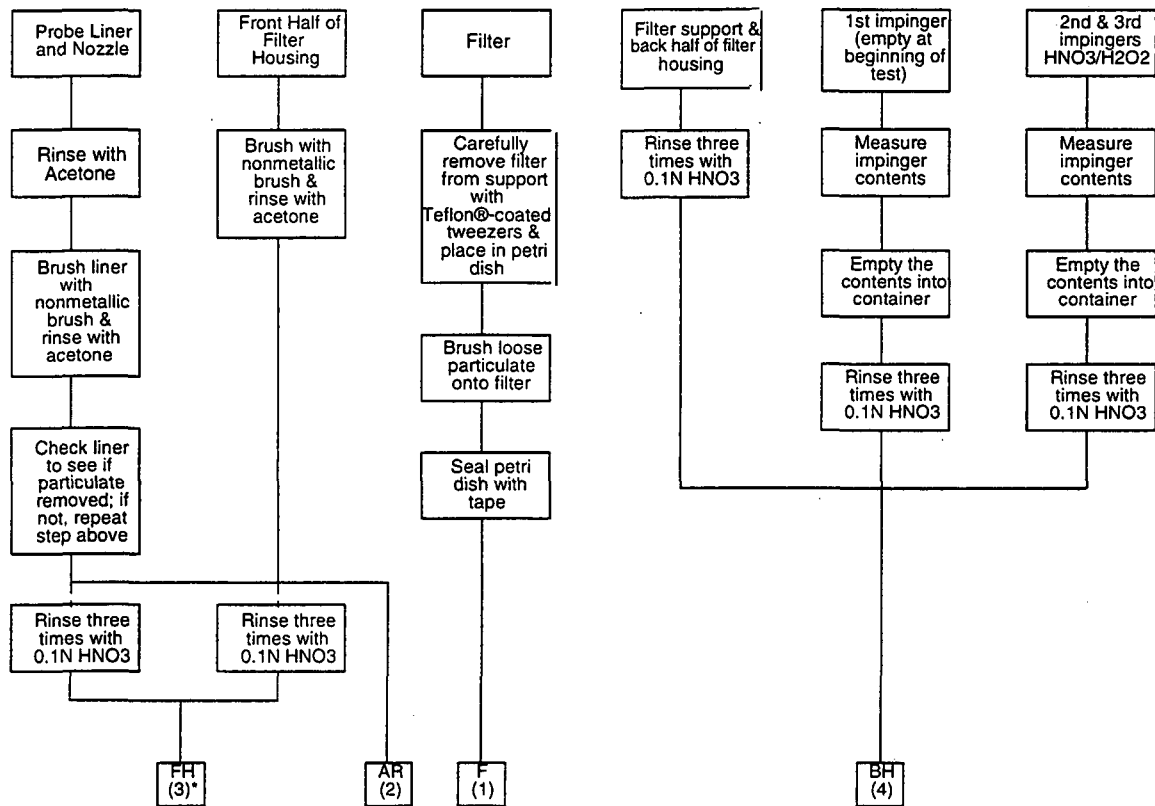
approval of the EPA test administrator. If so, the measured leak rate was reduced by subtracting the allowable leak rate from it and then multiplied for the period of time in which the leak occurred. This "leaked volume" is then subtracted from the measured gas volume in order to determine the final gas sample volume.

5.1.4 Method 29 Sample Recovery

Recovery procedures began as soon as the probe was removed from the stack and the post-test leak check was completed.

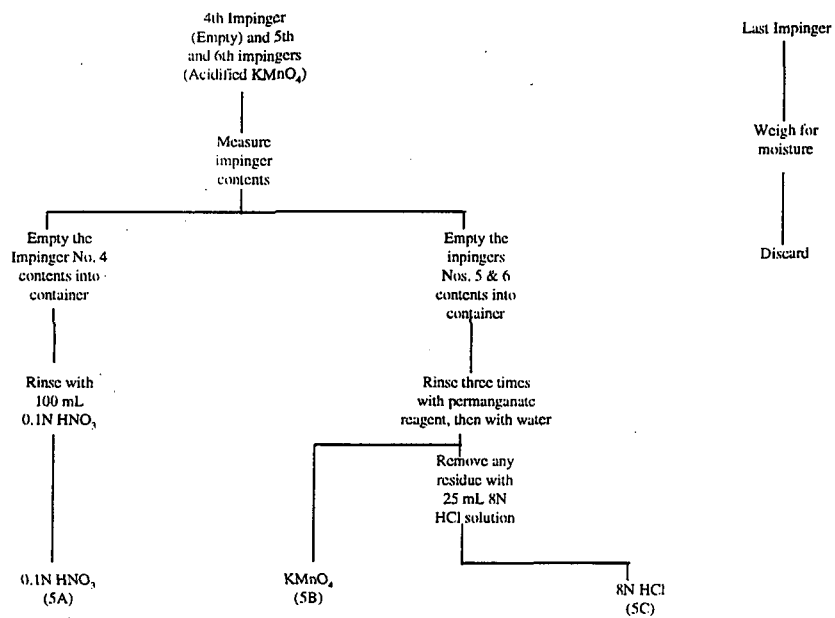
To facilitate transfer from the sampling location to the recovery trailer, the sampling train was disassembled into three sections: the nozzle/probe liner, filter holder and impingers in their bucket. Each of these sections was capped with Teflon® tape before removal to the recovery trailer. All train components were rinsed and the samples collected in separate, prelabeled, precleaned sample containers.

Once in the trailer, the sampling train was recovered as separate front and back half fractions. A diagram illustrating front half and back half sample recovery procedures is shown in Figure 5-2. No equipment with exposed metal surfaces was used in the sample recovery procedures. The weight gain in each of the impingers was recorded to determine the moisture content of the flue gas. Following the weighing of the impingers, the front half of the train was recovered, which included the filter and all sample-exposed surfaces forward of the filter. The probe liner was rinsed with acetone by tilting and rotating the probe while squirting acetone into its upper end so that all inside surfaces were wetted. The acetone was quantitatively collected into the appropriate bottle. This rinse was followed by additional brush/rinse procedures using a non-metallic brush; the probe was held in an inclined position and acetone was squirted into the upper end as the brush was pushed through with a twisting action. All of the acetone and particulate was caught in the sample container. This procedure was repeated until no visible



* Number in parentheses indicates container number

Figure 5-2. Method 29 Sample Recovery Scheme



Method 29 Sample Recovery Scheme, Continued

Figure 5-2. Continued

particulate remains and finished with a final acetone rinse of the probe and brush. The front half of the filter holder was also rinsed with acetone until all visible particulate was removed. After all front half acetone washes were collected, the cap was tightened, the liquid level marked and the bottle weighed to determine the acetone rinse volume. The method specifies that a total of 100 mL of acetone must be used for rinsing these components. For blank correction purposes, the exact weight or volume of acetone used was measured. An acetone reagent blank of approximately the same volume as the acetone rinses was analyzed with the samples.

The nozzle/probe liner and front half of the filter holder were rinsed three times with 0.1N HNO₃ and placed into a separate amber bottle. The bottle was capped tightly, weighed and the liquid level marked. Approximately 100 mL of this rinse was required. The filter was placed in a clean, well-marked glass petri dish (Container 1) and sealed with Teflon® tape.

Prior to recovering the back half impingers, the contents were weighed for moisture content determinations. Any unusual appearance of the filter or impinger contents was noted.

The content of the knockout impinger was recovered into a pre-weighed, pre-labeled bottle with the contents from the HNO₃/H₂O₂ impingers (Container 4). These impingers and connecting glassware were rinsed thoroughly with 0.1N HNO₃, the rinse captured in the impinger contents bottle, and a final weight taken. Again, the method specifies a total of 100 mL of 0.1N HNO₃ be used to rinse these components. A nitric acid reagent blank of approximately the same volume as the rinse volume was collected with the samples. The acidified permanganate impinger solutions were combined into a single sample container. Any residue from the impingers was recovered with 25 mL of 8N HCl solution and collected in a separate container.

After final weighing, the silica gel from the train was saved for regeneration. The ground glass fittings on the silica gel impinger were wiped clean after sample recovery to assure a leak tight fit for the next test.

A reagent blank was recovered in the field for each of the following reagents;

- Acetone blank - 100 mL sample size;
- 0.1N nitric acid blank - 300 mL sample size;
- 5% nitric acid/10% hydrogen peroxide blank - 200 mL sample size;
- Acidified potassium permanganate blank - 200 mL sample size (this blank should have a vented cap);
- 8N hydrochloric acid blank - 225 mL sample size (25 mL 8N HCl plus 200 mL water);
- Deionized water - 200 mL sample size; and
- Filter blank - one each.

Each reagent blank was of the same lot as used during the sampling program. The volumes collected were greater than required for sample preparation in order to provide sufficient amounts in case of sample loss during preparation or to compensate for larger volumes of train rinses. Each lot number and reagent grade were recorded on the field blank label. One field blank at each location was collected using an on-site sampling train. One glassware proof blank was collected for each train prior to sampling.

The liquid level of each sample container was marked on the bottle in order to determine if any sample loss occurred during shipment. If sample loss occurred, the sample may be voided or a correction factor may be used to scale the final results depending on the volume of the loss.

The detection limits of the individual metals are dependent on the detection limit of the analytical method, the volume of the aqueous sample presented for analysis and the total volume of gaseous sample collected in the sampling trains. Following the protocol of Method 29, the fractions that were collected for analysis from each train were:

- Fraction 1--Filter;
- Fraction 2--Probe and filter front half acetone rinses;
- Fraction 3--Probe and filter front half acid rinse;
- Fraction 4--Impingers 1-3 contents and acid rinse of impingers and filter back half;
- Fraction 5a--Impinger 4 contents and 100 mL 0.1N nitric acid rinse;
- Fraction 5b--Impinger 5-6 contents plus 100 mL permanganate and 100 mL water rinses; and
- Fraction 5c--25 mL 8N HCl acid rinse and water rinses of impingers 5-6, place in containers with 200 mL water.

After sample preparation, Fractions 1-3 were combined for analysis for all target analytes (an aliquot is removed for Hg). Fractions 4, 5a, 5b and 5c were analyzed individually after preparation. Fraction 4 was analyzed for all analytes (aliquot for Hg removed). Fractions 5a, 5b, and 5c were analyzed for Hg only. Since there were multiple fractions to be analyzed (5 for Hg and 2 for other metals) the method detection limit (MDL) is the sum of the individual detection limits for each fraction analyzed. For Hg this will increase the MDL over that seen for Method 101a where the permanganate is the only collection medium. Using an instrumental detection limit (IDL) for cold vapor atomic absorption (CVAA) and inductively coupled argon plasma (ICAP), Table 5-3 gives the total detectable amounts that were possible.

The method detection limits for the various metals of interest are summarized in Table 5-4. The sampling flow rate at the inlet and outlet locations were dictated by the flow rate of the stack gas since isokinetic sampling was performed at these locations. The nominal sample time and flow rate selected by the EPA Work Assignment Manager are presented in Table 5-4 along with the associated method detection limits.

Table 5-3. Analytical Detection Limits

Metal	IDL µg/mL	Analysis Fraction					Total Detectable Amount µg
		1, µg	2, µg	3, µg	4, µg	5, µg	
Hg	0.0002	0.4	0.6	0.2	0.6	1 µg	2.8
As	0.005	1.0	1.13	NA	NA	NA	2.1
Be	0.001	0.2	0.23	NA	NA	NA	0.43
Cd	0.001	0.2	0.23	NA	NA	NA	0.43
Cr	0.002	0.4	0.45	NA	NA	NA	0.85
Pb	0.002	0.4	0.45	NA	NA	NA	0.85
Sb	0.004	0.8	0.9	NA	NA	NA	1.7
Co	0.001	0.2	0.225	NA	NA	NA	0.43
Mn	0.002	0.4	0.45	NA	NA	NA	0.85
Ni	0.003	0.6	0.68	NA	NA	NA	1.28
Se	0.003	0.6	0.68	NA	NA	NA	1.28

Note: Hg analysis by CVAA Method 7470A, all others by Method 6010A (ICAPS). CVAA assumes an analysis volume of 10 mL. NA = Not applicable.

Table 5-4. Method 29 Detection Limits

Sampling Time, Hours	4
Sampling Rate, cfm	0.75
Sampling Volume, m ³	5.1
	MDL, µg/m³
Hg	0.55
As	0.41
Be	0.08
Cd	0.08
Cr	0.17
Pb	0.17
Sb	0.33
Co	0.08
Mn	0.17
Ni	0.25
Se	0.25

5.1.5 Particulate Analysis

The same general gravimetric procedure described in Method 5, Section 4.3, was followed. Both filters and precleaned beakers were weighed to a constant weight before use in the field. The same balance used for taring was used for weighing the samples.

The acetone rinses were evaporated to dryness under a clean hood at room temperature in a tared beaker. The residue was desiccated for 24 hours in a desiccator containing activated silica gel. The filter was also desiccated under the same conditions. Each was then weighed to a constant weight, reporting the weight gain to the nearest 0.1 mg. Replicate weighings were performed until two consecutive weighing agreed to within 0.5 mg or 1% of total weight less tare

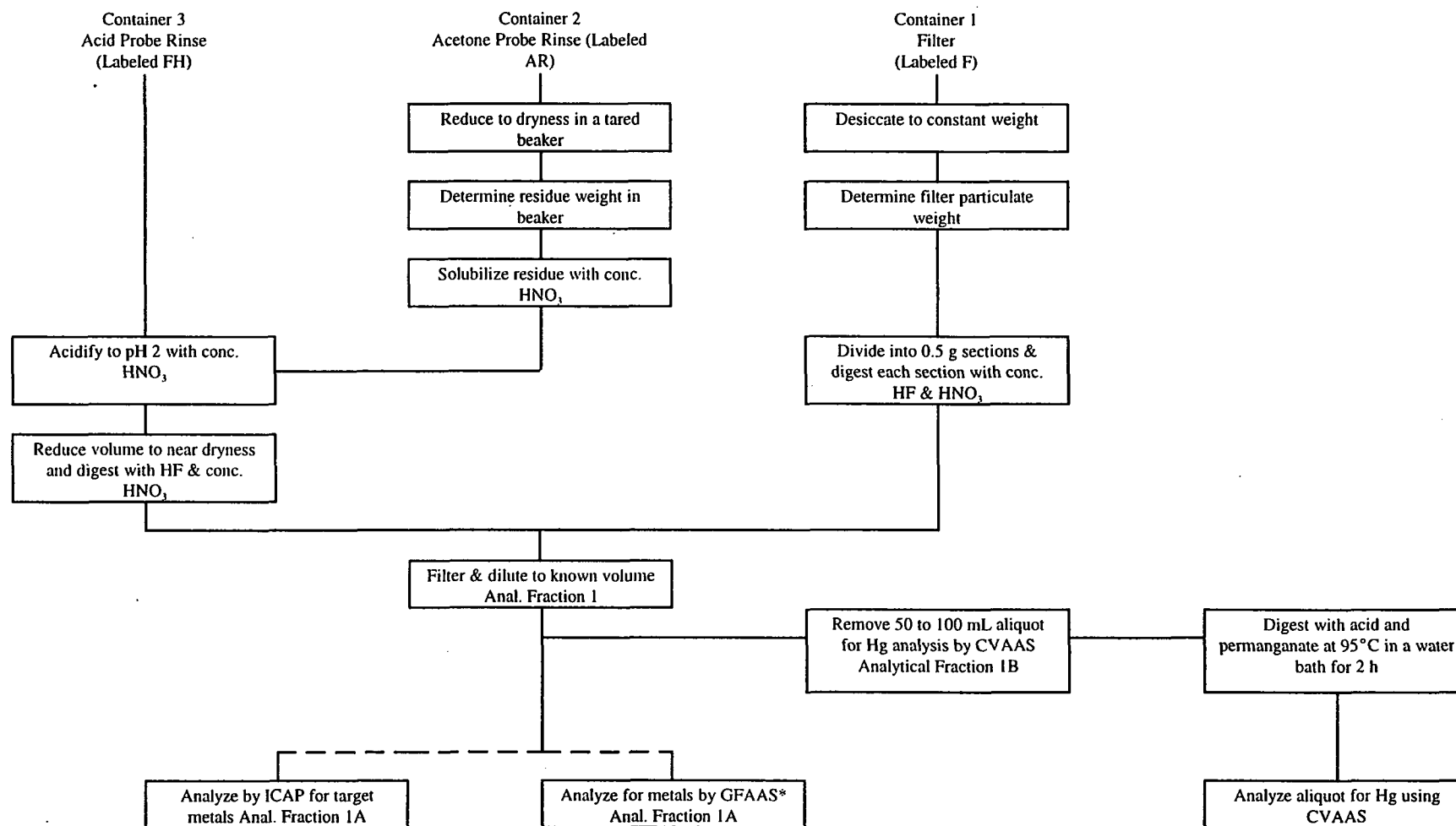
weight, whichever was greater, between two consecutive weighings, at least 6 hours apart. The balance room was temperature and humidity controlled. The filter tare and final weights were determined under the same conditions.

5.1.6 Metals Analytical Procedures

A diagram illustrating the sample preparation and analytical procedures for the target metals is shown in Figure 5-3.

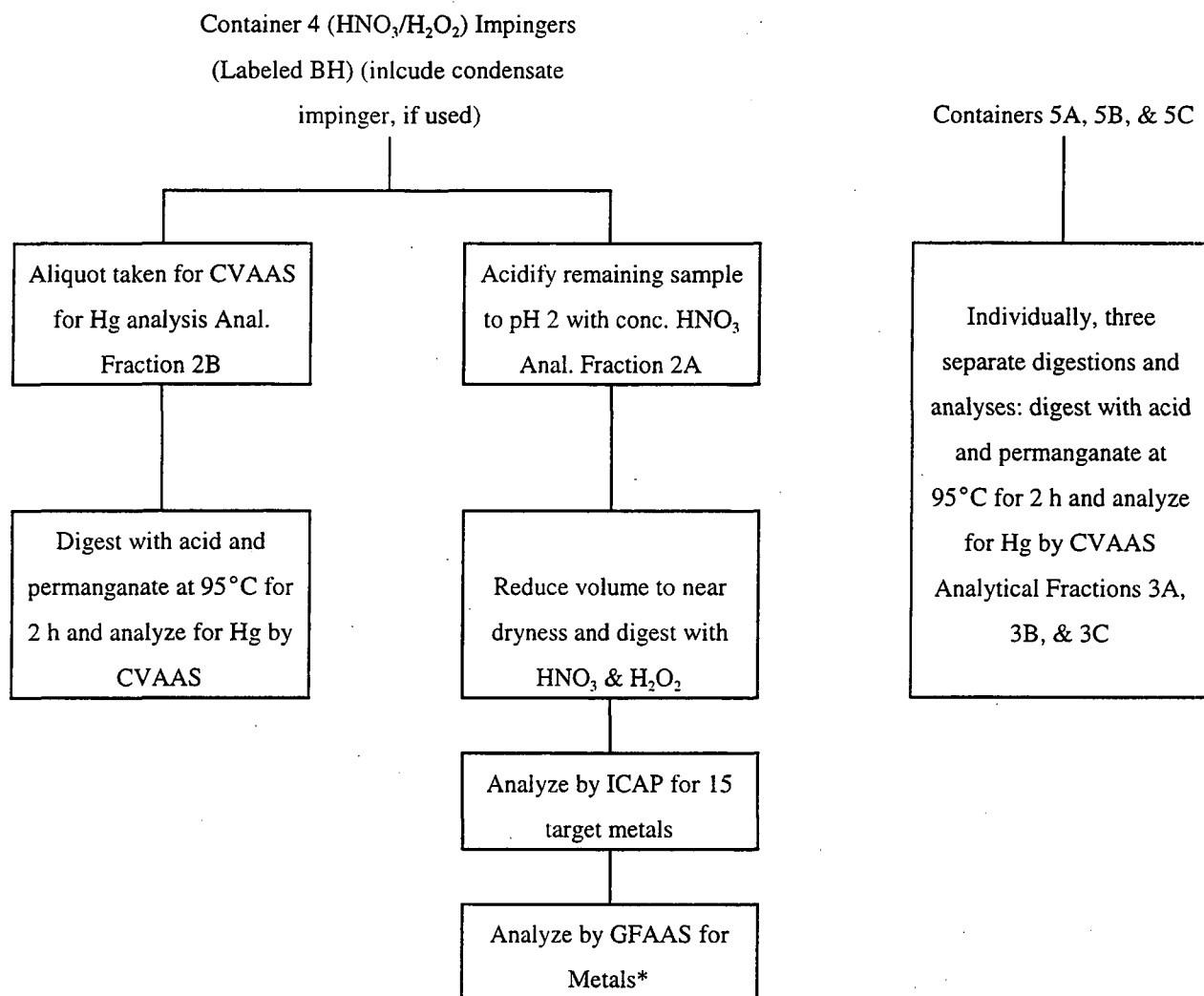
The acetone probe rinse (container No. 2) was taken to dryness in a tared beaker and any residue was weighed to a constant weight. This residue was then solubilized with concentrated nitric acid and this solution was added to the nitric acid rinse of the probe/nozzle (Container No. 3). This combined solution was then acidified to a pH of 2 with concentrated nitric acid, the volume reduced to near dryness and digested with concentrated nitric and hydrofluoric acids in a microwave pressure vessel.

The filter (Container No. 1) was weighed to a constant weight and then divided into 0.5 g sections and digested with concentrated nitric and hydrofluoric acids in a microwave pressure vessel. The microwave digestion took place over a period of 10 to 15 minutes in intervals of 1 to 2 minutes at 600 watts. Both the digested filter and the digested probe rinses were combined, filtered and brought to a known volume (nominally 200 mL). This analysis fraction was then divided for analysis by CVAA for Hg (following additional digestion) and by ICAPS for the other target metals.



*Analyze by AAS for metals found at less than 2 µg/mL in digestate solution, if desired. Or analyze for each metal by AAS, if desired.

Figure 5-3. Method 29 Sample Preparation and Analysis Scheme



*Analysis by AAS for metals found at less than $2\text{ }\mu\text{g/mL}$ in digestate solution, if desired. Or analyzed for each metal by AAS, if desired.

Figure 5-3. Continued

An aliquot from the contents of container No. 4 (nitric acid/peroxide impinger absorbing solution) was removed and digested following the procedures given in Method 29 and then analyzed for Hg by CVAA. The remaining volume was acidified to pH 2, the volume reduced to near dryness and digested in a microwave as discussed above. After bringing the digestate to a known volume, the solution was analyzed by ICAPS for the remaining target metals.

The contents of containers 5A, 5B and 5C were digested separately by the procedures given in Method 29 and then analyzed for Hg by CVAA.

A total of two (2) fractions were analyzed for all target metals except Hg by Method 6010A and a total of five (5) fractions were analyzed for Hg by Method 7470A.

5.1.7 Quality Control for Metals Analytical Procedures

All quality control procedures specified in the test method were followed. All field reagent blanks were processed, digested and analyzed as specified in the test method. For optimum sensitivity in measurements, the concentrations of target metals in the solutions should be at least 10 times analytical detection limits.

5.1.7.1 ICAP Standards and Quality Control Samples

The quality control procedures included running two standards for instrument checks (or frequency of 10%), two calibration blank runs (or frequency of 10%), one interference check sample at the beginning of the analysis (must be within 10% or analyze by standard addition), one quality control sample to check the accuracy of the calibration standards (must be within 10% of calibration), one duplicate analysis and one standard addition for every 10 samples (must be within 5% of average or repeat all analysis).

Standards less than 1 $\mu\text{g/mL}$ of a metal were prepared daily; those with concentrations greater than this were made weekly or bi-monthly.

All samples were analyzed in duplicate. A matrix spike on one front half sample and one back half for each 10 field samples was analyzed. One quality control sample was analyzed to check the accuracy of the calibration standards. If the results were not within 10% the calibration was repeated.

5.1.7.2 Cold Vapor Atomic Absorption Standards and Quality Control Samples

A 10 $\mu\text{g/mL}$ intermediate Hg standard was prepared fresh weekly. A daily 200 mg/mL Hg working standard was also prepared. At least five separate aliquots of the working Hg standard solution and a blank were used to prepare the standard curve. Quality control samples were prepared by making a separate 10 $\mu\text{g/mL}$ standard and diluting it until the control sample was within the calibration range. These procedures assessed the quality control of the analysis, but did not address the potential negative bias due to Hg losses from the filter due to volatilization during gravimetric analysis.

5.2 CDD/CDF and PAH Emissions Testing Using EPA Method 23

The sampling and analytical method for determining flue gas emissions of Polychlorinated Dibenzo-*p*-Dioxins and Polychlorinated Dibenzofurans (CDD/CDF) is EPA Method 23. Samples collected with this method were also analyzed for Polycyclic Aromatic Hydrocarbons (PAHs) emissions.

5.2.1 Method 23 Sampling Equipment

The method uses the sampling train shown in Figure 5-4. Basically, the sampling system is similar to a Method 5 train with the following exceptions:

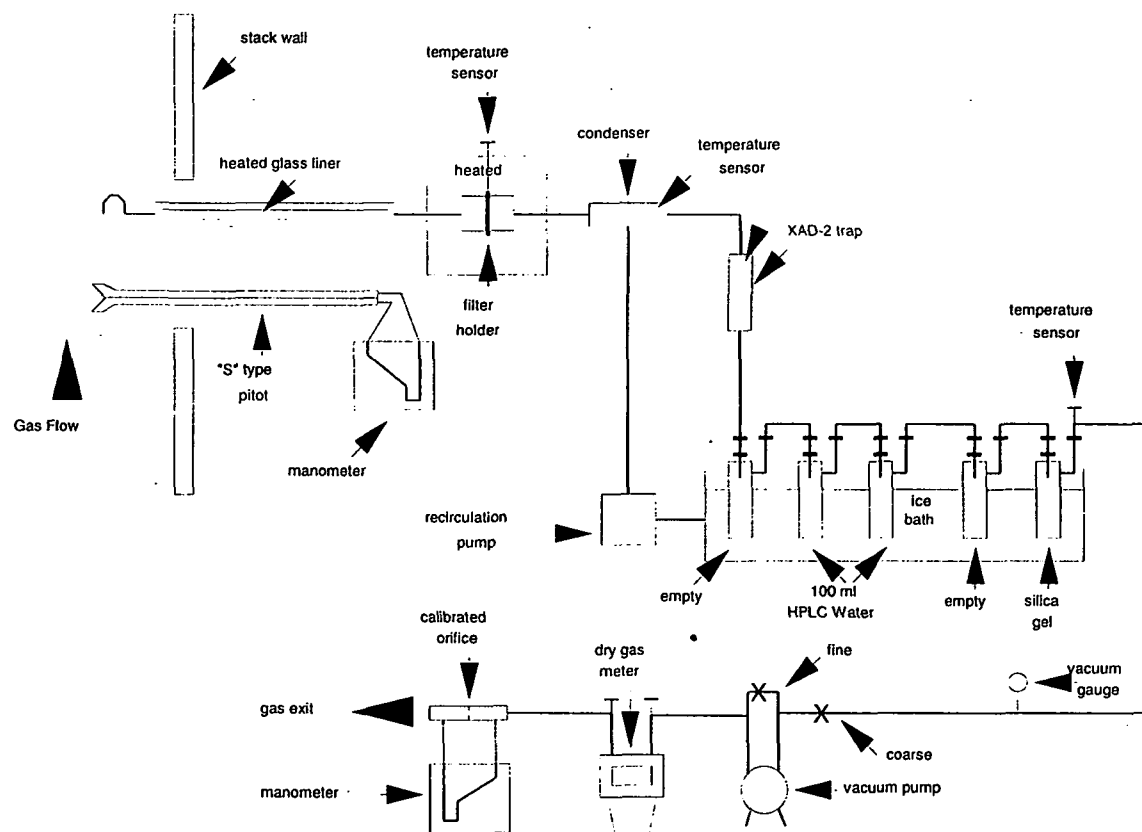


Figure 5-4. Method 23 Sampling Train Configuration

- All components (glass probe/nozzle liner, all other glassware, filters) are pre-cleaned using solvent rinses and extraction techniques; and
- A condensing coil and XAD-2® resin absorption module are located between the filter and impinger train.

All sampling equipment specifications are detailed in the reference method.

5.2.2 Method 23 Equipment Preparation

In addition to the standard EPA Method 5 requirements, Method 23 includes several unique preparation steps which ensure that the sampling train components are not contaminated with organics that may interfere with analysis. The glassware, glass fiber filters and absorbing resin were cleaned and the filters and resin were checked for 42 residuals before they were packed.

5.2.2.1 Glassware Preparation

Glassware was cleaned as shown in Table 5-5. Glassware was washed in soapy water, rinsed with distilled water, baked and then rinsed with acetone followed by methylene chloride. Clean glassware was allowed to dry under a hood loosely covered with foil to prevent laboratory contamination. Once the glassware was dry, the air exposed ends were sealed with methylene chloride rinsed aluminum foil. All the glass components of the sampling train including the glass nozzles plus any flasks, petri dishes, graduated cylinders and pipets that are used during sampling and recovery were cleaned according to this procedure. Non-glass components (such as the Teflon®-coated filter screens and seals, tweezers, Teflon® squeeze bottles, Nylon® probe/nozzle brushes) were cleaned following the same procedure except that no baking was performed.

Table 5-5. Method 23 Glassware Cleaning Procedure (Train Components, Sample Containers and Laboratory Glassware)

NOTE: USE VITON® GLOVES AND ADEQUATE VENTILATION WHEN RINSING WITH SOLVENTS

1. Soak all glassware in hot soapy water (Alconox®).
 2. Tap water rinse to remove soap.
 3. Distilled/deionized H₂O rinse (X3).^a
 4. Bake at 450°F for 2 hours.^b
 5. Acetone rinse (pesticide grade) (X3).
 6. Methylene chloride (pesticide grade) (X3).
 7. Cap glassware with clean glass plugs or methylene chloride rinsed aluminum foil.
 8. Mark cleaned glassware with color-coded identification sticker.
 9. Glassware is rinsed immediately before using with acetone and methylene chloride (laboratory proof).
-

^a (X3) = three times.

^b Step (4) has been added to the cleanup procedure to replace the dichromate soak specified in the reference method. ERG has demonstrated in the past that it sufficiently removes organic artifacts. Step 4 is not used for probe liners and non-glass components of the train that cannot withstand 450°F (i.e., Teflon®-coated filter screen and seals, tweezers, Teflon® squeeze bottles, nylon probe and nozzle brushes).

5.2.2.2 XAD-2® Resin and Filters Preparation

XAD-2® absorbing resin and glass fiber filters were pre-cleaned by separate procedures according to the specified method. Only pesticide grade solvents and HPLC grade water were used to prepare for organic sampling, and to recover these samples. The lot number, manufacturer and grade of each reagent used were recorded.

To prepare the filters, a batch of 50 was placed in a Soxhlet extractor pre-cleaned by extraction with toluene. The Soxhlet was charged with fresh toluene and refluxed for 16 hours. After the extraction, the toluene was analyzed as described in Sections 5.2 and 5.3 of the reference method for the presence of tetrachlorodibenzo-*p*-dioxin (TCDD), tetrachlorodibenzofurans (TCDF) or PAHs. If these analytes are found, the filters are re-extracted until the analyte was not detected. The filters were then dried completely under a clean nitrogen (N₂) stream. Each filter was individually checked for holes, tears, creases or discoloration, and if any were found, were discarded. Acceptable filters were stored in a pre-cleaned petri dish, labeled by date of analyses and sealed with Teflon® tape.

To prepare the absorbing resin, the XAD-2® resin was cleaned in the following sequential order:

- Rinse with HPLC grade water, discard water;
- Soak in HPLC grade water overnight, discard water;
- Extract in Soxhlet with HPLC grade water for 8 hours, discard water;
- Extract with methanol for 22 hours, discard solvent;
- Extract with methylene chloride for 22 hours, discard solvent;
- Extract with methylene chloride for 22 hours, retain an aliquot of solvent for analysis of CDDs, CDFs and PAHs by GC/MS; and
- Dry resin under a clean N₂ stream.

Once the resin was completely dry, it was checked for the presence of methylene chloride, CDDs, CDFs and PAHs as described in Section 3.1.2.3.1 of the reference method. If any analytes were found, the resin was re-extracted. If methylene chloride was found, the resin was dried until the excess solvent was removed. The absorbent was used within four weeks of cleaning.

The cleaned XAD-2® resin was spiked before shipment to the field with five CDD/CDF and one PAH internal standards. Due to the special handling considerations required for the internal standards, the spiking was performed by Triangle Laboratories. For convenience and to minimize contamination, Triangle Laboratories also performed the resin and filter cleanup procedures and loaded the resin into the glass traps.

5.2.2.3 Method 23 Sampling Train Preparation

The remaining preparation included calibration and leak checking of all sampling train equipment, including meterboxes, thermocouples, nozzles, pitot tubes, and umbilicals. Referenced calibration procedures were followed when available. The results were documented.

5.2.3 *Method 23 Sampling Operations*

5.2.3.1 Preliminary Measurements

Prior to sampling, preliminary measurements were required to ensure isokinetic sampling. These measurements included determining the traverse point locations, performing a preliminary velocity traverse, cyclonic flow check and moisture determination. These measurements were used to calculate a “K factor.” The K factor was used to determine an isokinetic sampling rate from stack gas flow readings taken during sampling.

Measurements were then made of the duct inside diameter, port nipple length, and the distances to the nearest upstream and downstream flow disturbances. These measurements were

then used to determine sampling point locations by following EPA Reference Method 1 guidelines. The distances were then marked on the sampling probe using an indelible marker.

5.2.3.2 Assembling the Train

The assembly of the Method 23 sampling train components was completed in the recovery trailer and final train assembly was performed at the stack location. First, the empty, clean impingers were assembled and laid out in the proper order in the recovery trailer. Each ground glass joint was carefully inspected for hairline cracks. The first impinger was a knockout impinger which had a short tip. The purpose of this impinger was to collect condensate which formed in the coil and XAD-2® resin trap. The next two impingers were modified tip impingers, each containing 100 mL of HPLC grade water. The fourth impinger was empty, and the fifth impinger contained 200 to 300 grams of blue indicating silica gel. After the impingers were loaded, each impinger was weighed, the initial weight and contents of each impinger were recorded on a recovery data sheet. The heights of all the impingers were approximately the same to aid in obtaining a leak free seal. The open ends of the train were sealed with methylene chloride-rinsed aluminum foil.

The filter was loaded into the filter holder in the recovery trailer. The filter holder was then capped off and placed with the resin trap and condenser coil (capped) into the impinger bucket. A supply of precleaned foil and socket joints was also placed in the bucket in a clean plastic bag for the convenience of the samplers. Sealing greases were not used thus avoiding contamination of the sample. The train components were transferred to the sampling location and assembled as previously shown in Figure 5-4.

5.2.3.3 Sampling Procedures

After the train was assembled, the heaters were turned on for the probe liner and heated filter box and the sorbent module/condensor coil recirculating pump was turned on. When the system reached the appropriate temperatures, the sampling train was ready for pre-test leak

checking. The temperature of the sorbent module resin must not exceed 50°C (120°F) at any time and during testing it must not exceed 20°C (68°F). The filter temperature was maintained at 120 ±14°F (248 ±25°F). The probe temperature was maintained above 100°C (212°F).

The sampling trains were leak checked at the start and finish of sampling. (Method 5/23 protocol only requires post-test leakchecks and recommends pre-test leak checks.) ERG protocol also incorporates leak checks before and after every port change. An acceptable pre-test leak rate is less than 0.02 acfm (ft³/min) at approximately 15 inches of Hg. If during testing, a piece of glassware needed to be emptied or replaced, a leak check was performed before the glassware piece was removed, and after the train was re-assembled.

To leak check the assembled train, the nozzle end was capped off and a vacuum of 15 inches Hg was pulled in the system. When the system was evacuated, the volume of gas flowing through the system was timed for 60 seconds. After the leak rate was determined, the cap was slowly removed from the nozzle end until the vacuum dropped off, and then the pump was turned off. If the leak rate requirement was not met, the train was systematically checked by first capping the train at the filter, at the first impinger, etc., until the leak was located and corrected.

After a successful pre-test leak check had been conducted, all train components were at their specified temperatures and initial data were recorded (DGM reading), the test was initiated. Sampling train data were recorded every five minutes on standard data forms. A checklist for CDD/CDF sampling is included as Table 5-6. A sampling operation that is unique to CDD/CDF sampling is that the gas temperature entering the resin trap must be below 20°C (68°F). The gas was cooled by a water jacket condenser through which ice water was circulated.

The leak rates and sampling start and stop times were recorded on the sampling task log. Also, any other events that occurred during sampling were recorded on the task log such as sorbent module heat excursions, pitot cleaning, thermocouple malfunctions, heater malfunctions or any other unusual occurrences.

Table 5-6. CDD/CDF Sampling Checklist

Before test starts:

1. Check impinger set to verify the correct order, orientation and number of impingers. Verify probe markings, and remark if necessary.
 2. Check that you have all the correct pieces of glassware. Have a spare probe liner, probe sheath, meter box and filter ready to go at location.
 3. Check for data sheets and barometric pressure.
 4. Bag sampling equipment for CO₂/O₂ needs to be ready except when using CEMs for CO₂/O₂ determinations.
 5. Examine meter box - level it, zero the manometers and confirm that the pump is operational.
 6. Verify the filter is loaded correctly and as tightly as possible; place filter in line with the train and leak check at 15 inches Hg.
 7. Add probe to train.
 8. Check thermocouples - make sure they are reading correctly.
 9. Conduct pitot leak check, recheck manometer zero.
 10. Do final leak check; record leak rate and vacuum on sampling log.
 11. Turn on variacs and check to see that the heat is increasing.
 12. Check that cooling water is on and flowing. Add ice to impinger buckets.
 13. Check isokinetic K-factor - make sure it is correct. (Refer to previous results to confirm assumptions. Two people should calculate this independently to double check it.)
-

Table 5-6. Continued

During Test:

1. Notify crew chief of any sampling problems ASAP. Train operator should fill in sampling log and document any abnormalities.
2. Perform simultaneous/concurrent testing with other locations (if applicable). Maintain filter temperature between $248^{\circ}\text{F} \pm 25^{\circ}\text{F}$. Keep temperature as steady as possible. Maintain the resin trap and impinger temperatures below 68°F . Maintain probe temperature above 212°F .
3. Leak check between ports and record on data sheet. Leak check if the test is stopped to change silica gel, to decant condensate, or to change filters.
4. Record sampling times, rate, and location for the fixed gas bag sampling (CO , CO_2 , O_2), if applicable.
5. Blow back pitot tubes periodically if moisture entrapment is expected.
6. Change filter if vacuum suddenly increases or exceeds 15 inches Hg.
7. Check impinger solutions every 1/2 hour; if the knockout impinger is approaching full, stop test and empty it into a pre-weighed bottle and replace it in the train.
8. Check impinger silica gel every 1/2 hour; if indicator color begins to fade, request a prefilled, preweighed impinger from the recovery trailer.
9. Check the ice in the impinger bucket frequently. If the stack gas temperatures are high, the ice will melt at the bottom rapidly. Maintain condenser coil and silica gel impinger gas temperatures below 20°C (68°F).

After test is completed:

1. Record final meter reading.
 2. Do final leak check of sampling train at maximum vacuum during test.
 3. Do final pitot leak check.
-

Table 5-6. Continued

-
4. Check completeness of data sheet. Verify the impinger bucket identification is recorded on the data sheets. Note any abnormal conditions.
 5. Leak check, check functions (level, zero, etc.) of pitot tubes and inspect for tip damage.
 6. Disassemble train, cap sections, and take each section and all data sheets down to recovery trailer.
 7. Probe recovery (use 950 mL bottles)
 - a) Bring probes into recovery trailer (or other enclosed area).
 - b) Wipe the exterior of the probe to remove any loose material that could contaminate the sample.
 - c) Carefully remove the nozzle/probe liner and cap it off with prerinsed aluminum foil.
 - d) For acetone rinses (all trains)
 - Attach precleaned cyclone flask to probe to catch rinses
 - Wet all sides of probe interior with acetone
 - While holding the probe in an inclined position, put precleaned probe brush down into probe and brush it in and out
 - Rinse the brush, while in the probe, with acetone
 - Do this at least 3 times until all the particulate has been recovered.
 - Recover acetone into a preweighed, prelabeled sample container
 - e) Follow the procedure outlined in (d) using methylene chloride. Recover the solvent into the same acetone recovery bottle.
 - f) Follow the procedure outlined in (d) using toluene. Recover this solvent into a separate preweighed prelabeled sample container.
 8. Cap both ends of nozzle/probe liner for the next day, and store in dry safe place.
 9. Make sure data sheets are completely filled out, legible, and give them to the Crew Chief.
-

At the conclusion of the test run, the sample pump (or flow) was turned off, the probe was removed from the duct, a final DGM reading was taken, and a post-test leak check was completed. The procedure is identical to the pre-test procedure. However, the vacuum was at least one inch Hg higher than the highest vacuum attained during sampling. An acceptable leak rate was less than 4% of the average sample rate or 0.02 acfm (whichever is lower).

5.2.4 CDD/CDF/PAH Sample Recovery

To facilitate transfer from the sampling location to the recovery trailer, the sampling train was disassembled into the following sections: the probe liner, filter holder, filter to condenser glassware, condenser sorbent module, and the impingers in their bucket. Each of these sections was capped with methylene chloride rinsed aluminum foil or ground glass caps before removal to the recovery trailer. Once in the trailer, field recovery followed the scheme in Figure 5-5. The samples were recovered and stored in cleaned amber glass bottles to minimize sample degradation by exposure to light.

The probe and nozzle was first rinsed with approximately 100 mL of acetone and brushed to remove any particulate. This first rinse was followed with a rinse of methylene chloride. Both of these rinses were collected in the same bottle. The same two solvents were used to rinse the cyclone, front/back half filter holder, filter support, connecting glassware and condenser. These rinses were added to the probe rinse bottle. All of the components listed above were again rinsed with toluene, but collected in a separate container.

The contents of impingers 1-4 (H₂O) were discarded.

The solvents used for train recovery were all pesticide grade. The use of the highest grade reagents for train recovery was essential to prevent the introduction of chemical impurities which could interfere with the quantitative analytical determinations.

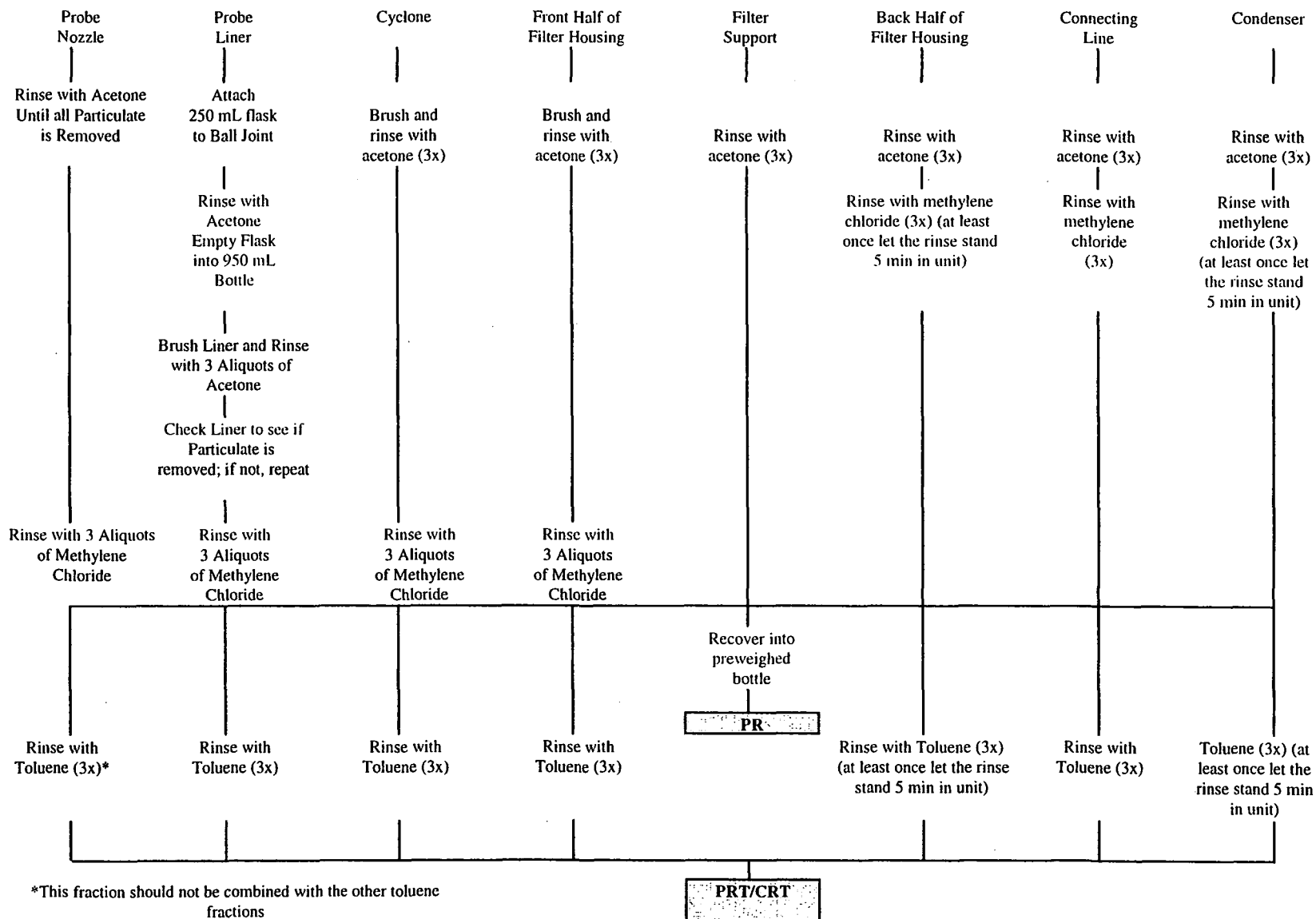


Figure 5-5. Method 23 Field Recovery Scheme

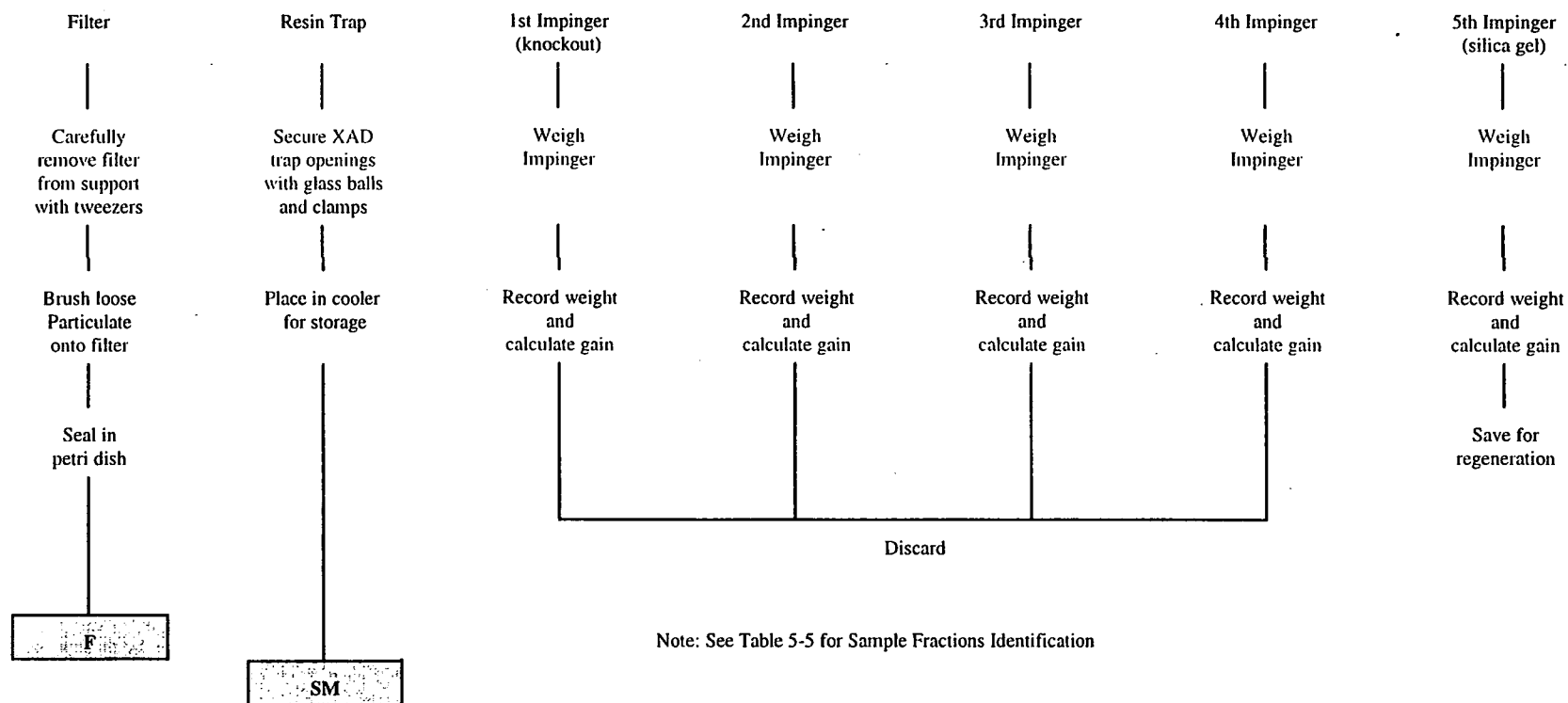


Figure 5-5. Continued

The train components recovered in the field are listed in Table 5-7. The sorbent modules were stored in coolers on ice at all times. The samples were delivered to the analytical laboratory upon return to ERG accompanied by written information designating target analyses.

Table 5-7. Method 23 Sample Fractions Shipped To Analytical Laboratory

Container/ Component	Code	Fraction
1	F	Filter(s)
2	Pr ^a	Acetone and methylene chloride rinses of nozzle/probe, cyclone, front half/back filter holder, filter support, connecting glassware, condenser
3	PRT CRT	Toluene rinse of nozzle/probe, cyclone, front half/back half filter holder, filter support, connecting line and condenser
4	SM	XAD-2® resin trap (sorbent module)
5	IC	Contents of Impingers 1-4 (H ₂ O) plus methylene chloride rinses

^a Rinses include acetone and methylene chloride recovered into the same sample bottle.

5.2.5 CDD/CDF/PAH Analytical Procedures

The analytical procedure used to obtain analyte concentrations from a single flue gas sample is high resolution gas chromatography (HRGC) and high resolution mass spectrometry (HRMS) (resolution from 8000-10000 m/z). The target CDD/CDF congeners are listed in Table 5-8. The PAH analytes are listed in Table 5-9. The analyses were performed by Triangle Laboratories, Inc., by Method 23/8290.

The Method 23 samples were prepared and analyzed according to the scheme in Figure 5-6. The XAD-2® (along with the acetone/methylene chloride rinses) was extracted with methylene chloride and this extract was added to the extract from the extraction of the impinger water. This combined extract was split 1:1, with one half being added to the toluene rinses and

Table 5-8. CDD/CDF Congeners To Be Analyzed

DIOXINS:

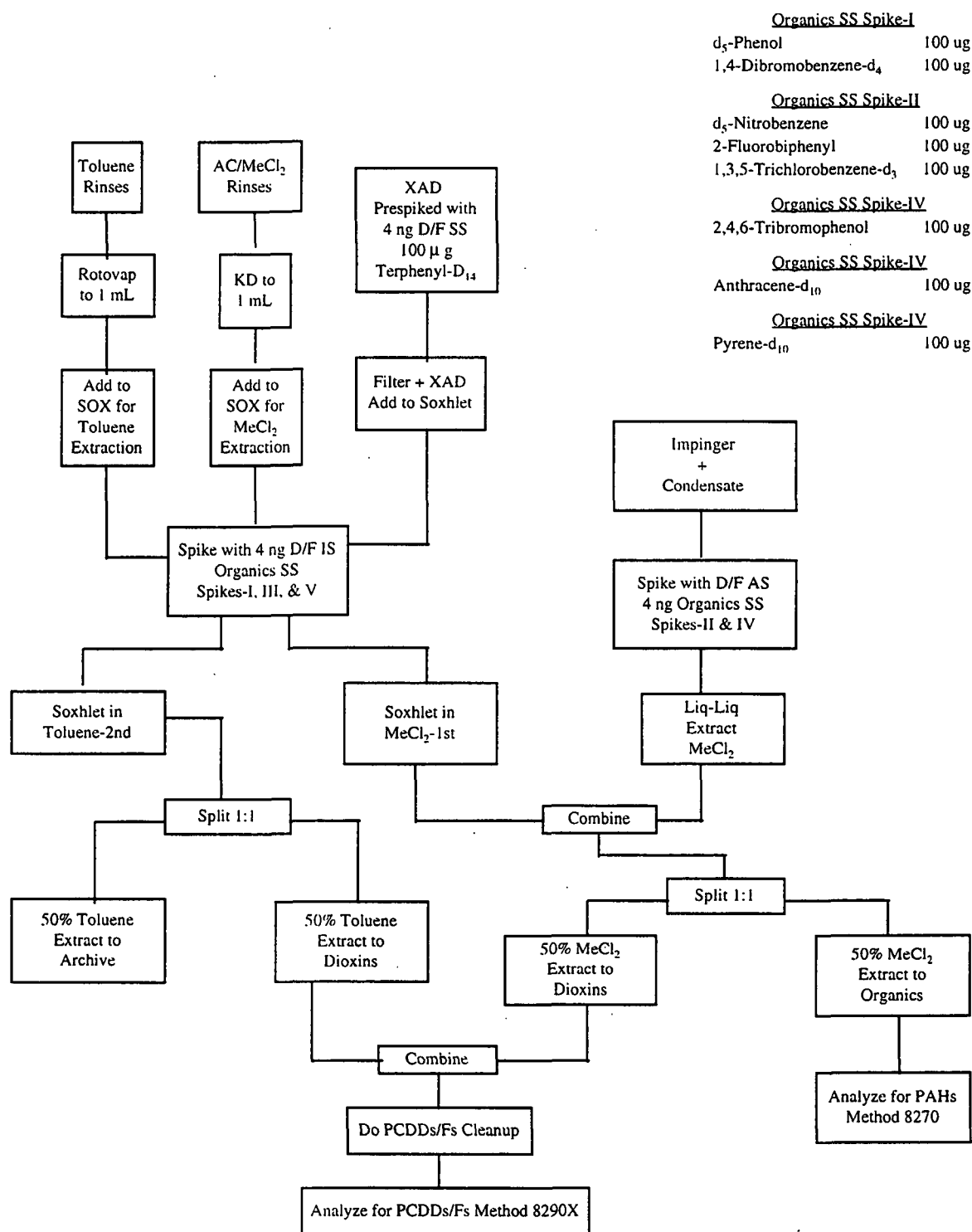
2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD)
Total tetrachlorinated dibenzo-*p*-dioxins (TCDD)
1,2,3,7,8-pentachlorodibenzo-*p*-dioxin (1,2,3,7,8-PeCDD)
Total pentachlorinated dibenzo-*p*-dioxins (PeCDD)
1,2,4,5,7,8-hexachlorodibenzo-*p*-dioxin (1,2,3,4,7,8-HxCDD)
1,2,3,6,7,8-hexachlorodibenzo-*p*-dioxin (1,2,4,5,7,8-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:

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-hexachlorodibenzofurans (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)

Table 5-9. PAH to be Analyzed

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(b)fluoranthrene
Benzo(k)fluoranthrene
Benzo(g,h,i)perylene
Benzo(e)pyrene
2-Chloronaphthalene
Chrysene
Dibenzo(a,b)anthracene
Fluorenone
Fluorene
Indeno(1,2,3-cd)pyrene
2-Methylnaphthalene
Naphthalene
Perylene
Phenanthrene
Pyrene



Extraction and Analysis Schematic for Method 23 Samples

Figure 5-6. Extraction and Analysis Schematic for Method 23 Samples

toluene extract of the XAD® for D/F analysis, and the remaining being used for PAH analysis. For the D/F analysis, isotopically-labeled surrogate compounds and internal standards and surrogates that were used are described in detail in EPA Method 23.

Data from the mass spectrometer were recorded and stored on a computer file as well as printed on paper. Results such as amount detected, detection limit, retention time, and internal standard and surrogate standard recoveries were calculated by computer. The chromatograms were retained by the analytical laboratory with copies included in the analytical report delivered to ERG.

5.2.5.1 Preparation of Samples for Extraction

Upon receiving the sample shipment, the samples were checked against the Chain-of-Custody forms and then assigned an analytical laboratory sample number. Each sample component was reweighed to determine if leakage occurred during travel. Color, appearance, and other particulars of the samples were noted. Samples were extracted within 21 days of collection and processed through cleanup procedures before concentration and analysis.

5.2.5.2 Calibration of GC/MS System

A five-point calibration of the GC/MS system was performed to demonstrate instrument linearity over the concentration range of interest. Relative response factors were calculated for each congener or compound of interest. The response factors were verified on a daily basis using a continuing calibration standard consisting of a mid-level isomer standard. The instrument performance was acceptable only if the measured response factors for the labeled and unlabeled compounds and the ion-abundance ratios were within the allowable limits specified in the method.

5.2.6 CDD/CDF Analytical Quality Control

All quality control procedures specified in the test method were followed. Blanks were used to determine analytical contamination, calibration standards were used for instrument calibration and linearity checks, internal standards were used to determine isomer recoveries and adjust response factors for matrix effects, surrogate standards were used to measure the collection efficiency of the sampling methodology and an alternate standard was used as a column efficiency check.

5.2.6.1 CDD/CDF Quality Control Blanks

Four different types of sample blanks were collected for D/F analysis. The type of blanks that are required are shown in Table 5-10.

Table 5-10. Method 23 Blanks Collected

Blank	Collection	Analysis
Field Blanks	One run collected and analyzed	Analyze with flue gas samples
Glassware Proof Blank	Each train to be used (2) will be loaded and quantitatively recovered prior to sampling	Archive for potential analysis
Method Blank	At least one for each analytical batch	Analyze with each analytical batch of flue gas samples
Reagent Blanks	One 1000 mL sample for each reagent and lot	Archive for potential analysis

Reagent blanks of 1000 mL of each reagent used at the test site were saved for potential analysis. Each reagent blank was of the same lot as was used during the sampling program. Each lot number and reagent grade was recorded on the field blank label and in the laboratory notebook (acetone, methylene chloride, toluene, HPLC water, filter, XAD-2®).

A glassware blank (proof blank) was recovered from each set of sample train glassware that was used to collect the organic samples. The precleaned glassware, which consists of a probe liner, filter holder, condensor coil, and impinger set, was loaded as if for sampling and then quantitatively recovered exactly as the samples were. Analysis of the generated fractions were used to check the effectiveness of the glassware cleaning procedure only if sample analysis indicates a potential contamination problem.

A field blank was collected from a set of D/F glassware that had been used to collect at least one sample. The train was prepared as if for sampling, leak checked and left at a sampling location during a test run. The train was then recovered. The purpose of the field blank was to measure the level of contamination that occurs from handling, loading, recovering, and transporting the sampling train. The field blanks were analyzed with the flue gas samples. If they are unsatisfactory in terms of contamination, reagent blanks may be analyzed to help determine the specific source of contamination.

In addition to the three types of blanks that are required for the sampling program, the analytical laboratory analyzed a method blank with each set of flue gas samples. This method blank consisted of preparing and analyzing an aliquot of toluene by the exact procedure used for the samples analysis. The purpose of this method blank was to verify that there was no laboratory contamination of the field samples.

5.2.6.2 Quality Control Standards and Duplicates

Recoveries of the internal standards must be between 40 to 130% for the tetra-through hexachlorinated compounds and in the range of 25 to 130% for the hepta-and octachlorinated homologues. If these requirements are not met, the data will be acceptable if the signal to noise ratio is greater than or equal to ten. If these requirements are met, the results for the native (sampled) species are adjusted according to the internal standard recoveries.

Surrogate standard recoveries must be between 70 to 130%. If the recoveries of all standards are less than 70%, the project director will be notified immediately to determine if the surrogate results will be used to adjust the results of the native species.

5.2.7 Analytes and Detection Limits for Method 23

The target analytes are the tetra- through octachlorinated dibenzodioxins and chlorinated dibenzofurans. The detection limit of the individual compounds is dependent on the detection limit of the analytical method, the volume of the final extract and the total volume of gaseous sample collected in the sampling trains. Following the protocol of Method 23, the fractions to be collected for analysis from each train are:

- Fraction 1—Filter;
- Fraction 2—XAD-2® sorbent module;
- Fraction 3—Acetone and methylene chloride rinses of all train components prior to sorbent module and;
- Fraction 4—Toluene rinses of all train components prior to the sorbent module.
- Fraction 5—Impinger contents 1-4 plus methylene chloride rinses

Following the sample preparation protocol outlined in Method 23, a single combined sample was presented for analysis for D/F by high resolution gas chromatography/high resolution mass spectrometry. (The individual samples were no longer available for analysis). The final volume of this sample was 200 μL of which a 2 μL aliquot was injected into the instrument. Using an instrument detection limit of 50 pg for tetra-, 250 pg for penta- through hepta-, and 500 pg for octa-, the total minimum detectable amounts were calculated and are given in Table 5-11. Using a four hour sampling time as selected by the EPA Work Assignment Manager at an assumed sampling rate of 0.75 cfm, the MDLs shown in Table 5-12 were possible. The sampling flow rate at the outlet location was dictated by the flow rate of the stack gas since isokinetic sampling was performed.

Table 5-11. Analytical Detection Limits For Dioxins/Furans

Analyte	Total Detectable Amount, ng
Tetra CDDs	5
Penta CDDs	25
Hexa CDDs	25
Hepta CDDs	25
Octa CDDs	50
Tetra CDFs	5
Penta CDFs	25
Hexa CDFs	25
Hepta CDFs	25
Octa CDFs	50

NOTE: D/F analysis by High Resolution Mass Spectrometry assumes a 2 μL injection of a 200 μL sample extract.

Table 5-12. CDD/CDF Method Detection Limits

Sampling Time, Hours	4
Sampling Rate, cfm	0.75
Sample Volume, m ³	5.1
	MDL, ng/m³
Tetra CDDs	0.98
Penta CDDs	4.9
Hexa CDDs	4.9
Hepta CDDs	4.9
Octa CDDs	9.8
Tetra CDFs	0.98
Penta CDFs	4.9
Hexa CDFs	4.9
Hepta CDFs	4.9
Octa CDFs	9.8

5.3 Analysis of Method 23 Samples for PAHs

The Method 23 sample preparation scheme shown in Figure 5-6 includes the splitting of prepared sample extracts for both CDD/CDF and PAH analyses. Split extracts were analyzed for the PAH compounds shown in Table 5-9. Due to the high levels of some PAHs, the extracts were analyzed using low resolution mass spectrometry. Table 5-13 lists the analytical detection limits for each of the PAHs to be determined.

Table 5-13. Analytical Detection Limits For PAHs

Analyte	Total Detectable Amount, μg
Acenaphthene	20
Acenaphthylene	10
Anthracene	10
Benzo(a)anthraene	10
Benzo(b)fluoranthene	10
Benzo(k)fluorethene	10
Benzo(g,h,i)perylene	10
Benzo(a)pyrene	10
Benzo(e)pyrene	10
2-Chloronaphthalene	10
Chrysene	10
Dibenzo(a,h)anthracene	10
Fluoranthene	20
Fluorene	35
Indeno(1,2,3-cd)pyrene	10
2-Methylnaphthalene	150
Naphthalene	900
Perylene	10
Phenanthrene	100
Pyrene	15

Using a four hour sampling time as selected by the EPA Work Assignment Manager, at an assumed sampling rate of 0.75 cfm, the method detection limits shown in Table 5-14 were possible.

5.4 EPA Methods 1-4

5.4.1 *Traverse Point Location By EPA Method 1*

The number and location of sampling traverse points necessary for isokinetic sampling were dictated by EPA Method 1 protocol. These parameters were based upon how much duct distance separates the sampling ports from the closest downstream and upstream flow disturbances. The minimum number of traverse points for a circular duct with an I.D. of 12 feet is 12.

5.4.2 *Volumetric Flow Rate Determination by EPA Method 2*

Volumetric flow rate was measured according to EPA Method 2. A type K thermocouple and S-type pitot tube were used to measure flue gas temperature and velocity, respectively.

5.4.2.1 Sampling and Equipment Preparation

For EPA Method 2, the pitot tubes were calibrated before use following the directions in the method. Also, the pitots were leak checked before and after each run.

5.4.2.2 Sampling Operations

The parameters that were measured include the pressure drop across the pitots, stack temperature, stack static and ambient pressure. These parameters were measured at each traverse

Table 5-14. PAH Method Detection Limits

Sampling Time, Hours	4
Sampling Rate, cfm	0.75
Sample Volume, m ³	5.1
	MDL, µg/m³
Acenaphthene	8
Acenaphthylene	4
Anthracene	4
Benzo(a)anthracene	4
Benzo(b)fluoranthene	4
Benzo(k)fluoranthene	4
Benzo(g,h,i)perylene	4
Benzo(a)pyrene	4
Benzo(e)pyrene	4
2-Chloronaphthalene	4
Chrysene	4
Dibenzo(a,h)anthracene	4
Fluoranthene	8
Fluorene	14
Indeno(1,2,3-cd)pyrene	4
2-Methylnaphthalene	59
Naphthalene	350
Perylene	4
Phenanthrene	40
Pyrene	6

point, as applicable. A computer program was used to calculate the average velocity during the sampling period.

5.4.3 *O₂ and CO₂ Concentrations by EPA Method 3*

The O₂ and CO₂ concentrations were determined by using a Fyrite analyzer following EPA Method 3. Flue gas was extracted from the duct for analysis. The Method 3 analysis for O₂ and CO₂ were performed approximately every 30 minutes as a grab sample at the outlet and at the inlet.

5.4.4 *Average Moisture Determination by EPA Method 4*

The average flue gas moisture content was determined according to EPA Method 4. Before sampling, the initial weight of the impingers was recorded. When sampling was completed, the final weights of the impingers were recorded, and the weight gain was calculated. The weight gain and the volume of gas sampled were used to calculate the average moisture content (%) of the flue gas. The calculations were performed by computer. Method 4 was incorporated in the technique used for the Method 29 manual sampling method that was used during the test.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific Quality Assurance/Quality Control (QA/QC) procedures were strictly followed during this test program to ensure the production of useful and valid data throughout the course of the project. A detailed presentation of QC procedures for all sampling and analysis activities can be found in the Site Specific Test Plan and Quality Assurance Project Plan for this project. This section reports the results of all QC analyses so that the degree of data quality can be ascertained.

In summary, a high degree of data quality was maintained throughout the project. All sampling train leak checks met the QC criteria as specified in the methods, except for the first and second D/F/PAH sampling runs. Five total D/F/PAH runs were performed in order to obtain sufficient data of good quality. Isokinetic sampling rates were kept within the 10% of 100% for all test runs. Acceptable spike recoveries and close agreement between duplicate analyses were shown for the sample analyses.

6.1 Sampling QC Results

The following sections discuss the QC results of the specific sampling methods employed during this project.

6.1.1 D/F/PAH Sampling QC

Table 6-1 lists the pre- and post-test and port change leak check results. The acceptance criteria are that all post-test leak checks must be less than 0.02 cfm or 4 percent of the average sampling rate (whichever is less). All D/F/PAH leak checks met this criterion, except as discussed for Runs 1 and 2.

Table 6-1. Summary of D/F/PAH Leak Checks, Strand Baghouse Outlet

Date	Run #/Port	Initial leak Check	Port Change Leak Check	Final Leak Check
8/12/97	1/B 1/A	0.010 @ 10"	Broken by-pass	Not Taken
8/13/97	2/B 2/A 3/B	0.010 @ 16" 0.009 @ 10"	Broken by-pass	Stopped sampling @ 1 Hour
8/14/97	3/A 4/B 4/A	0.014 @ 15"	0.010 @ 10" 0.014 @ 12"	0.009 @ 12" 0.020 @ 17"
8/15/97	5/A 5/B	0.004 @ 19"	0.006 @ 17"	0.004 @ 19"

Table 6-2 presents the isokinetic sampling rates for the D/F/PAH sampling runs. The acceptance criterion is that the average sampling rate must be within 10% of 100% isokinetic. All sampling runs met this criterion.

All dry gas meters are fully calibrated every six months against an EPA approved intermediate standard. The full calibration factor is used to correct the actual metered sample volume to the true sample volume. To verify the full calibration, a post-test calibration is performed. The full and post-test calibrations coefficients must be within 5% to meet ERG's internal QA/QC acceptance criterion. As shown in Table 6-3, the meter box used for the D/F/PAH testing met this criterion.

Field blanks are collected to verify the absence of any sample contamination. A D/F/PAH train was assembled as if for sampling, leak checked at the sampling location, left at the sampling location for the duration of a test run and then recovered. Table 6-4 presents the analytical results for the field blank as well as the laboratory method blank. The only D/F compounds detected in the field blank were 1,2,3,4,6,7,8,9-OCDD, 2,3,7,8-TCDF and

Table 6-2. Summary of Isokinetic Percentages

Date	Run #	Percent Isokinetic
Multi-Metals—Strand Baghouse Inlet		
8/12/97	1	101
8/13/97	2	104
8/14/97	3	105
Multi-Metals—Strand Baghouse Outlet		
8/12/97	1	97.1
8/13/97	2	96.7
8/14/97	3	92.7
Multi-Metals—Baghouse A Outlet		
8/15/97	1	94.3
8/15/97	2	92.8
8/16/97	3	94.9
Dioxin/PAHs—Strand Baghouse Outlet		
8/12/97	1	99.2
8/13/97	2	99.9
8/13 and 8/14/97	3	102
8/14/97	4	99.3
8/15/97	5	101

Table 6-3. Dry Gas Meter Post Calibration Results

Sampling Train	Meter Box Number	Full Calibration Factor	Post-Test Calibration Factor	Post-Test* Deviation %
D/F/PAH, Strand Baghouse Outlet	39	0.996	1.001	0.5
Metals/PM, Strand Baghouse Outlet	36	0.997	0.990	-0.7
Metals/PM, Strand Baghouse Inlet and Baghouse A Outlet	38	0.984	0.978	-0.6

*

$$\frac{\text{Post} - \text{Full}}{\text{Full}} \times 100$$

Table 6-4. Dioxin/Furan Field Blank Analysis Results

Congener	Field Blank ng Detected	Lab Method Blank ng Detected
2,3,7,8 -TCDD	<0.01	<0.01
1,2,3,7,8-PeCDD	<0.02	<0.03
1,2,3,4,7,8-HxCDD	<0.02	<0.03
1,2,3,6,7,8-HxCDD	<0.01	<0.02
1,2,3,7,8,9-HxCDD	<0.01	<0.02
1,2,3,4,6,7,8--HpCDD	<0.02	<0.03
1,2,3,4,6,7,8,9-OCDD	0.07	<0.07
2,3,7,8-TCDF	0.05	<0.01
1,2,3,7,8-PeCDF	<0.01	<0.02
2,3,4,7,8-PeCDF	<0.01	<0.02
1,2,3,4,7,8-HxCDF	<0.01	<0.02
1,2,3,6,7,8-HxCDF	<0.007	<0.01
2,3,4,6,7,8-HxCDF	<0.01	<0.01
1,2,3,7,8,9-HxCDF	<0.01	<0.02
1,2,3,4,6,7,8-HpCDF	<0.01	<0.02
1,2,3,4,7,8,9-HpCDF	<0.02	<0.03
1,2,3,4,6,7,8,9-OCDF	<0.03	<0.05

1,2,3,4,7,8-HxCDF, but at levels at the detection limit and much lower than in any of the test runs. Any PAHs detected in the field blank were at levels less than 0.5% of any detected in the test runs. Because the amount of contamination was so low, no blank corrections were made on the emissions results.

6.1.2 Metals/PM Sampling QC

Tables 6-5 and 6-6 list the pre- and post-test and port change leak check results for the Strand baghouse outlet and inlet sampling trains respectively. Table 6-7 lists the leak check results for the Baghouse A outlet. The acceptance criteria of less than 0.02 cfm or 4% of the average sampling rate (whichever is less) were met by all sampling trains.

Table 6-2 presents the isokinetic sampling rates for the metals/PM sampling runs. The sampling rate acceptance criterion of being within 10% of 100% isokinetic was met for all sampling runs at both the inlet and outlet.

As shown in Table 6-3, the calibration coefficients of the meter boxes used for the metals/PM testing were within 5% of their full calibration coefficient, thus meeting the acceptance criterion.

Table 6-8 presents the analytical results for the three Method 29 field blanks, a reagent blank train (which was prepared from components consisting of an unused filter, and aliquots of nitric acid, deionized water and hydrogen peroxide reagents) and the average of the three sampling runs performed at each of three locations (Strand baghouse inlet and outlet and Baghouse A outlet). Of the target metals found in the reagent blank train more than 90% of the amount detected can be attributed to the filter. The amounts of Hg, As, Be, Cd, Co, Cr, Ni, Sb, and Se detected in the three field blanks are equivalent to that detected in the reagent field blank and again coming from contributions from the filter. The consistency between these data for these metals indicate that good sample recovery was achieved and that no residual sample was

Table 6-5. Summary of Metals Train Leak Checks, Strand Baghouse Outlet

Date	Run #/Port	Initial leak Check	Leak Check	Final Leak Check
8/12/97	1/A 1/B	0.011 @ 15"	0.009 @ 10"	0.006 @ 16"
8/13/97	2/B 2/A	0.009 @ 12"	0.002 @ 18"	0.011 @ 19"
8/14/97	3/A 3/B	0.012 @ 15"	0.011 @ 18"	0.008 @ 19"

Table 6-6. Summary of Metals Train Leak Checks, Strand Baghouse Inlet

Date	Run #/Port	Initial leak Check	Leak Check	Final Leak Check
8/12/97	1/A 1/B 1/C 1/D	0.008 @ 10"	0.0088 @ 14" 0.025 @ 14" 0.00 @ 14"	0.009 @ 10"
8/13/97	2/A 2/B 2/C 2/D	0.015 @ 15"	0.00 @ 15" 0.00 @ 15" 0.00 @ 10"	0.018 @ 15"
8/14/97	3/A 3/B 3/C 3/D	0.00 @ 10"	0.002 @ 11" 0.016 @ 13" 0.016 @ 22"	0.012 @ 23"

Table 6-7. Summary of Metals Train Leak Checks, Baghouse A Outlet

Date	Run #/Port	Initial leak Check	Leak Check	Final Leak Check
8/15/97	1/A 1/B	0.016 @ 10"	0.016 @ 13"	0.016 @ 13.5"
8/15/97	2/B 2/A	0.020 @ 10"	0.020 @ 15"	0.20 @ 14"
8/16/97	3/A 3/B	0.020 @ 10"	0.016 @ 10"	0.012 @ 15"

Table 6-8. Metals QC Results: (µg detected)

Metal	Strand Baghouse Outlet Field Blk	Strand Baghouse Inlet Field Blk	Baghouse A Outlet Field Blk	Train Reagent Blk	Average Run Values		
					Strand Outlet	Strand Inlet	Baghouse A Outlet
Hg	<4.008	<4.21	<2.82	<4.67	28.6	17.3	<4.79
As	1.56	1.497	1.53	1.45	2.59	27.2	1.71
Be	<0.200	<0.200	<0.200	<0.200	<0.215	0.314	<0.221
Cd	0.219	0.432	<0.200	<0.200	1.04	91.8	<0.284
Co	0.310	0.390	0.320	0.430	0.778	26.6	0.667
Cr	13.7	10.6	14.8	14.5	25.5	277	20.1
Mn	95.6	304	4.92	8.33	167	6460	141
Ni	9.36	7.71	10.2	8.79	11.8	56.1	16.7
Pb	26.0	156	1.40	1.21	122	20304	17.5
Sb	7.43	4.90	8.94	8.03	6.92	7.51	8.07
Se	6.67	4.56	8.01	7.06	103	75.0	7.25

carried over to the next train being prepared. However, carry over to the next train being prepared most likely occurred for Mn and Pb as indicated by the high levels detected in the Stand Baghouse inlet and outlet field blanks compared to the reagent field blank and the Baghouse A field blank. This carry over is probably due to the significantly higher levels of these two metals collected in the trains during the three sampling runs and not laboratory contamination or field contamination. This carry over may have biased high the results for these two metals in the Strand Baghouse data. The Baghouse A results do not appear to be affected by any analyte carry over. The results presented in this report have not been blank corrected.

6.2 Analytical QC Results

The following section reports QA parameters for the D/F/PAH and Metals/PM analytical results.

6.2.1 D/F/PAH Analytical Quality Control

D/F—One sample was generated for D/F analysis for each stack gas sample collected and was subjected to both a full screen and confirmation analysis. The full screen analyses were conducted using a DB-5 GC column which allows the separation of each class of chlorinated (i.e., tetra, penta, etc.) and fully resolves 2,3,7,8-TCDD from the other TCDD isomers. The confirmation analysis, performed on a DB-225 GC column, is needed to fully resolve the 2,3,7,8-TCDF from the other TCDF isomers.

A component of the D/F QC program is adding isotopically labeled standards to each sample during various stages of analysis to determine recovery efficiencies and to aid in the quantitation of native D/F species. Four different types of standards are added:

- Surrogate standards are usually spiked on the XAD-2® absorbent prior to sampling. Recovery of these compounds allows for the evaluation of overall sample collection efficiency and analytical matrix effects.

- Internal standards are spiked after sampling but prior to extraction.
- Alternate standards are also spiked at this stage.
- Recovery percentages of internal standards are used in quantifying the D/F native to the stack gas being sampled. Recovery of alternate standards for extraction/fractionation efficiencies to be determined.
- Recovery standards are added after fractionation, just prior to analysis by HRGC/HRMS.

The recovery of each of the spiked isotopically labeled compounds was within the acceptance criteria set forth in Method 23, except for the surrogate standard $^{13}\text{C}_{12}$ -1,2,3,4,7,8,9-HpCDF in Run 3 at the Strand baghouse outlet. The percent recovery was 68.8%, which was just outside of the lower limit of 70%. This low recovery will have no effect on the reported results.

PAH—The sample extracts were analyzed after sample dilution by HRGC/LRMS, due to the high level of many of the PAHs found in the samples. The sample extracts were analyzed following the protocol given in EPA Method 8270A. The internal standard areas for Runs 1 and 3 were high for chrysene- d_{12} and perylene- d_{12} specified in Method 8270A quality control criteria. The perylene- d_{12} internal standard was high for Runs 4 and 5 only. This high value was observed each time after multiple analysis indicating the likely presence of a matrix effect. The analytes quantified against the internal standards should be considered as estimates (see Appendix B for raw data).

6.2.2 Metals Analytical Quality Control

ICAP Metals—The analytical methods used for the stack gas samples are discussed in Section 5 of this report. The following paragraphs discuss the metals QC results.

Serial dilutions were performed on the Outlet Run 1 front half and back samples for the ICAP metals. A serial dilution is performed to determine if there is any interference specific to an analyte in the native sample matrix. The relative percent difference (RPD) between the

analysis of the undiluted and the serially diluted sample is determined. Only those analytes with detectable amounts above 10 times the reportable detection limit (RDL) after dilution are reported. Cadmium, manganese, and lead in the front half sample were within the $\pm 10\%$ RPD criterion. Chromium had a RPD of 24.5% which does not indicate any significant interferent.

Duplicate ICAP analysis was performed on Outlet Run 2 front half and back half samples. Only those analytes with detectable amounts above 10 times the reportable detection limit are reported. The RPD between the two analyses must be $\pm 20\%$ to be acceptable. All of the metals detected above 10 times the RDL demonstrated RPDs less than 10%.

Post digestion matrix spikes were performed on the Outlet Run 1 front half and back samples for the ICAP metals. Each of the target metals is spiked at a known level into an aliquot of the sample. A percent recovery between 75 and 125 is acceptable and indicates the lack of interference from the native sample matrix. The percent recovery for all the metals except lead in the front half sample were within 75-125% range. The level of spike for this metal was insignificant compared to the native amount and could not be quantitated. The percent recovery for all of the metals except selenium in the back half sample were within the acceptance criterion. Again, the level of spike for selenium was insignificant compared to the native amount and could not be quantitated.

No ICAP metals except nickel were detected in the laboratory method blank above the instrument detection limit. Nickel was detected at 6.55 $\mu\text{g/L}$ which is not considered significant based on the detection limit (less than 3 times the DL). The recoveries of each of the metals in the laboratory control spike were within the acceptance criterion of 80-120%.

CVAA—Every sample was analyzed in duplicate for the presence of mercury. All duplicate analyses were within the acceptance criterion of $\pm 20\%$. Matrix spikes and matrix spike duplicates were performed on the front-half (fritter and probe rinses) and back-half (nitric acid/peroxide) impinger contents, as well as KMNO_4 , nitric, and hydrochloric acid rinses. Percent recoveries for all sample spikes were within the acceptance criterion of 75-125. All

laboratory control spikes and laboratory control spike duplicates were also within this acceptance criterion.

6.2.3 *PM Analytical Quality Assurance*

All filters and acetone probe rinse residues were weighed to a constant weight following the procedures given in EPA Method 5. The acetone probe rinse residues were blank corrected using a known volume of acetone reagent. The five place analytical balance calibration was verified prior to use by weighing a series of Class S weights which covered the range of weights encountered with the samples.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-454/R-99-041 a		2.	3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE Integrated Iron and Steel Industry Final Report Manual Testing Volume I of III - Youngstown Sinter Company Youngstown, Ohio			5. REPORT DATE September 1999	
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16. ABSTRACT <p>The purpose of the testing at the Youngstown Sinter Company (YSC) plant in Youngstown, Ohio was to perform all activities necessary to characterize the baghouse sintering plant windbox (Strand Baghouse) for the following emission components: 1) Particulate matter and metal HAPs using EPA Method 29; and 2) Dioxins/furans (D/F) and polynuclear aromatic hydrocarbons (PAH) using EPA Method 23 in support of a national emission standard for hazardous air pollutants (NESHAP) for the Integrated Iron and Steel Manufacturing category.</p> <p>Sampling was also performed on the discharge end baghouse (Baghouse A) for PM and metals.</p>				
17. MACT Rule Support				
KEY WORDS AND DOCUMENT ANALYSIS				
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