

Air



# **NESHAP - Glass Manufacturing - Arsenic**

## **Emission Test Report Fostoria Glass Moundsville, West Virginia**

Copy No. \_\_\_\_\_ of \_\_\_\_\_

NESHAP DEVELOPMENT  
ARSENIC EMISSION TESTING AT  
THE FOSTORIA GLASS COMPANY  
LEAD CRYSTAL GLASS FURNACE  
MOUNDSVILLE, WEST VIRGINIA  
OCTOBER-NOVEMBER, 1983



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## 1.0 INTRODUCTION

### 1.1 Background

Section 112 of the Clean Air Act of 1977 charges the Administrator of the United States Environmental Protection Agency with the responsibility of establishing National Emission Standards for Hazardous Air Pollutants (NESHAP) that may significantly contribute to air pollution. Emission data collected from this plant may provide a portion of the data base used by EPA to develop NESHAP.

The EPA Industrial Studies Branch (ISB) selected the Fostoria Glass Company in Moundsville, West Virginia as a site for an arsenic emission measurement program because it uses a lead arsenic glass recipe and the furnace emissions were controlled by an electrostatic precipitator (ESP).

The test program was designed to determine arsenic concentrations and mass emissions at the inlet and outlet of the electrostatic precipitator serving the lead crystal glass furnace.

TRC Environmental Consultants, Inc. was retained by the EPA Emission Measurement Branch (EMB) to perform emission measurements at the Fostoria Glass Company. Testing was performed at the inlet and outlet of the ESP during the weeks of October 10 and October 31, 1983. This report has been prepared in accordance with EPA Contract No. 68-02-3543 under the provisions of Work Assignment No. 10.

The EPA, Industrial Studies Branch (ISB), was responsible for assuring that process operations were suitable for testing. Process data were monitored by Radian Corporation.

### 1.2 Summary of Process, Emissions, and Operating Conditions

The lead crystal glass furnace is a regenerative-recuperative natural gas fired glass furnace. The furnace produces 24% lead crystal glass. A complete

rebuild of the furnace was underway at the time of the pretest survey, and completed in September, 1983. The furnace has maximum rated capacity of approximately 16 tons per day (TPD). During the test program the furnace was charged with raw batches containing arsenic trioxide ( $\text{As}_2\text{O}_3$ ), the usual additive, and then with raw batches containing arsenic acid ( $\text{H}_3\text{AsO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$ ).

Lead crystal glass is produced by blending the raw materials and melting them at approximately  $2800^\circ\text{F}$ . Arsenic is added in small quantities to the raw material as a fining and clarifying agent. During the melting of the glass batch raw materials, gaseous reaction products such as oxygen, nitrogen, and carbon dioxide evolve and rise through the glass to form bubbles, reducing the quality of the glass. The added inorganic arsenic causes the bubbles to rise more rapidly to the melt surface and to dissipate. Arsenic-induced chemical reactions may also reduce the rate of formation of nitrogen and carbon dioxide bubbles.

The furnace is equipped with a United McGill 2-75-2 electrostatic precipitator (ESP) rated at 95% collection efficiency.

Combustion air for the furnace is preheated in primary and secondary checkers and a recuperator. Hot gases from the furnace are exhausted to the atmosphere through one set of checkers, the ESP, the recuperator and the exhaust stack while combustion air is drawn through the recuperator and the other set of checkers.

A schematic of the crystal lead glass furnace is presented in Figure 1-1. The regenerative cycle is 20 minutes. The unit normally fires 24 hours per day, seven days per week.

The acceptability of furnace operation for NESHAP performance testing was determined by ISB and Radian on site. Emission sampling was performed under



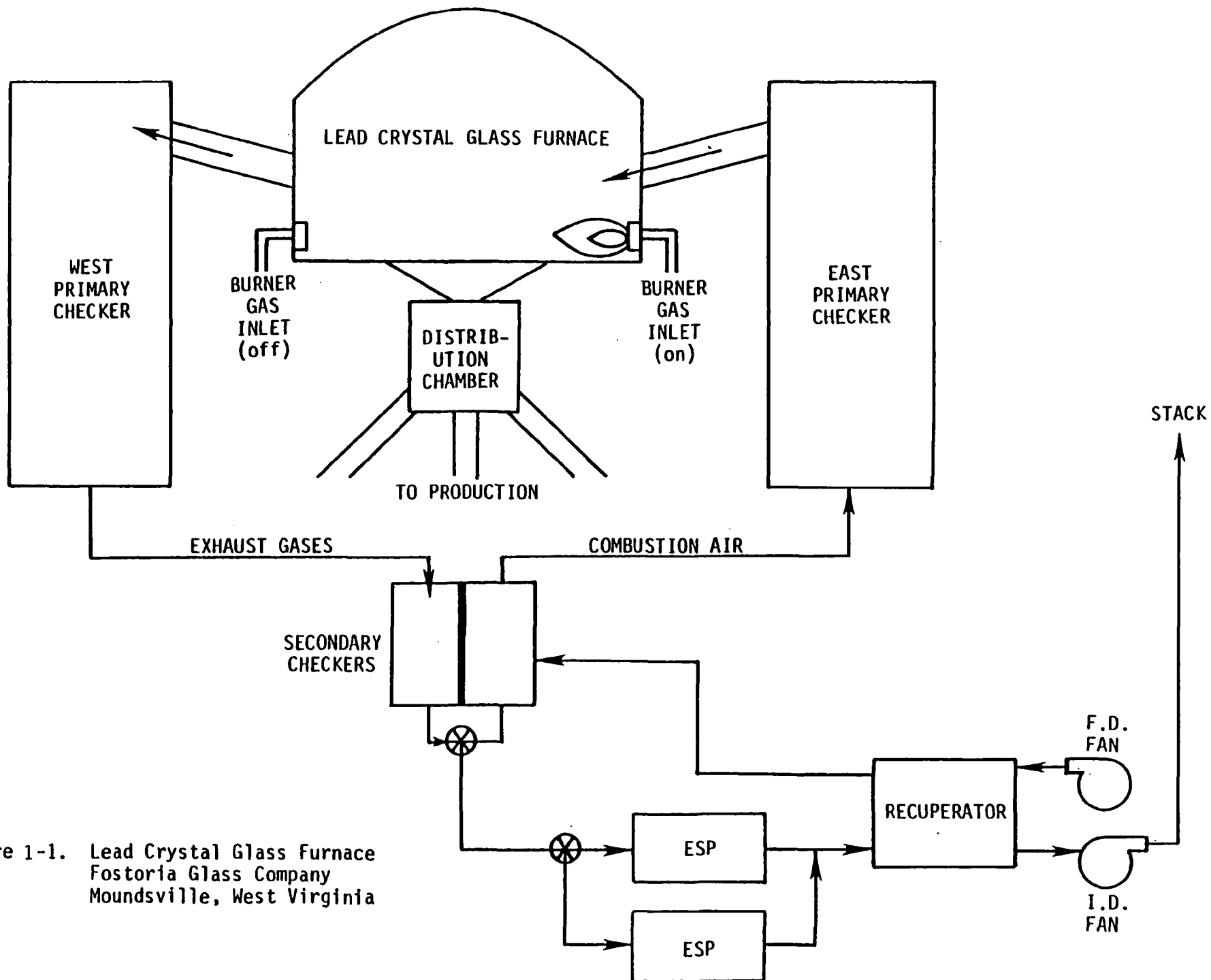


Figure 1-1. Lead Crystal Glass Furnace  
Fostoria Glass Company  
Moundsville, West Virginia

normal Fostoria operating conditions. Process operational data was recorded by ISB/Radian personnel during the test program and is presented in Section 3.0 and Appendix H.

### 1.3 Applicability of EPA Reference Test Methods

EPA is required to publish a national reference test method for each regulated source category and pollutant for which a National Emission Standard for Hazardous Air Pollutants (NESHAP) is established. Reference test methods are usually specified by a State regulatory agency during the State Implementation Planning process and may be different from national reference test methods.

The purpose of establishing a national reference test method is to ensure that emission data collected from a specific source is representative of that source and comparable to data collected at other designated sources. The primary purpose of this test program was to collect emission data using standardized test methods which allow the data to be evaluated to develop a NESHAP. Two test methods were selected by EPA to measure emissions from glass furnaces. These methods are briefly described in the following subsections and are described in detail in Section 5.

#### 1.3.1 EPA Method 5A

EPA Method 5A measures particulate and condensible organic matter. "Particulate matter" is defined as any finely divided solid or liquid material, other than uncombined water, that condenses in the filtration temperature range of  $250^{\circ} \pm 25^{\circ}\text{F}$  ( $120^{\circ} \pm 14^{\circ}\text{C}$ ), and is collected by the probe and filter (front half of the sampling train). "Condensible organic matter" is defined as any material remaining after extraction, filtration and

ambient evaporation of the ether-chloroform extract of the impinger portion of the sampling train. Particulate matter and condensible organic matter are quantified gravimetrically and results are expressed as the mass of collected material.

#### 1.3.2 EPA Method 108 (Proposed)

EPA Method 108 (proposed) was designed for the determination of inorganic arsenic emissions from smelting processes. Particulate and gaseous emissions are withdrawn isokinetically from the sources and collected on a glass fiber filter and in water. The sampling train is similar to that of Method 5. The collected arsenic is then analyzed by means of atomic absorption spectrophotometry.

Method 108, as drafted, is intended for use at non-ferrous smelting processes where high concentrations of  $\text{SO}_2$  are encountered. Hydrogen peroxide impinger solutions are included in the sampling train to scrub out this  $\text{SO}_2$ . Since only small amounts of  $\text{SO}_2$  are encountered in glass furnace exhausts, no peroxide impinger solutions were used in this test program. Impingers contained deionized-distilled water and were rinsed with a 0.1 N sodium hydroxide solution.

#### 1.4 Measurement Program Summary

The emission measurement program was conducted at the Fostoria Glass Company during the weeks of October 10 and October 31, 1983. All emission testing was performed by TRC at the inlet and outlet of the ESP serving the lead-crystal glass furnace. Radian monitored process operations and obtained product samples. The following measurements were performed.

#### 1.4.1 Preliminary Measurements

Preliminary testing was performed at the inlet and outlet of the ESP to determine volumetric flow rate and stack gas moisture content. The stack diameters and sampling port configurations were each checked.

#### 1.4.2 Clean-Up Evaluations

Prior to emissions testing during each of the two weeks, three Method 108 sampling trains were prepared and charged, ready to perform a test. In addition, one Method 5A sampling train was prepared and charged. The unexposed trains were then cleaned and the samples recovered in accordance with the methods. The samples were then analyzed to establish background and/or contamination levels of the sampling equipment.

#### 1.4.3 Primary Tests

Three emissions tests were performed simultaneously at the inlet and outlet of the ESP utilizing Method 108 during the week of October 10 with  $\text{As}_2\text{O}_3$  in the raw batch. Three more simultaneous sets of emissions tests were performed during the week of October 31 with  $\text{H}_3\text{AsO}_4$  in the raw batch mixture. Visible emissions evaluations were performed concurrently with each test.

#### 1.4.4 Secondary Tests

Three sets of two simultaneous, single point secondary tests were performed during the week of October 10 at the ESP Inlet utilizing Method 108 modified by altering the probe and filter temperatures. Three more sets of secondary tests were performed during the week of October 31 at the ESP Inlet. Concurrent with each set of secondary Method 108 tests performed at

the ESP Inlet, a single particulate/condensable organics emission test was performed at the ESP Outlet. Visible emissions evaluations were performed concurrently with these tests.

#### 1.5 Report Sections

The remaining sections of this report present the Summary and Discussion of Results (Section 2), Process Description and Operations (Section 3), Description of Sampling Locations (Section 4), Sampling and Analytical Procedures (Section 5), and Quality Assurance (Section 6). Descriptions of methods and procedures, field and laboratory data, and calculations are presented in various appendices as noted in the Table of Contents.

## 2.0 SUMMARY AND DISCUSSION OF RESULTS

A summary of all collected emission data is presented in this section. Section 2.1 provides a brief background discussion and definition of the measured parameters. Section 2.2 presents Method 108 (modified) arsenic emission results acquired during primary testing. Section 2.3 presents arsenic emission results acquired during the secondary phase of the test program. Method 5A particulate emission results are presented in Section 2.4. Section 2.5 summarizes the visible emission evaluations performed during the primary test program. The results of the clean-up evaluations are presented in Section 2.6. Section 2.7 presents the results of product sample analyses for arsenic. Raw batch constituent arsenic analyses are in Section 2.8. Ambient air monitoring results for each sampling location are presented in Section 2.9.

### 2.1 Background and Definitions

This test program was designed to measure particulate and gaseous emissions of arsenic from the lead-crystal glass furnace. Particulate and condensible organic emissions were also measured. In addition, visible emissions were evaluated.

#### 2.1.1 Particulate Arsenic

Particulate arsenic emissions, for the purposes of this test program, are defined as any arsenic that condenses at or above a specified temperature ( $250 \pm 25^{\circ}\text{F}$  or  $550 \pm 25^{\circ}\text{F}$  - See Section 5) and is collected in the probe and filter (front half) of the Method 108 sampling train. Analysis is by atomic absorption spectrophotometry.

#### 2.1.2 Gaseous Arsenic

Gaseous arsenic emissions, for the purposes of this sampling program, are defined as any arsenic that does not condense at the temperatures specified in Section 2.1.1 and that is captured in the back half of the filter holder, the Teflon sample line, and the first three impingers of the Method 108 sampling train. Analysis is by atomic absorption spectrophotometry.

#### 2.1.3 Particulate

Particulate matter, for the purposes of this test program, is defined as any finely divided solid or liquid matter, other than uncombined water, that condenses at  $250 \pm 25^{\circ}\text{F}$  and is collected in the probe and filter (front half) of the Method 5 sampling train. Analyses are performed gravimetrically after evaporation and desiccation of the samples.

#### 2.1.4 Condensable Organics

Condensable organic matter, for the purposes of this test program, is defined as that matter which remains in the impinger solution and the back-half rinse of the Method 5 sampling train after extraction, filtration and evaporation.

#### 2.1.5 Visible Emissions

Visible emissions are evaluated according to appearance of a discharge plume to a certified observer. The observer evaluates the plume by opacity in accordance with EPA Method 9 as described in Section 5.

## 2.2 Primary Arsenic Emission Tests

A summary of measured particulate arsenic and gaseous arsenic emission data collected during primary testing at the ESP Inlet is presented in Table 2-1A (English units) and Table 2-1B (metric units). Tables 2-2A (English units) and 2-2B (metric units) present particulate arsenic and gaseous arsenic emission data collected during primary testing at the ESP Outlet. Table 2-3 presents the measured arsenic collection efficiencies of the ESP. These tables include test dates and times; raw batch mixture ( $\text{As}_2\text{O}_3$  or  $\text{H}_3\text{AsO}_4$ ); stack gas temperatures, flowrates, and moisture contents; sample volumes and sample catches; as well as particulate arsenic, gaseous arsenic, and total arsenic emission concentrations and mass emission rates. Emission data is presented for six primary tests at the Inlet and Outlet of the ESP.

### 2.2.1 ESP Inlet

Each primary arsenic emission test performed at the ESP Inlet was 128 minutes in duration. Two tests were performed on October 11 and one test on October 12. Solid arsenic trioxide ( $\text{As}_2\text{O}_3$ ) was the raw batch constituent of interest during these first three tests (Tests P-1, P-2, and P-3). After change-over to liquid arsenic acid ( $\text{H}_3\text{AsO}_4 \cdot 1/2 \text{H}_2\text{O}$ ) and adequate time to purge the glass furnace, two primary tests were performed on November 1 and another test on November 2 (Tests P-4, P-5, and P-6). Furnace operating conditions were otherwise equivalent during all six primary tests performed.

During Tests P-1, P-2, and P-3, at the ESP Inlet the average particulate arsenic (front half) emissions were  $2.05 \times 10^{-2}$  gr/DSCF (0.431 lbs/hr) or  $46.98 \text{ mg/Nm}^3$  (196 g/hr). The average gaseous arsenic (back half) emissions were  $3.33 \times 10^{-5}$  gr/DSCF (0.0007 lbs/hr) or  $7.65 \times 10^{-2} \text{ mg/Nm}^3$  ( $3.16 \times 10^{-1}$  g/hr). The average total arsenic emission rate was  $2.06 \times 10^{-2}$  gr/DSCF



TABLE 2-1A

SUMMARY OF PRIMARY ARSENIC EMISSION TESTING AT THE ESP INLET (English Units)  
THE FOSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Text Number	Date	Time	Stack Gas Conditions			Sample				Arsenic Emissions				Total	
			Temperature (°F)	Moisture (%)	Flowrate (DSCFM)*	Volume (DSCF)	Arsenic Catch (mg)			Particulate		Gaseous		(gr/DSCF)	(Lba/hr)
							Particulate (Front Half)	Gaseous (Back Half)	Total	(Front Half)	(Back Half)				
												(gr/DSCF)	(Lba/hr)		
Batch Mixture As <sub>2</sub> O <sub>3</sub>															
P-1-I	10/11/83	0914-1138	387	10.1	2450	82.02	92.84	0.053	92.89	1.75 x 10 <sup>-2</sup>	0.366	9.80x10 <sup>-6</sup>	0.0002	1.75 x 10 <sup>-2</sup>	0.366
P-2-I	10/11/83	1358-1618	391	10.5	2540	87.18	126.3	0.204	126.5	2.24 x 10 <sup>-2</sup>	0.487	3.61 x 10 <sup>-5</sup>	0.0008	2.24 x 10 <sup>-2</sup>	0.487
P-3-I	10/12/83	0957-1217	382	11.2	2370	80.92	114.0	0.283	114.3	2.17 x 10 <sup>-2</sup>	0.441	5.40 x 10 <sup>-5</sup>	0.0011	2.18 x 10 <sup>-2</sup>	0.443
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	387	10.6	2450	83.37	111.0	0.180	111.2	2.05 x 10 <sup>-2</sup>	0.431	3.33 x 10 <sup>-5</sup>	0.0007	2.06 x 10 <sup>-2</sup>	0.432
Batch Mixture H <sub>3</sub> AsO <sub>4</sub>															
P-4-I	11/01/83	0900-1123	389	11.0	2380	79.01	84.56	0.082	84.64	1.65 x 10 <sup>-2</sup>	0.337	1.60 x 10 <sup>-5</sup>	0.0003	1.65 x 10 <sup>-2</sup>	0.337
P-5-I	11/01/83	1415-1632	382	11.6	2310	75.28	114.44	0.332	114.77	2.35 x 10 <sup>-2</sup>	0.465	6.80 x 10 <sup>-5</sup>	0.0014	2.35 x 10 <sup>-2</sup>	0.466
P-6-I	11/02/83	0902-1121	379	11.6	2320	77.40	122.52	0.403	122.92	2.44 x 10 <sup>-2</sup>	0.486	8.03 x 10 <sup>-5</sup>	0.0016	2.45 x 10 <sup>-2</sup>	0.488
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	383	11.4	2340	77.23	107.17	0.272	107.44	2.15 x 10 <sup>-2</sup>	0.429	5.48 x 10 <sup>-5</sup>	0.0011	2.15 x 10 <sup>-2</sup>	0.430

\* Standard Conditions: 29.92 in. Hg @ 68 degrees F.  
All tests were 100 ± 10% isokinetic.

TABLE 2-1B

SUMMARY OF PRIMARY ARSENIC EMISSION TESTING AT THE BSP INLET (Metric Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Stack Gas Conditions			Volume (Nm <sup>3</sup> )	Sample			Arsenic Emissions				Total		
			Temperature (°C)	Moisture (%)	Flowrate (Nm <sup>3</sup> /min)*		Arsenic Catch (mg)			Particulate (Front Half)		Gaseous (Back Half)		Total		
							Particulate (Front Half)	Gaseous (Back Half)	Total	(mg/Nm <sup>3</sup> )	(g/hr)	(mg/Nm <sup>3</sup> )	(g/hr)	(mg/Nm <sup>3</sup> )	(g/hr)	
Batch Mixture As <sub>2</sub> O <sub>3</sub>																
P-1-I	10/11/83	0914-1138	197	10.1	69.4	2.32	92.84	0.053	92.89	40.02	166	2.28 x 10 <sup>-2</sup>	9.51 x 10 <sup>-2</sup>	40.1	166.1	
P-2-I	10/11/83	1358-1618	199	10.5	71.9	2.47	126.3	0.204	126.5	51.13	221	8.26 x 10 <sup>-2</sup>	3.56 x 10 <sup>-1</sup>	51.3	221.3	
P-3-I	10/12/83	0957-1217	194	11.2	67.1	2.29	114.0	0.283	114.3	49.78	200	1.24 x 10 <sup>-1</sup>	4.98 x 10 <sup>-1</sup>	49.9	200.5	
			---	---	---	---	---	---	---	---	---	---	---	---	---	
Average	-	-	197	10.6	69.4	2.36	111.0	0.180	111.2	46.98	196	7.65 x 10 <sup>-2</sup>	3.16 x 10 <sup>-1</sup>	47.2	196.3	
Batch Mixture H <sub>3</sub> AsO <sub>4</sub>																
P-4-I	11/01/83	0900-1123	198	11.0	67.4	2.24	84.56	0.082	84.64	37.8	153	3.66 x 10 <sup>-2</sup>	1.48 x 10 <sup>-1</sup>	37.8	153.1	
P-5-I	11/01/83	1415-1632	194	11.6	65.4	2.13	114.44	0.332	114.77	53.7	211	1.56 x 10 <sup>-1</sup>	6.11 x 10 <sup>-1</sup>	53.8	211.6	
P-6-I	11/02/83	0902-1121	193	11.6	65.7	2.19	122.52	0.403	122.92	55.9	221	1.84 x 10 <sup>-1</sup>	7.25 x 10 <sup>-1</sup>	56.1	221.7	
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Average	-	-	195	11.4	66.3	2.19	107.17	0.272	107.44	49.2	195	1.26 x 10 <sup>-1</sup>	4.95 x 10 <sup>-1</sup>	49.2	195.5	

\* Standard Conditions: 760 mm Hg @ 20 degrees C.  
All tests were 100 ± 10% isokinetic.

TABLE 2-2A

SUMMARY OF PRIMARY ARSENIC EMISSION TESTING AT THE ESP OUTLET (English Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Stack Gas Conditions			Volume (DSCFM)	Sample Arsenic Catch (mg)			Arsenic Emissions				Total	
			Temperature (°F)	Moisture (%)	Flowrate (DSCF)*		Particulate (Front Half)	Gaseous (Back Half)	Total	Particulate		Gaseous		(gr/DSCF)	(Lbs/hr)
										(gr/DSCF)	(Lbs/hr)	(gr/DSCF)	(Lbs/hr)		
Batch Mixture As <sub>2</sub> O <sub>3</sub>															
P-1-O	10/11/83	0914-1116	205	7.8	4050	82.71	2.34	0.008	2.348	4.37 x 10 <sup>-4</sup>	0.0152	1.46 x 10 <sup>-6</sup>	0.0001	4.38 x 10 <sup>-4</sup>	0.0152
P-2-O	10/11/83	1420-1619	205	8.1	3920	78.41	1.65	0.026	1.676	3.25 x 10 <sup>-4</sup>	0.0109	5.12 x 10 <sup>-6</sup>	0.0002	3.30 x 10 <sup>-4</sup>	0.0111
P-3-O	10/12/83	0955-1158	207	9.0	3680	73.91	0.85	0.121	0.971	2.03 x 10 <sup>-4</sup>	0.0056	2.52 x 10 <sup>-5</sup>	0.0008	2.28 x 10 <sup>-4</sup>	0.0064
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	206	8.3	3880	78.34	1.61	0.052	1.665	3.22 x 10 <sup>-4</sup>	0.0106	1.06 x 10 <sup>-5</sup>	0.0004	3.32 x 10 <sup>-4</sup>	0.0109
Batch Mixture H <sub>3</sub> AsO <sub>4</sub>															
P-4-O	11/01/83	0905-1110	196	7.5	4100	87.90	0.69	0.024	0.714	1.21 x 10 <sup>-4</sup>	0.0043	4.21 x 10 <sup>-6</sup>	0.0001	1.25 x 10 <sup>-4</sup>	0.0044
P-5-O	11/01/83	1417-1617	201	8.0	3890	83.56	1.36	0.067	1.427	2.51 x 10 <sup>-4</sup>	0.0083	1.22 x 10 <sup>-5</sup>	0.0004	2.64 x 10 <sup>-4</sup>	0.0088
P-6-O	11/02/83	0910-1113	196	7.7	3870	84.23	1.22	0.081	1.301	2.24 x 10 <sup>-4</sup>	0.0074	1.49 x 10 <sup>-5</sup>	0.0005	2.38 x 10 <sup>-4</sup>	0.0079
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	197	7.7	3950	85.23	1.09	0.057	1.147	1.99 x 10 <sup>-4</sup>	0.0067	1.04 x 10 <sup>-5</sup>	0.0003	2.09 x 10 <sup>-4</sup>	0.0070

\* Standard Conditions: 29.92 in. Hg @ 68 degrees F.  
All tests were 100 ± 10% isokinetic.

TABLE 2-2B

SUMMARY OF PRIMARY ARSENIC EMISSION TESTING AT THE ESP OUTLET (Metric Units)  
THE FOSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Stack Gas Conditions			Volume (Nm <sup>3</sup> )	Sample			Arsenic Emissions				Total	
			Temperature (°C)	Moisture (%)	Flowrate (Nm <sup>3</sup> /min)*		Arsenic Catch (mg)			Particulate (Front Half)		Gaseous (Back Half)		Total	
							Particulate (Front Half)	Gaseous (Back Half)	Total	(mg/Nm <sup>3</sup> )	(g/hr)	(mg/Nm <sup>3</sup> )	(g/hr)	(mg/Nm <sup>3</sup> )	(g/hr)
Batch Mixture As <sub>2</sub> O <sub>3</sub>															
P-1-O	10/11/83	0914-1116	96.1	7.8	115	2.34	2.34	0.008	2.348	1.00	6.90	3.42 x 10 <sup>-3</sup>	2.36 x 10 <sup>-2</sup>	1.00	6.90
P-2-O	10/11/83	1420-1619	96.1	8.1	111	2.22	1.65	0.026	1.676	0.740	4.95	1.17 x 10 <sup>-2</sup>	7.80 x 10 <sup>-2</sup>	0.756	5.04
P-3-O	10/12/83	0955-1158	97.2	9.0	104	2.09	0.85	0.121	0.971	0.408	2.54	5.79 x 10 <sup>-2</sup>	3.61 x 10 <sup>-1</sup>	0.465	2.91
			----	---	---	----	----	-----	-----	-----	----	-----	-----	-----	-----
Average	-	-	96.7	8.3	110	2.22	1.61	0.052	1.665	0.717	4.81	2.43 x 10 <sup>-2</sup>	1.54 x 10 <sup>-1</sup>	0.740	4.95
Batch Mixture H <sub>2</sub> SO <sub>4</sub>															
P-4-O	11/01/83	0905-1110	91.1	7.5	116	2.49	0.69	0.024	0.714	0.277	1.95	9.64 x 10 <sup>-3</sup>	6.71 x 10 <sup>-2</sup>	0.286	2.00
P-5-O	11/01/83	1417-1617	93.9	8.0	110	2.37	1.36	0.067	1.427	0.575	3.77	2.81 x 10 <sup>-2</sup>	1.85 x 10 <sup>-1</sup>	0.605	4.00
P-6-O	11/02/83	0910-1113	91.1	7.7	110	2.39	1.22	0.081	1.301	0.513	3.36	3.41 x 10 <sup>-2</sup>	2.25 x 10 <sup>-1</sup>	0.545	3.59
			----	---	---	----	----	-----	-----	-----	----	-----	-----	-----	-----
Average	-	-	92.0	7.7	112	2.42	1.09	0.057	1.147	0.456	3.04	2.40 x 10 <sup>-2</sup>	1.58 x 10 <sup>-1</sup>	0.479	3.18

\* Standard Conditions: 760 mm Hg @ 20 degrees C.  
All tests were 100 ± 10% isokinetic.

TABLE 2-3

MEASURED ESP ARSENIC COLLECTION EFFICIENCY  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Flowrate (DSCFM)*	Inlet Arsenic Emissions (Lbs/hr)			Flowrate (DSCFM)*	Outlet Arsenic Emissions (Lbs/hr)			ESP Arsenic Collection Efficiency** (%)		
				Particulate	Gaseous	Total		Particulate	Gaseous	Total	Particulate	Gaseous***	Total
(As <sub>2</sub> O <sub>3</sub> )													
P-1	10/11/83	0914-1138	2450	0.366	0.0002	0.366	4050	0.0152	0.0001	0.0152	95.8	50.0	95.8
P-2	10/11/83	1358-1619	2540	0.487	0.0008	0.487	3920	0.0109	0.0002	0.0111	97.7	75.0	97.7
P-3	10/12/83	0955-1217	2370	0.441	0.0011	0.443	3680	0.0056	0.0008	0.0064	98.7	27.2	98.6
			----	-----	-----	-----	----	-----	-----	-----	----	----	----
Average			2450	0.431	0.0007	0.432	3880	0.0106	0.0004	0.0109	97.5	42.9	97.5
(H <sub>3</sub> AsO <sub>4</sub> )													
P-4	11/01/83	0900-1123	2380	0.337	0.0003	0.337	4100	0.0043	0.0001	0.0044	98.7	66.7	98.7
P-5	11/01/83	1415-1632	2310	0.465	0.0014	0.466	3890	0.0083	0.0004	0.0088	98.2	71.4	98.1
P-6	11/02/83	0902-1121	2320	0.486	0.0016	0.488	3870	0.0074	0.0005	0.0079	98.5	68.8	98.4
			----	-----	-----	-----	----	-----	-----	-----	----	----	----
Average			2340	0.429	0.0011	0.430	3950	0.0067	0.0003	0.0070	98.4	72.7	98.4

\* Standard Conditions: 29.92 in. Hg @ 68 degrees F.

\*\* Percent Efficiency =  $\frac{(\text{Lbs/hr in}) - (\text{Lbs/hr out})}{(\text{Lbs/hr in})} \times 100$

\*\*\* Not actual efficiency - see text.

(0.432 lbs/hr) or  $47.2 \text{ mg/Nm}^3$  (196 g/hr). 99.8% of the collected arsenic was in the particulate phase. The average volumetric flowrate of gases entering the ESP was 2450 DSCFM ( $69.4 \text{ Nm}^3/\text{min}$ ) at  $387^\circ\text{F}$  ( $197^\circ\text{C}$ ) and 10.6% moisture (v/v).

During Tests P-4, P-5, and P-6 at the ESP Inlet, particulate arsenic (front half) emissions averaged  $2.15 \times 10^{-2} \text{ gr/DSCF}$  (0.429 lbs/hr) or  $49.2 \text{ mg/Nm}^3$  (195 g/hr). Gaseous arsenic (back half) emissions averaged  $5.48 \times 10^{-5} \text{ gr/DSCF}$  (0.0011 lbs/hr) or  $1.26 \times 10^{-1} \text{ mg/Nm}^3$  ( $4.99 \times 10^{-1} \text{ g/hr}$ ). The average total arsenic emission rate was  $2.15 \times 10^{-2} \text{ gr/DSCF}$  (0.430 lbs/hr) or  $49.2 \text{ mg/Nm}^3$  (195 g/hr). 99.7% of the collected arsenic was in the particulate phase. The average volumetric flowrate of gases entering the ESP during these tests was 2340 DSCFM ( $66.3 \text{ Nm}^3/\text{min}$ ) at  $383^\circ\text{F}$  ( $195^\circ\text{C}$ ) and 11.4% moisture.

These results indicate that no significant differences in particulate, gaseous, or total arsenic emissions are realized by changing raw batch constituent mixtures from arsenic trioxide to arsenic acid.

Leak checks were performed following each test and found acceptable at less than 0.02 cfm. Isokinesis was  $100 \pm 10\%$  for each test performed.

#### 2.2.2 ESP Outlet

Each primary arsenic emission test performed at the ESP Outlet was 120 minutes in duration. These tests were performed simultaneously with the primary tests at the ESP Inlet.

During Tests P-1, P-2, and P-3 at the ESP Outlet ( $\text{As}_2\text{O}_3$  in the raw batch mixture), particulate arsenic (front half) emissions averaged  $3.22 \times 10^{-4} \text{ gr/DSCF}$  (0.0106 lbs/hr) or  $0.717 \text{ mg/Nm}^3$  (4.81 g/hr). Gaseous arsenic (back half) emissions averaged  $1.06 \times 10^{-5} \text{ gr/DSCF}$  (0.0004 lbs/hr) or

$2.43 \times 10^{-2}$  mg/Nm<sup>3</sup> (0.154 g/hr). Total arsenic emissions from the ESP averaged  $3.22 \times 10^{-4}$  gr/DSCF (0.0109 lbs/hr) or 0.740 mg/Nm<sup>3</sup> (4.95 g/hr). Particulate phase arsenic accounted for 96.7% of the total arsenic collected. The average volumetric flowrate exiting the ESP was 3880 DSCFM (110 Nm<sup>3</sup>/min) at 206°F (96.7°C) and 8.3% moisture (v/v).

During Tests P-4, P-5, and P-6 (H<sub>3</sub>AsO<sub>4</sub> in the raw batch mixture) at the ESP Outlet, particulate arsenic (front half) emissions averaged  $1.99 \times 10^{-4}$  gr/DSCF (0.0067 lbs/hr) or 0.456 mg/Nm<sup>3</sup> (3.04 g/hr). The average gaseous arsenic (back half) emission rate was  $1.04 \times 10^{-5}$  gr/DSCF (0.0003 lbs/hr) or  $2.40 \times 10^{-2}$  mg/Nm<sup>3</sup> (0.158 g/hr). The average total arsenic emission rate was  $2.09 \times 10^{-4}$  gr/DSCF (0.0070 lbs/hr) or 0.479 mg/Nm<sup>3</sup> (3.18 g/hr). Particulate phase arsenic accounted for 95% of the total arsenic sample catch. The average volumetric flowrate of gases exiting the ESP was 3950 DSCFM (112 Nm<sup>3</sup>/min) at 196°F (92.0°C) and 7.7% moisture (v/v).

The differences in arsenic emissions measured between tests performed with arsenic trioxide and arsenic acid in the raw batch mixtures are probably attributable to the increase in precipitator collection efficiencies as discussed in Section 2.2.3.

Leak checks were performed following each test and found acceptable at less than 0.02 cfm. Isokinesis was  $100 \pm 10\%$  for each test performed.

### 2.2.3 ESP Arsenic Collection Efficiency

The measured arsenic collection efficiencies (%) of the ESP during the primary test program are presented in Table 2-3. Approximately 58% more gas was measured exiting the ESP than was measured entering the ESP at standard conditions. This was due to ambient air leaking into the system at various

points (e.g., the recuperator and I.D. fan). For this reason, collection efficiency was calculated using actual emission rates rather than emission concentrations. In addition, the collection efficiencies for particulate arsenic and gaseous arsenic presented do not take into account any phase change of the arsenic as the gas temperatures decrease from approximately 400°F at the ESP Inlet to approximately 200°F at the ESP Outlet.

During Tests P-1, P-2, and P-3, with  $\text{As}_2\text{O}_3$  in the raw batch, the particulate arsenic collection efficiency of the ESP averaged 97.5%, while the measured gaseous arsenic collection efficiency averaged 42.9%, probably due in the most part to arsenic phase change rather than actual collection. The average total arsenic collection efficiency was 97.5%.

During Tests P-4, P-5, and P-6, with  $\text{H}_3\text{AsO}_4$  in the raw batch, the particulate arsenic collection efficiency of the ESP averaged 98.4%, while the measured gaseous arsenic collection efficiency averaged 72.7%, also probably due to arsenic phase change rather than actual collection. The average total arsenic collection efficiency for these tests was 98.4%.

### 2.3 Secondary Arsenic Emission Tests

During the secondary arsenic emission tests performed at the ESP Inlet, emissions were sampled with two trains simultaneously at two single points of approximately equal temperatures and velocities. Sampling probe and filter outlet gas stream temperatures were varied between the two trains at  $250 \pm 25^\circ\text{F}$  and  $550 \pm 25^\circ\text{F}$  in order to determine the effect of elevated temperatures on the phase (particulate or gaseous) of the arsenic. It was hypothesized that as temperatures were increased, more arsenic would be in the gaseous phase and therefore captured in the back half (impingers) of the sampling train rather than on the glass fiber filter (front half).



A summary of measured particulate arsenic and gaseous arsenic emission data collected during the secondary testing at the ESP Inlet is presented in Tables 2-4A (English units) and 2-4B (metric units). These tables include test dates and times, raw batch mixture, probe and filtered gas stream temperatures, stack gas temperatures, moisture contents, and velocities; sample volumes and catches; as well as particulate arsenic, gaseous arsenic, and total arsenic concentrations. Data is presented for three sets of secondary tests with  $\text{As}_2\text{O}_3$  in the raw batch mixture (Tests S-1, S-2, and S-3) and three more sets of secondary tests with  $\text{H}_3\text{AsO}_4$  in the raw batch mixture (Tests S-4, S-5, and S-6).

Secondary arsenic emission tests were originally planned to be 120 minutes in duration. It became apparent, however, that the tests could not run this long due to high particulate loading and the low vacuum capability of the thimble-type filters used for this test program. These filter holders were used for their high temperature capability needed to maintain filter outlet temperatures at  $550 \pm 25^\circ\text{F}$ . The sampling time was shortened to 90 minutes for Test S-1. Tests S-2 and S-3 were shortened even more as sampling train vacuums approached the maximum rating for the thimble filters. Smaller nozzles were used for Tests S-4, S-5, and S-6, thereby reducing the sample volume and allowing 90 minute tests. The minimum allowable sample volume of 30 DSCF was exceeded for all tests.

During testing performed with arsenic trioxide in the raw batch, particulate arsenic accounted for an average of 99.6% of the total sample catch with a filtered gas stream temperature of  $250^\circ \pm 25^\circ\text{F}$  and 99.7% of the total sample catch with a filtered gas stream temperature of  $550^\circ \pm 25^\circ\text{F}$ . During testing performed with arsenic acid in the raw batch, particulate arsenic accounted for 99.4% of the total sample catch with a

TABLE 2-4A

SUMMARY OF SECONDARY ARSENIC EMISSION TESTING AT BSP INLET (English Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Filtered Gas Stream Temp. ( $\pm 25^{\circ}\text{F}$ )	Stack Gas Conditions			Volume (DSCFH)**	Sample Arsenic Catch (mg)			Particulate (Front Half) (gr/DSCP)	Arsenic Emissions		Total (gr/DSCP)
				Temperature ( $^{\circ}\text{F}$ )	Moisture (%)	Velocity* (fpm)		Arsenic Catch (mg)		Gaseous (Back Half) (gr/DSCP)		Total		
								Particulate (Front Half)	Gaseous (Back Half)					
Batch Mixture $\text{As}_2\text{O}_3$														
S-1A-I	10/12/83	1516-1646	550	396	12.4	1560	57.75	71.29	0.237	71.53	$1.90 \times 10^{-2}$	$6.33 \times 10^{-5}$	$1.91 \times 10^{-2}$	
S-1B-I	10/12/83	1515-1645	250	372	12.6	1510	60.48	98.93	0.135	99.07	$2.52 \times 10^{-2}$	$3.44 \times 10^{-5}$	$2.53 \times 10^{-2}$	
S-2A-I	10/13/83	0901-1006	550	379	11.6	1330	35.64	59.60	0.196	59.80	$2.58 \times 10^{-2}$	$8.47 \times 10^{-5}$	$2.59 \times 10^{-2}$	
S-2B-I	10/13/83	0901-1006	250	403	12.8	1490	41.69	70.75	0.226	70.98	$2.62 \times 10^{-2}$	$8.36 \times 10^{-5}$	$2.63 \times 10^{-2}$	
S-3A-I	10/13/83	1300-1415	550	389	11.9	1480	45.23	61.10	0.175	61.28	$2.09 \times 10^{-2}$	$5.95 \times 10^{-5}$	$2.09 \times 10^{-2}$	
S-3B-I	10/13/83	1300-1415	250	386	11.9	1430	46.17	77.94	0.697	78.64	$2.61 \times 10^{-2}$	$2.33 \times 10^{-4}$	$2.63 \times 10^{-2}$	
			---	---	---	---	---	---	---	---	---	---	---	
Average A			550	388	12.0	1460	46.21	64.00	0.203	64.20	$2.19 \times 10^{-2}$	$6.52 \times 10^{-5}$	$2.19 \times 10^{-2}$	
Average B			250	387	12.4	1480	49.45	82.54	0.353	82.90	$2.58 \times 10^{-2}$	$1.17 \times 10^{-4}$	$2.60 \times 10^{-2}$	
-----														
Batch Mixture $\text{H}_3\text{AsO}_4$														
S-4A-I	11/02/83	1437-1607	250	395	11.2	1300	35.42	60.20	0.345	60.55	$2.62 \times 10^{-2}$	$1.50 \times 10^{-4}$	$2.64 \times 10^{-2}$	
S-4B-I	11/02/83	1437-1607	550	402	11.2	1550	41.97	58.60	0.284	58.92	$2.15 \times 10^{-2}$	$1.04 \times 10^{-4}$	$2.17 \times 10^{-2}$	
S-5A-I	11/03/83	0909-1039	250	385	12.2	1560	43.21	54.00	0.221	54.22	$1.93 \times 10^{-2}$	$7.88 \times 10^{-5}$	$1.94 \times 10^{-2}$	
S-5B-I	11/03/83	0909-1039	550	395	12.4	1600	42.52	50.6	0.181	50.80	$1.84 \times 10^{-2}$	$6.55 \times 10^{-5}$	$1.84 \times 10^{-2}$	
S-6A-I	11/03/83	1327-1457	250	381	11.9	1240	34.44	33.80	0.207	34.01	$1.51 \times 10^{-2}$	$9.29 \times 10^{-5}$	$1.52 \times 10^{-2}$	
S-6B-I	11/03/83	1327-1457	550	320	12.0	1310	37.60	40.0	0.176	40.18	$1.64 \times 10^{-2}$	$7.22 \times 10^{-5}$	$1.64 \times 10^{-2}$	
			---	---	---	---	---	---	---	---	---	---	---	
Average A			250	387	11.8	1370	37.69	49.30	0.257	49.59	$2.02 \times 10^{-2}$	$1.07 \times 10^{-4}$	$2.03 \times 10^{-2}$	
Average B			550	372	11.9	1490	41.70	49.70	0.214	49.97	$1.88 \times 10^{-2}$	$8.06 \times 10^{-5}$	$1.88 \times 10^{-2}$	

\* Single point samples: only velocity reported.

\*\* Standard Conditions: 29.92 in. Hg @ 68 degrees F.

All tests were  $100 \pm 10\%$  isokinetic.

TABLE 2-4B

SUMMARY OF SECONDARY ARSENIC EMISSION TESTING AT ESP INLET (Metric Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Filtered Gas Stream Temp. ( $\pm 14^{\circ}\text{C}$ )	Stack Gas Conditions			Volume ( $\text{Nm}^3$ )	Sample Arsenic Catch (mg)			Particulate (Front Half) ( $\text{mg}/\text{Nm}^3$ )	Arsenic Emissions		Total ( $\text{mg}/\text{Nm}^3$ )
				Temperature ( $^{\circ}\text{C}$ )	Moisture (%)	Velocity (M/min)		Particulate (Front Half)	Gaseous (Back Half)	Total		Gaseous (Back Half) ( $\text{mg}/\text{Nm}^3$ )		
Batch Mixture $\text{As}_2\text{O}_3$														
S-1A-I	10/12/83	1516-1646	288	202	12.4	475	1.64	71.29	0.237	71.53	43.5	$1.45 \times 10^{-1}$		43.7
S-1B-I	10/12/83	1515-1645	121	189	12.6	460	1.71	98.93	0.135	99.07	57.8	$0.79 \times 10^{-1}$		57.9
S-2A-I	10/13/83	0901-1006	288	193	11.6	405	1.01	59.60	0.169	59.77	59.0	$1.67 \times 10^{-1}$		59.3
S-2B-I	10/13/83	0901-1006	121	206	12.8	454	1.18	70.75	0.226	70.98	60.0	$1.92 \times 10^{-1}$		60.2
S-3A-I	10/13/83	1300-1415	288	198	11.9	451	1.28	61.10	0.175	61.28	47.7	$1.37 \times 10^{-1}$		48.0
S-3B-I	10/13/83	1300-1415	121	197	11.9	436	1.31	77.94	0.697	78.64	59.5	$5.32 \times 10^{-1}$		60.2
			---	---	---	---	---	---	---	---	---	---	---	---
Average A			121	198	12.0	445	1.31	64.00	0.194	64.19	50.1	$1.49 \times 10^{-1}$		50.2
Average B			288	197	12.4	451	1.40	82.54	0.353	82.90	59.1	$2.68 \times 10^{-1}$		59.5
Batch Mixture $\text{H}_3\text{AsO}_4$														
S-4A-I	11/02/83	1437-1607	121	202	11.2	396	1.00	60.2	0.345	60.55	60.2	$3.45 \times 10^{-1}$		60.5
S-4B-I	11/02/83	1437-1607	288	206	11.2	472	1.19	58.6	0.284	58.92	49.2	$2.39 \times 10^{-1}$		49.6
S-5A-I	11/03/83	0909-1039	121	196	12.2	475	1.22	54.0	0.221	54.22	44.3	$1.81 \times 10^{-1}$		44.5
S-5B-I	11/03/83	0909-1039	288	202	12.4	488	1.20	50.6	0.181	50.80	42.2	$1.51 \times 10^{-1}$		42.2
S-6A-I	11/03/83	1327-1457	121	194	11.9	378	0.98	33.8	0.207	34.01	34.5	$2.11 \times 10^{-1}$		34.7
S-6B-I	11/03/83	1327-1457	288	160	12.0	399	1.06	40.0	0.176	40.18	37.7	$1.66 \times 10^{-1}$		37.9
			---	---	---	---	---	---	---	---	---	---	---	---
Average A			121	197	11.8	418	1.07	49.3	0.257	49.59	46.3	$2.46 \times 10^{-1}$		46.6
Average B			288	189	11.9	454	1.18	49.7	0.214	49.97	43.0	$1.85 \times 10^{-1}$		43.2

\* Single point samples: only velocity reported.

\*\* Standard Conditions: 760 mm Hg @  $20^{\circ}\text{C}$ .All tests were  $100 \pm 10\%$  isokinetic.

filtered gas stream temperature of  $250^{\circ} \pm 25^{\circ}\text{F}$  and 99.5% of the total sample catch with a filtered gas stream temperature of  $550^{\circ} \pm 25^{\circ}\text{F}$ . As is demonstrated by these results, there are no significant differences in arsenic phase effected by the alteration of filtered gas stream temperatures or raw catch mixture constituents.

#### 2.4 Secondary Particulate Emission Tests

Secondary testing was performed at the ESP Outlet concurrent with secondary testing at the ESP Inlet to determine the emission rate of particulate and condensible organic matter in accordance with EPA Method 5A. A summary of these measured particulate emissions is presented in Table 2-5A (English units) and 2-5B (metric units). These tables include sampling dates and times, raw batch mixture, stack gas temperatures, moistures, and flowrates; sample volumes and catches; and particulate, condensible organics, and total particulate concentrations and emission rates.

Particulate (front half) emissions from the ESP during Tests S-1, S-2, and S-3 (with  $\text{As}_2\text{O}_3$  in the raw batch) averaged 0.211 lbs/hr ( $6.86 \times 10^{-3}$  gr/DSCF) or 95.6 g/hr ( $15.7 \text{ mg/Nm}^3$ ). Condensible organic (back half) emissions averaged 0.048 lbs/hr ( $1.56 \times 10^{-3}$  gr/DSCF) or 21.8 g/hr ( $3.58 \text{ mg/Nm}^3$ ). Total particulate emissions averaged 0.259 lbs/hr ( $8.43 \times 10^{-3}$  gr/DSCF) or 118 g/hr ( $19.3 \text{ mg/Nm}^3$ ). The average volumetric flowrate measured was 3580 DSCPM ( $101 \text{ Nm}^3/\text{min}$ ) at  $204^{\circ}\text{F}$  ( $95.6^{\circ}\text{C}$ ) and 9.3% moisture (v/v).

Particulate (front half) emissions from the ESP during Tests S-4, S-5, and S-6 (with  $\text{H}_3\text{AsO}_4$  in the raw batch) averaged 0.122 lbs/hr ( $3.79 \times 10^{-3}$  gr/DSCF) or 55.1 g/hr ( $8.68 \text{ mg/Nm}^3$ ). Condensible organic (back half) emissions averaged 0.019 lbs/hr ( $0.60 \times 10^{-3}$  gr/DSCF) or 8.81 g/hr

TABLE 2-5A

SUMMARY OF PARTICULATE EMISSION TESTING AT THE ESP OUTLET (English Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Stack Gas Conditions			Volume (DSCPM)	Sample		Total	Particulate Emissions				Total	
			Temperature (°F)	Moisture (%)	Flowrate (DSCPM)*		Particulate Catch (mg)			Particulate (Front Half)		Gaseous (Back Half)		Total	
							Particulate (Front Half)	Condensible Organic (Back Half)		(gr/DSCP)	(Lbs/hr)	(gr/DSCP)	(Lbs/hr)	(gr/DSCP)	(Lbs/hr)
Batch Mixture As <sub>2</sub> O <sub>3</sub>															
S-1-O	10/12/83	1520-1731	209	9.1	3560	105.97	42.88	9.42	52.30	6.24 x 10 <sup>-3</sup>	0.191	1.37 x 10 <sup>-3</sup>	0.042	7.62 x 10 <sup>-3</sup>	0.233
S-2-O	10/13/83	0900-1102	204	9.5	3560	108.62	42.91	9.67	52.58	6.10 x 10 <sup>-3</sup>	0.186	1.37 x 10 <sup>-3</sup>	0.042	7.47 x 10 <sup>-3</sup>	0.228
S-3-O	10/13/83	1253-1459	199	9.3	3630	110.14	58.88	13.87	72.75	8.25 x 10 <sup>-3</sup>	0.256	1.95 x 10 <sup>-3</sup>	0.060	10.19 x 10 <sup>-3</sup>	0.317
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	204	9.3	3580	108.24	48.22	10.99	59.21	6.86 x 10 <sup>-3</sup>	0.211	1.56 x 10 <sup>-3</sup>	0.048	8.43 x 10 <sup>-3</sup>	0.259
Batch Mixture H <sub>3</sub> AsO <sub>4</sub>															
S-4-O	11/02/83	1415-1620	193	7.6	3700	109.46	29.66	5.51	35.17	4.18 x 10 <sup>-3</sup>	0.133	0.78 x 10 <sup>-3</sup>	0.025	4.95 x 10 <sup>-3</sup>	0.157
S-5-O	11/03/83	0902-1104	188	8.3	3690	108.39	22.56	3.75	26.31	3.21 x 10 <sup>-3</sup>	0.102	0.53 x 10 <sup>-3</sup>	0.017	3.74 x 10 <sup>-3</sup>	0.119
S-6-O	11/03/83	1305-1507	182	7.9	3810	112.11	29.01	3.66	32.67	3.99 x 10 <sup>-3</sup>	0.130	0.50 x 10 <sup>-3</sup>	0.016	4.50 x 10 <sup>-3</sup>	0.147
			---	---	---	---	---	---	---	---	---	---	---	---	---
Average	-	-	188	7.9	3730	109.99	27.08	4.31	31.38	3.79 x 10 <sup>-3</sup>	0.122	0.60 x 10 <sup>-3</sup>	0.019	4.40 x 10 <sup>-3</sup>	0.141

\* Standard Conditions: 29.92 in Hg @ 68 degrees F.  
All tests were 100 ± 10% isokinetic.

TABLE 2-58

SUMMARY OF PARTICULATE EMISSION TESTING AT THE ESP OUTLET (Metric Units)  
THE POSTORIA GLASS COMPANY, MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Time	Stack Gas Conditions			Volume (Nm <sup>3</sup> )	Sample			Particulate Emissions				Total	
			Temperature (°C)	Moisture (%)	Flowrate (Nm <sup>3</sup> /min)*		Particulate Catch (mg)			Particulate		Gaseous			
							Particulate (Front Half)	Condensible Organic (Back Half)	Total	(mg/Nm <sup>3</sup> )	(g/hr)	(mg/Nm <sup>3</sup> )	(g/hr)		
Batch Mixture As <sub>2</sub> O <sub>3</sub>															
S-1-0	10/12/83	1520-1731	93.3	9.1	100.8	3.00	42.88	9.42	52.30	14.3	86.5	3.14	19.0	17.5	106
S-2-0	10/13/83	0900-1102	95.6	9.5	100.8	3.08	42.91	9.67	52.58	13.9	84.3	3.14	19.0	17.0	104
S-3-0	10/13/83	1253-1459	92.8	9.3	102.8	3.12	58.88	13.87	72.75	18.9	116	4.45	27.4	23.3	143
			----	---	-----	----	-----	-----	-----	----	----	----	----	----	---
Average	-	-	95.6	9.3	101.3	3.07	48.22	10.99	59.21	15.7	95.6	3.58	21.8	19.3	118
Batch Mixture H <sub>3</sub> AsO <sub>4</sub>															
S-4-0	11/02/83	1415-1620	89.4	7.6	104.8	3.10	29.66	5.51	35.17	9.57	60.2	1.78	11.2	11.4	71.4
S-5-0	11/03/83	0902-1104	86.7	8.3	104.5	3.07	22.56	3.75	26.31	7.35	46.1	1.22	7.59	8.57	53.7
S-6-0	11/03/83	1305-1507	83.3	7.9	107.6	3.17	29.01	3.66	32.67	9.15	59.1	1.15	7.45	10.3	66.6
			----	---	-----	----	-----	-----	-----	----	----	----	----	----	----
Average	-	-	86.7	7.9	105.6	3.11	27.08	4.31	31.38	8.68	55.1	1.36	8.81	10.1	63.9

\* Standard Conditions: 760 mm Hg @ 20 degrees C.  
All tests were 100 ± 10% isokinetic.

(1.36 mg/Nm<sup>3</sup>). Total particulate emissions averaged 0.141 lbs/hr (4.40 x 10<sup>-3</sup> gr/DSCF) or 63.9 g/hr(10.1 mg/Nm<sup>3</sup>). The average volumetric flowrate measured was 3730 DSCFM (106 Nm<sup>3</sup>/min) at 188<sup>0</sup>F (86.7<sup>0</sup>C) and 7.9% moisture (v/v).

The average total particulate emission rate measured during tests S-1, S-2, and S-3 was almost twice the average measured during tests S-4, S-5, and S-6. Primary testing indicated a greater particulate arsenic collection efficiency during the week of October 31 than during the week of October 10. If particulate collection efficiency followed the same trend later in the week of October 31, it could be a possible explanation of the reduced particulate emissions.

#### 2.5 Visible Emissions Evaluation

Visible emissions from the ESP were evaluated by a certified observer during each emission test performed. Evaluations began at least 10 minutes prior to the start of each test and concluded at least 10 minutes after the end of that test.

Although a plume opacity of 5% was observed occasionally, all six-minute opacity averages were zero, with the exception of a six-minute period from 1106 to 1112 during Test P-1 with a six-minute average of 3.75% was observed. Visible emission evaluation field data is presented in Appendix C-3.

#### 2.6 Clean-up Evaluations

A clean-up evaluation of each sampling train used was performed on-site prior to each part of the emission measurement program. A summary of the results of these evaluations is presented in Table 2-6. All results in Tables 2-1 through 2-5 have been corrected for the "blank" values determined during the clean-up evaluation.

TABLE 2-6

CLEAN-UP EVALUATIONS  
METHOD 108 AND METHOD 5A  
THE FOSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Sample	Date	Parameter	Sample Catch (mg)	
			Front	Back
(As <sub>2</sub> O <sub>3</sub> ) B-O-O	10/10	As	<0.053	0.0045
B-I-O <sub>A</sub>	10/10	As	<0.053	<0.0017
B-I-O <sub>B</sub>	10/10	As	<0.270	<0.0016
B-O-P	10/10	Particulate	<2.56	<5.95
(H <sub>3</sub> AsO <sub>4</sub> ) B-O-O	10/31	As	0.597	0.0013
B-I-O <sub>A</sub>	10/31	As	0.338	0.0047
B-I-O <sub>B</sub>	10/31	As	0.724	0.0011
B-O-P	10/31	Particulate	2.46	4.50



## 2.7 Product Sample Analyses

Samples of crystal were taken from the annealinglehr at regular intervals during each emission test performed. These samples were composited, pulverized, digested and analyzed for arsenic content by atomic absorption spectrophotometry. Results are presented in Table 2-7. With  $\text{As}_2\text{O}_3$  in the raw batch mixture, the finished crystal contained on average of 3000  $\mu\text{g}$  As per gram of glass and varied slightly between samples. With  $\text{H}_3\text{AsO}_4$  in the raw batch, the finished crystal contained an average of 2700  $\mu\text{g}$ As per gram of glass. Concentrations varied from 2080  $\mu\text{g}$ As per gram to 3568  $\mu\text{g}$ As per gram of glass.

TABLE 2-7  
ARSENIC CONTENT ANALYSES OF CRYSTAL  
THE POSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Raw Batch Mixture	Arsenic Content ( $\mu\text{g}$ As/g glass)
P-1	10/11	$\text{As}_2\text{O}_3$	3048
P-2	10/11	$\text{As}_2\text{O}_3$	2913
P-3	10/12	$\text{As}_2\text{O}_3$	2934
S-1	10/12	$\text{As}_2\text{O}_3$	3181
S-2	10/13	$\text{As}_2\text{O}_3$	2960
S-3	10/13	$\text{As}_2\text{O}_3$	2757
P-4	11/1	$\text{H}_3\text{AsO}_4$	3060
P-5	11/1	$\text{H}_3\text{AsO}_4$	2080
P-6	11/2	$\text{H}_3\text{AsO}_4$	2445
S-4	11/2	$\text{H}_3\text{AsO}_4$	3568
S-5	11/3	$\text{H}_3\text{AsO}_4$	2430
S-6	11/3	$\text{H}_3\text{AsO}_4$	2695

## 2.8 Raw Batch Constituent Analyses

Samples of raw batch materials were drawn on November 2 by Radian and analyzed for arsenic content by TRC. Results are presented in Table 2-8.

In all cases except barium carbonate, the level of arsenic contamination was below the detection limit of the method. Detection limits varied from sample to sample due to signal suppression on the spectrophotometer and the size of the sample aliquot.

TABLE 2-8

RAW BATCH CONSTITUENT ANALYSIS  
THE POSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Constituent	Arsenic Content ( $\mu\text{gAs/g}$ )
Dolomite	<0.54
Barium Carbonate	2.32
Sodium Sulfate	<2.7
Soda Ash	<0.55
Mississippi Lime	<0.55
Pennsylvania Sand	<5.4

## 2.9 Ambient Air Monitoring

Samples of ambient air at each sampling location were drawn during each test performed to determine concentrations of arsenic and lead. Sampling and analyses were in accordance with NIOSH Method P&CAM 173 for trace metals in air, discussed in more detail in Section 5. Results are presented in Table 2-9.

During testing performed with  $\text{As}_2\text{O}_3$  in the raw batch mixture, ambient levels of arsenic at the ESP Inlet sampling location were measured between  $0.59\mu\text{g}/\text{m}^3$  and  $3.85\mu\text{g}/\text{m}^3$  or below the detection limit. Ambient levels

TABLE 2-9

AMBIENT CONCENTRATIONS OF LEAD AND ARSENIC  
THE FOSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Test Number	Date	Metal Concentrations ( $\mu\text{g}/\text{m}^3$ )			
		Inlet		Outlet	
		Lead	Arsenic	Lead	Arsenic
P-1	10/11	43.4	0.61	37.6	<0.65
P-2	10/11	29.7	<0.28	8.39	<0.29
P-3	10/12	2.31	0.59	3.06	<0.30
S-1	10/12	3.99	<0.26	5.12	<0.28
S-2	10/13	2.19	<0.60	28.6	<0.30
S-3	10/13	19.5	3.85	4.75	<0.32
P-4	11/1	4.77	<0.25	2.65	<0.30
P-5	11/1	12.8	<0.26	7.26	<0.30
P-6	11/2	3.29	<0.26	3.93	<0.42
S-4	11/3	9.76	0.61	5.73	<0.30
S-5	11/3	1.30	<0.40	9.18	0.64
S-6	11/3	2.07	<0.40	0.92	<0.59

of arsenic at the ESP Outlet sampling location were below the detection limit of approximately  $0.3 \mu\text{g}/\text{m}^3$ .

Ambient concentrations of lead at the ESP Inlet sampling location measured during the first test series ranged from  $2.19 \mu\text{g}/\text{m}^3$  to  $43.4 \mu\text{g}/\text{m}^3$ . Concentrations of lead at the ESP Outlet sampling location ranged from  $3.06 \mu\text{g}/\text{m}^3$  to  $37.6 \mu\text{g}/\text{m}^3$ .

During testing performed with  $\text{H}_3\text{AsO}_4$  in the raw batch, ambient concentrations of arsenic at the ESP Inlet sampling location were below the detection limit. Ambient levels of arsenic at the ESP Outlet sampling location were also below the detection limit of the method.

Ambient concentrations of lead measured during the second test series at the ESP Inlet ranged from  $1.30 \mu\text{g}/\text{m}^3$  to  $12.8 \mu\text{g}/\text{m}^3$ . Concentrations of lead at the ESP Outlet sampling location ranged from  $0.92 \mu\text{g}/\text{m}^3$  to  $7.26 \mu\text{g}/\text{m}^3$ .

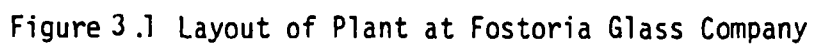
### 3.0 PROCESS DESCRIPTION AND OPERATIONS

#### 3.1 Process Description

The glass melting furnace at Postoria is a side-port regenerative design. The dimensions of the furnace are 15 feet long, 11 feet wide, and the depth of the melting area is 24 inches. Natural gas is fired preferentially, although No. 2 fuel oil can be used if necessary. Five burners are located on either side of the melter. Electric boosting is not employed. The furnace and its associated refractory brick air preheaters (checkers) were recently rebuilt. New burners were also installed. Prior to the test, the furnace had been operating continuously for about three weeks. Under normal conditions the furnace operates 24 hours/day, 365 days per year.

The "batch" mixture of raw materials are fed continuously into the furnace from a hopper at the rear of the melter. As the batch melts, it flows into the center of the furnace before exiting through a narrow throat at the front. From the throat, the molten glass enters the refining section and is then fed into one of three forehearths. The molten glass is removed from the forehearths through a single orifice and is immediately channeled into the molds and pressed into shape. During testing, only two of the three existing forehearths were in use at any given time.

Incoming combustion air is first preheated by the flue gases in a recuperator near the stack. It is then passed through a secondary regenerator before entering the primary regenerators located on either side of the furnace. Hot off-gases from the furnace pass through a primary regenerator opposite the one receiving the combustion air. The flue gases are ducted through the secondary regenerator and then the emission control devices. The clean gases are induced through the recuperator by a fan located at the base



of the stack. At 20-minute intervals, the flow of gas and air through the primary regenerators is reversed. Figure 3-1 illustrates the overall layout of the furnace and the air/gas handling systems.

### 3.2 Emission Control System

Twin United McGill electrostatic precipitators with about 4,000 ft<sup>2</sup> of total plate area each are available for controlling emissions from the glass furnace. The rapping cycle for the precipitators is every one hour on the front end, and every two hours on the back end.

### 3.3 Batch Composition

Fostoria produces a lead-crystal glass. The total weight of the raw batch is approximately 1,370 pounds. Normally, 5 pounds, 10 ounces of arsenic trioxide (99% pure) is added to each batch. For the November tests, arsenic acid was substituted for the arsenic trioxide. In addition to the raw batch ingredients, about 740 pounds of cullet (which is typical for the Fostoria operation) are included within each batch giving a total batch weight of approximately 2,110 pounds.

In order to test the accuracy of the scale used to weigh the arsenic trioxide, each day during the October tests the glass technologist at Fostoria (Carl Hoffman) prepared five bags of sand, each weighing 5 lb, 10 oz. These bags were subsequently weighed on the triple-beam balance used by TRC. There was no significant error in either the scale or the operator's technique. The arsenic acid is measured volumetrically. There was no practical way to independently verify the accuracy of this measurement, although based on observations of the procedure followed, any error can be expected to be quite small. Since the cullet fraction is not weighed prior to being added to the

batch materials, some variation in the amount of cullet entering the furnace can be expected. The glass technologist does monitor the weight of product output per raw material input. Roughly 2,000 pounds of glass should be derived from each 2,110 pounds of raw material input (fusion factor = 0.948). On this basis, the glass technologist estimated that the deviation in cullet feed rate never exceeded 50 pounds (plus or minus). Since the furnace produces only one type of glass, small variations in the amount of cullet added should have no significant effect on the chemical composition of the melt. The cullet feed rate will have some impact on the relative amounts of volatile alkalis present, however.

#### 3.4 Process Controls

The overall operation of the furnace is monitored in a control room adjacent to the furnace area. All of the operating parameters are controlled and monitored automatically. A digital recorder provides a continuous read-out of furnace performance. The recorder can be programmed to either print the absolute values of each of the parameters at one minute intervals, or to display them graphically in a "trend" mode. Normally, the latter display is used. The digital unit does not monitor glass level or combustion air flow; these parameters are recorded separately.

#### 3.5 Monitoring Procedures

During the October emissions test, the following procedure was followed to monitor the performance of the furnace. At the start of each run (and again at the end), the time required for 25 gobs of molten glass to be released from the forehearths was recorded. The digital recorder was temporarily programmed to print the absolute values of the operating parameters. At 15 minute



intervals, the glass level and combustion air flow charts were checked. Also every 15 minutes, readings were taken from the ESP control panel (voltage (AC); rectified voltage (DC); current; and inlet temperature). Since problems had occurred with the raw material feeding mechanism in September, the rear of the furnace was visually inspected for blockage every 30 minutes.

At the end of each run, five samples of the product were removed from each lehr. Since the residence time in the lehrs was approximately 15 minutes less than the typical duration of each run, the products removed were in a molten state within the furnace at the start of testing. During all three days of testing, part of the gob of glass exiting forehearth #1 was not incorporated into the final product. Therefore, five gobs were removed by the shop foreman directly from the forehearths and placed in the lehr. The products and gobs were subsequently weighed by TRC. These weights were multiplied by the rate of gob release from the forehearths in order to calculate the pull rate of the furnace.

A slightly modified procedure was followed during the tests conducted in November. Although the same process variables were monitored, readings were taken every 20 minutes instead of at 15 minute intervals. Also, during the November tests only Press #3 was in use for 5 out of the total of 6 test runs. Therefore, the forehearth above Press #2 was opened in order to increase the pull rate on the furnace to roughly that attained during the October tests. The quantity of glass streaming from this forehearth was measured by diverting the flow for 15 seconds and collecting the glass on a spatula. The gobs of glass collected were then placed in the lehr and subsequently weighed.

### 3.6 Results of the October Tests

During the period over which the October tests were conducted, all systems were properly functioning with two minor exceptions. First, the automatic valve controlling the flow of natural gas to one side of the furnace was out of order. It was therefore necessary for the furnace operator to manually open and shut this valve at each flow reversal. Second, the flue gas flow from the furnace after being rebuilt was only about half that of before. To compensate for the decrease in flow, all of the flue gas was ducted to one, rather than both, of the precipitators (ESP #1).

Throughout the October test periods the glass melting furnace operated smoothly. The greatest deviations occurred as a result of reversals of the firing cycles. These reversals cause a change in the temperature within the primary regenerators with a corresponding effect on the temperature of the flue gas at the ESP inlet. The temperature at the ESP inlet ranged from a recorded low of 335<sup>0</sup>F to a high 440<sup>0</sup>F. At each reversal of the firing cycle, there is also a brief fluctuation in the furnace pressure. These deviations are normal for all furnaces of this design.

A summary of the important process parameters as monitored during the tests is provided in Table 3-1. The major deviation is seen in the pull rate of the furnace which was about 25 percent higher during the final day of testing compared to the previous two days, and in the temperature profile within the melting area of the furnace.

More detailed data on the pull rate of the furnace during the six tests are provided in Appendix B.

The raw monitoring data sheets, as well as copies of the strip chart recorder printouts for each separate run, are provided in Appendix B.

TABLE 3-1 Typical Values for Selected Operating Variables During October Tests

	Oct 11		Oct 13		Oct 13	
	<u>Run #1</u>	<u>Run #2</u>	<u>Run #1</u>	<u>Run #2</u>	<u>Run #1</u>	<u>Run #2</u>
Rear Melter (°F)	2511	2512	2527	2525	2524	2524
Middle Melter (°F)	2537	2537	2557	2550	2553	2551
Front Melter (°F)	2635	2635	2557	2551	2553	2553
Refining Section (°F)	2214	2212	2214	2211	2229	2227
Air Flow Rate (ft <sup>3</sup> /hr)	83,000	83,000	83,000	84,000	82,000	84,000
ESP Inlet Temp (°F)	402	377	391	401	394	381
ESP DC Voltage (KV)	19.3	19.6	19.9	19.6	20.3	20.0
ESP DC Current (mA)	9.0	9.8	11.0	9.5	10.6	9.2
Furnace Pull Rate (lb/hr)	975.0	972.7	985.8	1004.3	1262.3	1280.8

The only upset in the operation of the furnace occurred during the first run on October 12, at twenty minutes past eleven, when the operator forgot to reopen the gas valves during a flow reversal. The flow of gas to the furnace remained off for approximately 7 minutes. As can be seen from the data sheets supplied in Appendix H, the disruption in the supply of gas had only a minor effect on the overall operation of the furnace. The temperature in the middle and front of the furnace began to decline, but returned to normal within five minutes of restoration of the gas supply. By eleven forty-five the operation of the furnace had restabilized.

### 3.7 Results of the November Tests

During the November tests the flue gas was still being ducted through ESP #1 only, and the valve controlling the flow of gas into one side of the furnace was still being operated manually.

The furnace operated smoothly throughout the test period. A summary of the important process variables as monitored during the six test runs is provided in Table 3-2. The temperature of the furnace was slightly higher on the final day of testing compared to the previous two days. There were also slight variations between the second day, and the first and third days, in the flow of combustion air into the furnace. A fairly uniform rate of pull on the furnace was achieved. During the second run on November 1, the operator again forgot to reopen the gas valve during a flow reversal. In this instance, however, gas flow was restored within one minute and the operation of the furnace was not impaired.

The raw data monitoring sheets are provided in appendix H. The only problems encountered during the November tests were in monitoring the pull rate of the furnace. First, the method employed to measure the flow of glass

TABLE 3-2 Values for Selected Operating Variables During November Test

	Nov 1		Nov 2		Nov 3	
	<u>Run #1</u>	<u>Run #2</u>	<u>Run #1</u>	<u>Run #2</u>	<u>Run #1</u>	<u>Run #2</u>
Rear Melter (°F)	2517	2513	2516	2505	2540	2538
Front Melter (°F)	2534	2534	2542	2529	2562	2561
Refining Section (°F)	2217	2218	2232	2222	2205	2217
Air Flow Rate (ft <sup>3</sup> /hr)	82,500	82,000	80,500	81,500	83,000	83,000
ESP Inlet Temp (°F)	407	419	403	404	385	375
ESP DC Voltage (KV)	20	21	20	20	20	20
ESP DC Current (mA)	12.5	13	12	12	12	12
Purnace Pull Rate (lb/hr)	950	1034	1370	1036	1043	1032

streaming from Forehearth #2 involved more room for error than when product samples were taken directly from the presses. As can be seen in the detailed data sheets given in Appendix H, however, the actual variation in the weight of the gobs obtained using this method was fairly small, especially during the last three runs. During the first day of testing, samples were taken from Forehearth #2 at the beginning, middle, and end of the run in order to account for any irregularities in the rate of flow from the newly opened forehearth. During the final two days, the rate of flow had stabilized and all of the samples were taken at the beginning of the run. In the morning of November 2, a utensil handle was being produced on Press #2, and thus the pull rate could be calculated from the actual product weight.

Second, during the first day of testing problems were encountered with Forehearth #3. This forehearth was feeding large gobs of glass to a press on which a heavy (~ 3 lb) plate was being produced. Because of the weight of the gob, some difficulty was experienced in getting the gob to form and shear properly from the base of the forehearth. In attempting to correct the problem, the plant operators were making small adjustments to the forehearth feeding mechanism during the middle of the first test run. Since these adjustments could alter the pull rate of the furnace, a second group of 5 gob samples were collected near the end of the run from Forehearth #3. As can be seen in the detailed data sheet in appendix H, the rate of glass pull from Forehearth #3 did decrease by about 50 lb/hr between the start and the end of the first run. The weights obtained from the samples collected at the start of the run were averaged with those collected at the end of the run in calculating the total furnace pull rate. The same problem briefly occurred intermittently during the following two runs; samples were taken at one hour

intervals in order to account for any variations in pull rate caused by this problem. By the beginning of the afternoon run on November 2, the problem had been completely rectified.

#### 4.0 SCOPE OF THE SAMPLING PROGRAM BY SITE

Emissions testing was performed on the exhaust of the lead crystal glass furnace at the inlet and outlet of the ESP. Sampling was performed in accordance with EPA Methods 1, 2, 3, 4, 5, 9 and 108 (modified) as described in Section 5 and presented in Appendix A. This section presents descriptions of each sampling location and a summary of the work performed.

Prior to any emissions testing the stack gas flow rate and percent moisture of the gas stream was determined in accordance with EPA Methods 1, 2, and 4 at each sampling location. Duct diameter and sampling port configurations were confirmed at this time.

##### 4.1 Glass Furnace Exhaust

The exhaust of the glass furnace was sampled at the ESP Inlet at the location illustrated in Figure 4-1. Four 3-inch NPT nipples were located on the vertical duct wall 53 inches downstream (2.5 equivalent diameters) and 13 inches upstream (0.6 equivalent diameters) from the nearest respective flow disturbances in the 30 inch x 14.75 inch uninsulated steel duct. Dust flows from the doghouse (a vent over the batch feeder) were shut off during all tests. The equivalent diameter of the duct is 20 inches. In accordance with EPA Method 1, 32 traverse points were sampled on four horizontal traverses (8 points per port). Traverse point locations are presented in Table 4-1.

The 32 traverse points were sampled for 4 minutes each for a test duration of 128 minutes for each primary test. Six primary tests were performed here. During the secondary phase of the test program, two traverse points of equivalent stack gas velocity and temperature on different traverses were chosen as the sampling points for the two separate sampling trains. Three sets of two simultaneous, single point tests were performed in accordance with



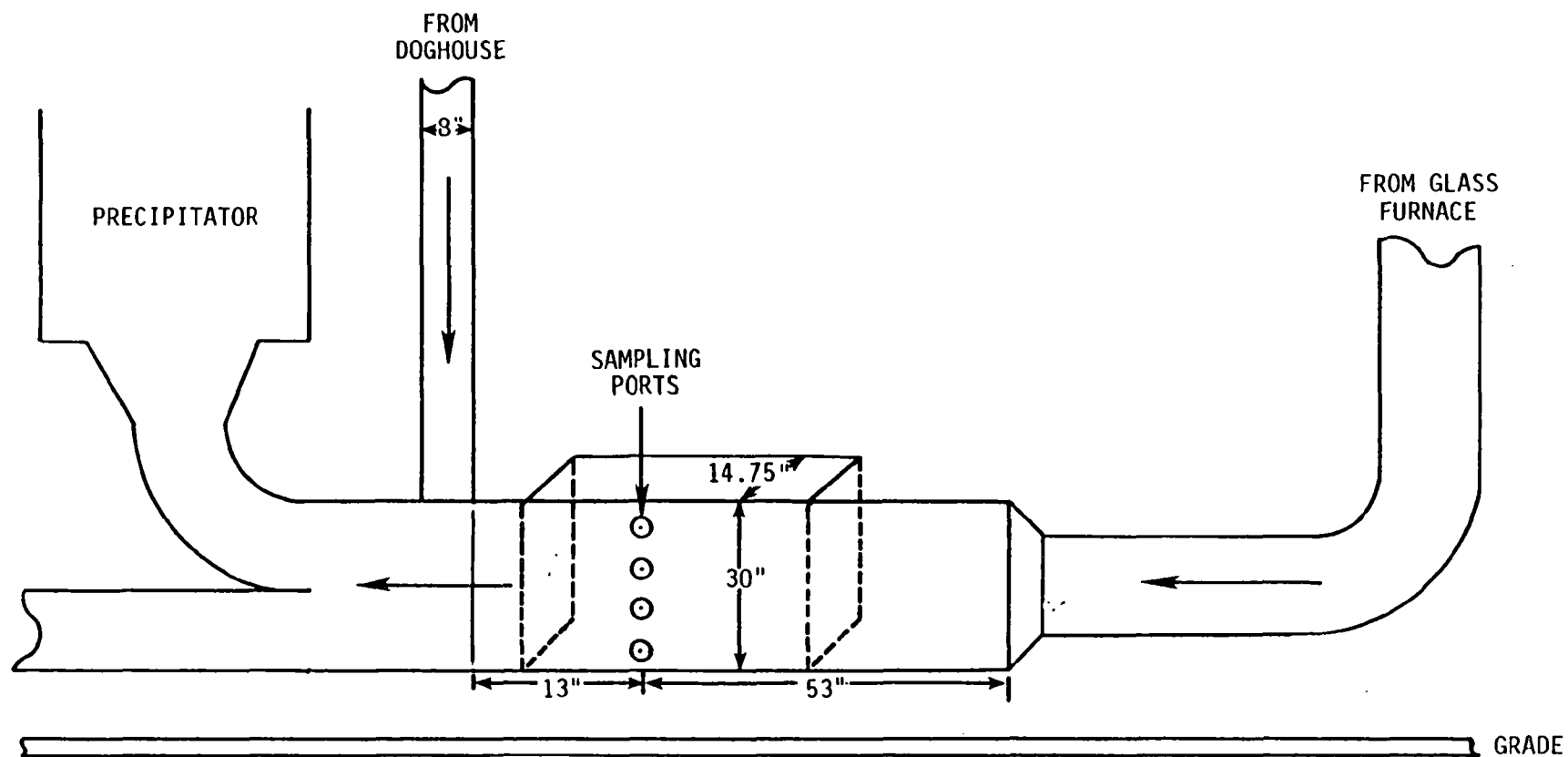


Figure 4-1. ESP Inlet Sampling Location  
Fostoria Glass Company,  
Moundsville, West Virginia

TABLE 4-1

TRAVERSE POINT LOCATIONS  
ESP INLET  
THE POSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Traverse Point Number	Percent Stack Diameter From Inside Wall	Distance From Inside Wall (inches)
1	NA*	0.95
2	NA*	2.8
3	NA*	4.7
4	NA*	6.6
5	NA*	8.4
6	NA*	10.3
7	NA*	12.2
8	NA*	14.0

\*Not applicable for rectangular ducts.

EPA Method 108 modified as described in Section 5.2. The probe and filter outlet temperatures for the two separate trains were 250°F and 550°F (+25°F), respectively. Sampling data was recorded at five-minute intervals.

During each primary and secondary test performed at this location, an integrated gas sample was drawn for Orsat analysis following EPA Method 3, as described in Section 5.3. Analysis for percent CO<sub>2</sub> and percent O<sub>2</sub> was performed following each test period.

An ambient air sample was drawn for arsenic and lead analysis at this location during each emission test performed. A total of twelve samples were drawn as described in Section 5.8.

#### 4.2 ESP Exhaust

The sampling location for the ESP outlet is shown in Figure 4-2. The location is inside the plant just behind the furnace and above the control room. There are two 3-inch NPT ports at 90° along the circumference of the stack. The steel stack is uninsulated and 24 inches in diameter. The distance downstream to the nearest flow disturbance, the ID fan, is 204 inches. The distance upstream to the nearest flow disturbance, the top of the stack, is greater than 48 inches. In accordance with EPA Method 1, a total of 8 traverse points were sampled at this location. Traverse point locations are presented in Table 4-2.

Primary testing to determine arsenic emissions and secondary testing to determine particulate emissions was performed at this location. Six 2-hour tests were performed concurrently with the six primary tests at the furnace exhaust to determine arsenic emissions. Six 2-hour particulate tests were performed concurrently with the secondary tests performed at the ESP inlet. Eight traverse points were sampled for 15 minutes each during testing per-

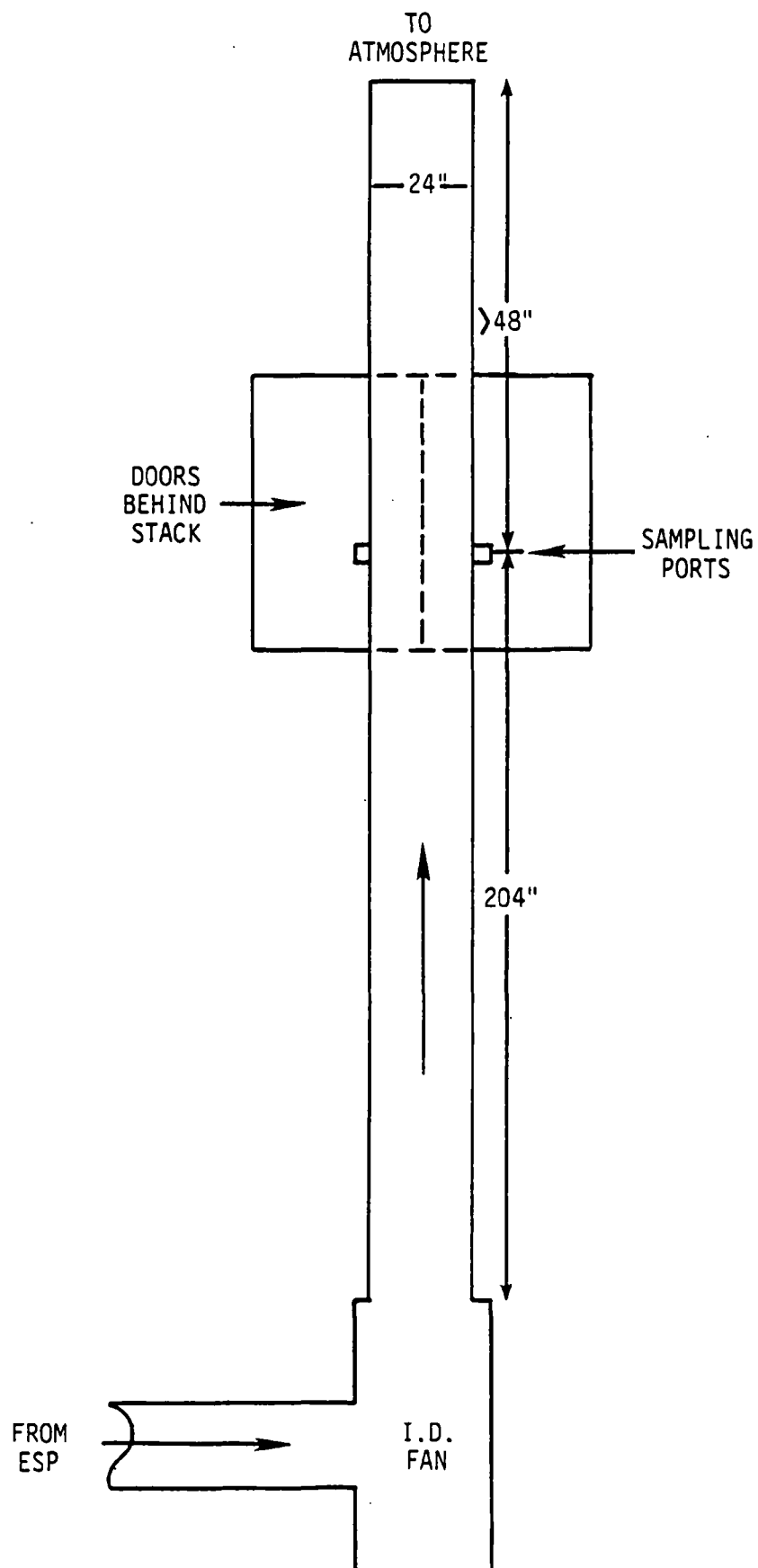


Figure 4-2. ESP exhaust sampling location  
Fostoria Glass Company, Moundsville, West Virginia

TABLE 4-2

TRAVERSE POINT LOCATIONS  
ESP OUTLET  
THE POSTORIA GLASS COMPANY  
MOUNDSVILLE, WEST VIRGINIA

Traverse Point Number	Percent Stack Diameter From Inside Wall	Distance From Inside Wall (inches)
1	6.7	1.6
2	25.0	6.0
3	75.0	18.0
4	93.3	22.4

formed in accordance with Methods 5A and 108. Data was recorded at 5-minute intervals.

During each test performed at this location, one integrated gas sample was drawn for Orsat analysis as described in Section 5.3. Analysis for percent CO<sub>2</sub> and O<sub>2</sub> was performed following each test. A comparison with the furnace exhaust Orsat analysis was indicative of leaks in the ESP system.

Visible emissions evaluations were performed concurrently with each test performed at this location in accordance with Method 9. Observations began at least ten minutes prior to and concluded at least ten minutes after each test. Evaluations were made at 15-second intervals by a certified observer and averaged for 24 consecutive readings (six minutes). A copy of the observer's certification is presented in Appendix E-4. The visible emission observation locations are shown in Figure 4-3.

One ambient air sample was drawn at this location for lead and arsenic analysis during each emission test performed. A total of twelve tests were performed as described in Section 5.8.

#### 4.3 Product Samples

Samples of the finished crystal product were taken from the annealinglehr during each emission test for arsenic analysis as described in Section 5.7. Three samples were taken during each test - one at the beginning, one in the middle, and one at the end. These samples were composited for each test and analyzed for arsenic content.

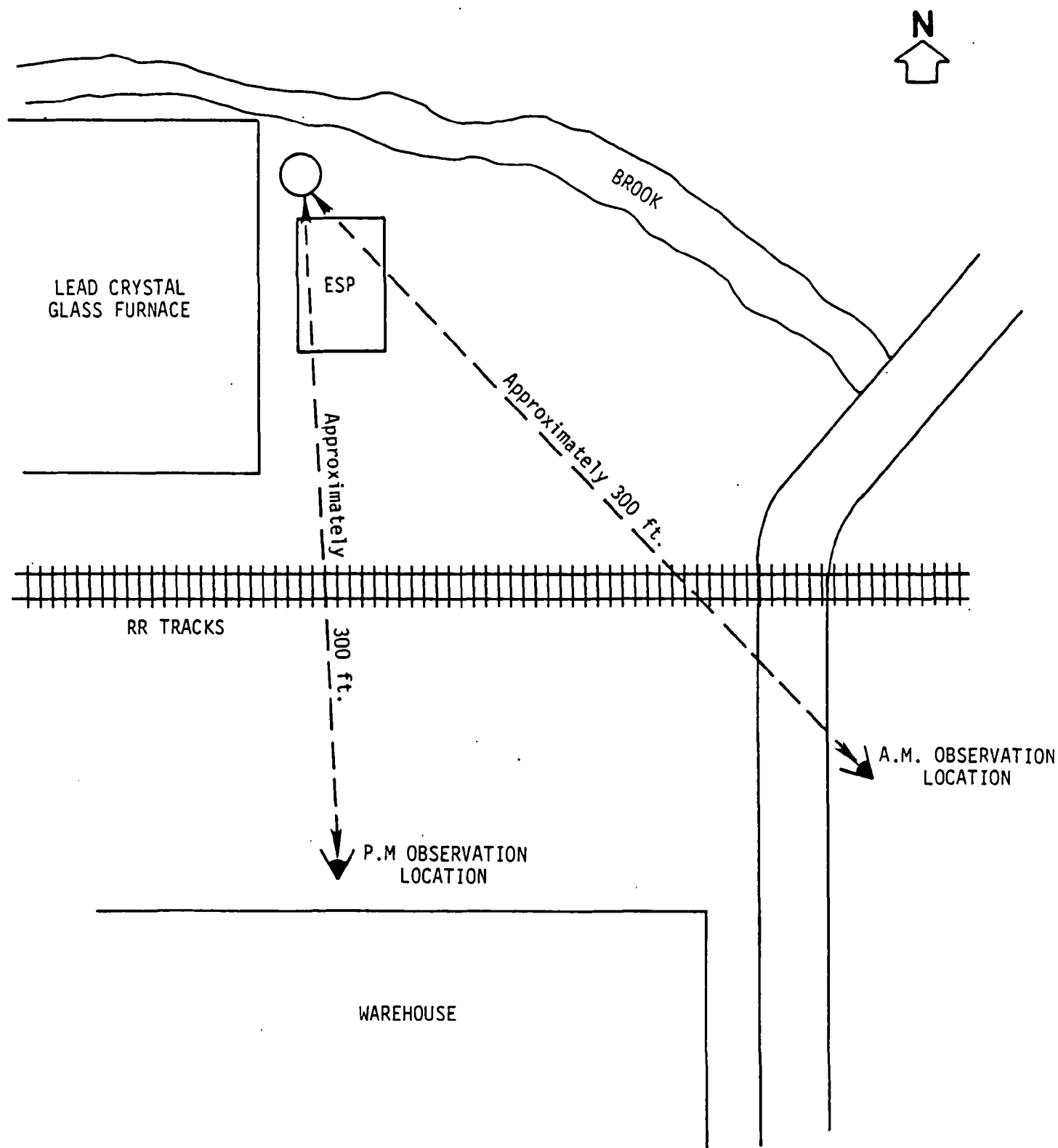


Figure 4-3. Visible Emissions Observation Locations  
The Fostoria Glass Company,  
Moundsville, West Virginia

## 5.0 SAMPLING AND ANALYTICAL PROCEDURES

The purpose of this sampling program was to determine the difference between arsenic emissions when arsenic trioxide and arsenic acid are used in the raw batch process and to determine the effect of temperature on the degree of arsenic control available for glass furnaces. Data acquired will be used for the development of an arsenic emission factor for lead glass production.

A combination of EPA Reference Methods 1, 2, 3, 4, 5, and a modified draft Method 108 was used to determine mass emissions of particulate matter and inorganic arsenic from the glass furnace and ESP. With Method 108, particulate and gaseous arsenic emissions are withdrawn isokinetically from the source and collected on a glass fiber filter and in impinger water. The collected arsenic is then analyzed by atomic absorption (AA) spectrophotometry. Details of these methods are presented in Appendix A.

Primary sampling was performed using EPA Methods 1-5, 9, and 108 to determine mass emissions of arsenic in accordance with the presently accepted methods as described in Section 5.1 below. Three tests were performed with only arsenic trioxide in the raw batch, followed by three more tests with only arsenic acid in the raw batch. All six tests were performed in accordance with Method 108 modified for glass furnaces. Exhaust plume opacity was determined during each primary test in accordance with Method 9.

Following each set of three primary tests, secondary testing was performed at the ESP Inlet using a modified Method 108 to determine the effect of elevated filter temperatures on measured arsenic emissions. The modifications consisted of varying the filter temperatures, utilizing out-of-stack heated thimble filters, and sampling at two single points simultaneously with two separate trains. Three sets of two simultaneous tests were performed with only arsenic trioxide in the raw batch, followed by three additional sets of



two simultaneous tests with only arsenic acid in the raw batch. During each secondary test performed at the ESP Inlet, one particulate emission test was performed at the ESP Outlet. These particulate tests enable correlation of the glass furnace emissions with the particulate emission standard for glass furnaces.

During each test, percent  $O_2$  and  $CO_2$ , and percent moisture were determined in accordance with EPA Reference Methods 3, and 4, respectively.

Product samples were drawn during each test and analyzed for arsenic content by ASTM methods. Ambient air samples were also drawn during each test for analysis of arsenic and lead by NIOSH methods.

#### 5.1 Primary Testing

Primary testing was performed at the ESP Inlet and ESP Outlet to determine emissions of inorganic arsenic in accordance with EPA Method 108 (modified). This Method 108, as drafted, is intended for use at non-ferrous smelters where high concentrations of  $SO_2$  are encountered, and includes hydrogen peroxide ( $H_2O_2$ ) impinger solutions to scrub out the  $SO_2$ . Since only small amounts of  $SO_2$  were expected in a glass furnace exhaust, no  $H_2O_2$  was used in the sampling train. Instead, the impingers contained distilled-deionized (D-D) water to trap gaseous arsenic and moisture in the exhaust gas stream. The impingers were rinsed with a 0.1 N sodium hydroxide (NaOH) solution in accordance with the method at the conclusion of each test. Three test runs were performed with arsenic trioxide in the raw batch during the week of October 10. Three additional tests were performed with arsenic acid in the raw batch during the week of October 31. A total of six primary tests were performed.

#### 5.1.1 Sample Collection

The sampling train used is presented in Figure 5-1. The sampling train consists of a stainless steel calibrated nozzle, a glass-lined probe, a glass-fiber filter and glass filter holder contained in a heated oven, a flexible Teflon tube, and four Greenburg-Smith impingers. The first two (pre-weighed) impingers each contain 150 ml D-D water, the third is empty, and the fourth contains 200 g of silica gel. The first, third, and fourth impingers are modified by removal of the tapered tip and impingement plate. The impinger train was immersed in an ice bath to maintain the outlet gas temperature of the fourth impinger less than 68°F. Sampling probe and filter temperatures were maintained in the range of 230° to 275°F. A thermocouple probe was inserted into the probe and filter outlet gas stream to ensure that proper temperatures are maintained.

The sampling train was leak checked prior to and following each test in accordance with EPA Method 5. Leak rates were less than 0.02 cfm. Isokinetic sampling was performed at rates less than 1.0 cfm. Data was recorded at five-minute intervals.

Simultaneously with each test performed, an integrated gas sample was drawn for Orsat analysis in accordance with EPA Method 3. Percent CO<sub>2</sub> and O<sub>2</sub>, and the molecular weight of the stack gas was determined from this analysis.

Visible emissions observations were made concurrently with all tests in accordance with EPA Method 9. Observations were made at 15-second intervals and averaged over six-minute periods. Observations began at least ten minutes prior to the commencement of each test and concluded at least ten minutes after the conclusion of each test.

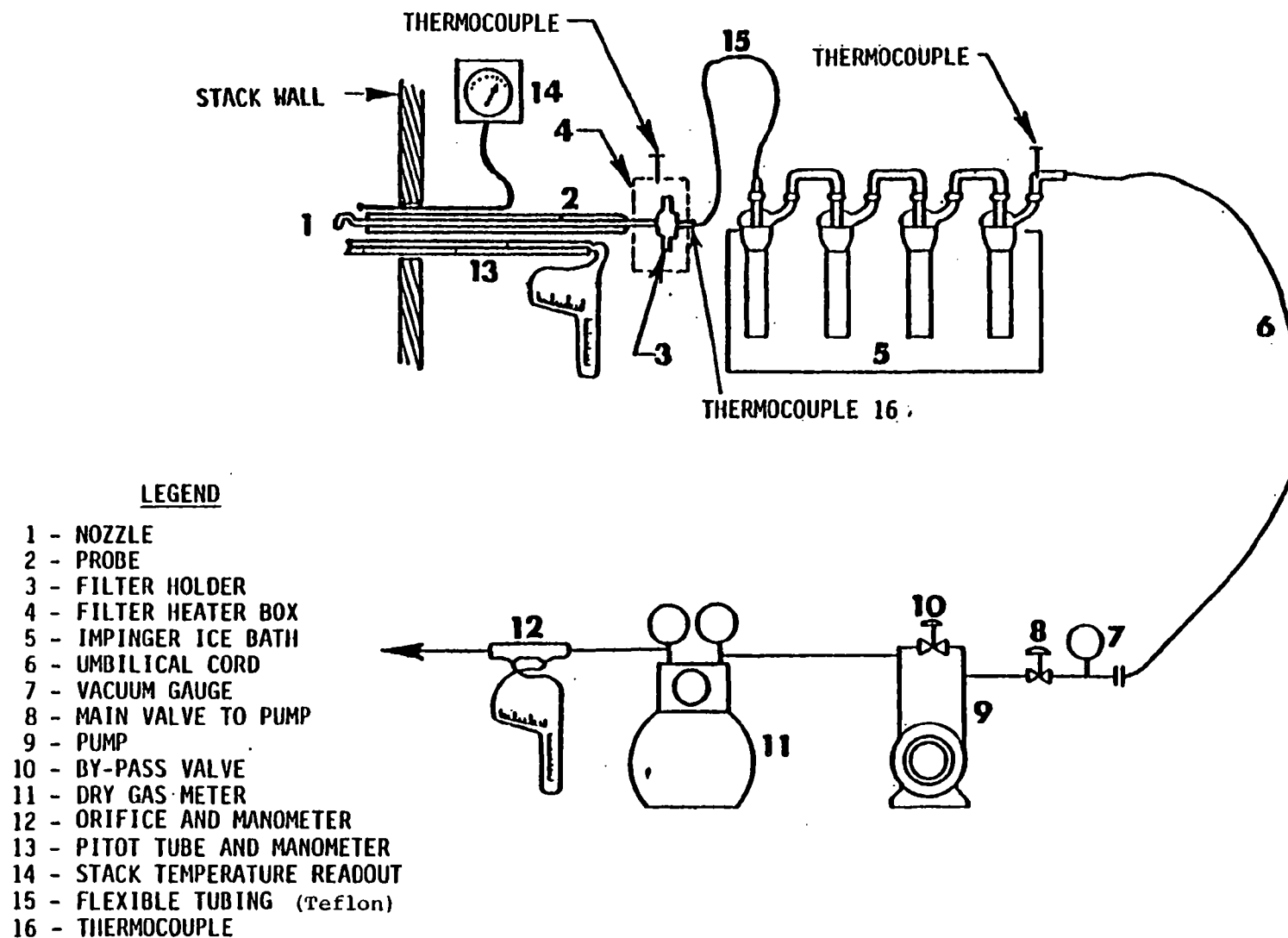


FIGURE 5+1: MODIFIED EPA PARTICULATE SAMPLING TRAIN  
AUGUST 18, 1977, FEDERAL REGISTER

### 5.1.2 Sample Recovery

Sample recovery was performed in the vacant foreman's office adjacent to the sampling area. After the probe was removed from the stack and allowed to cool, particulate matter was wiped from the exterior of the nozzle and the nozzle capped to prevent loss (or gain) of sample. The Teflon sample line was then removed from the filter holder and any condensate drained into the impingers. The filter outlet was wiped of any remaining silicone vacuum grease and sealed with parafilm. The Teflon sample line (now drained) was removed from the impinger train and sealed at both ends. The impinger outlet vacuum line was then removed and the impinger train sealed. The three units (probe and filter, Teflon line, and impinger train) were then transported to the sample recovery area. This area was clean and wind-free in order to minimize the chances of sample contamination.

The impinger train was inspected and abnormal conditions noted before disassembly. The sampling train was then completely disassembled and the liquid samples placed in polyethylene and polypropylene sample jars, while filters were placed in inert petri dishes and sealed. The sample fractions collected are as follows:

- Container No. 1 - The 4-1/2 inch glass fiber filter was removed from its holder and placed in a petri dish, sealed and labeled.
- Container No. 2 - The probe nozzle and front half of the filter holder was brushed three times with a nylon bristle brush and rinsed three times with 0.1N NaOH. These washes were deposited in a 500 ml sample jar and labeled.
- Container No. 3 - The color of the silica gel in the fourth impinger was noted and the silica gel weighed and then transferred to its original labeled Nalgene container.

Container No. 4 - The ball joints of the first impinger were wiped of silicone grease. The impinger was then weighed to the nearest 0.5 g and the net weight of the liquid recorded along with notations of color or film in the impinger catch. The impinger was then agitated in order to rinse the inside and the contents emptied through the outlet arm into a 1000 ml sample jar without disassembling the impinger. 30 ml of 0.1N NaOH was then poured into the impinger, and the impinger agitated and emptied in the above manner. This rinse was performed in triplicate. The back half of the filter holder and the Teflon sample line was rinsed with 0.1N NaOH three times and the wash deposited in the 1000 ml sample jar. The height of the fluid was marked and the jar labeled.

Container No. 5 - Impingers 2 and 3 were treated as impinger 1 described above and emptied into a separate sample jar.

Container No. 6 - 200 ml of D-D H<sub>2</sub>O as a blank.

Container No. 7 - 200 ml of 0.1N NaOH to serve as a blank.

### 5.1.3 Sample Analyses

All sample fractions were analyzed at the TRC environmental laboratories in East Hartford, Connecticut. Samples were transported to the lab in the TRC emission measurement van. All analyses were in accordance with EPA Method 108 as presented in Appendix A. The sample fractions were analyzed as follows:

Container No. 1 - The filter and loose particulate material was placed in a 250 ml beaker along with the contents of Container No. 2 (see below). The filter and probe washes were digested by the addition of concentrated HNO<sub>3</sub> and heat. The resultant solution was filtered and diluted to 50 ml with DD H<sub>2</sub>O. The arsenic concentration was determined by AA spectrophotometry.

Container No. 2 - The total content was placed with the filter into the probe wash beaker used for Container No. 1 and digested as described.

Container No. 3 - The silica gel was weighed to the nearest 0.5g to determine weight gain.

Container No. 4 - The liquid level in the sample jar was checked for leakage prior to analysis. The contents were diluted to 1000 ml with DD H<sub>2</sub>O and digested with concentrated HNO<sub>3</sub>. The resultant solution diluted and analyzed by AA spectrophotometry.

Container No. 5 - This sample was analyzed as described for Container No. 4.

Filter Blanks - Two blank filters were treated as described for Container No. 1.

0.1N NaOH Blank - 50 ml were treated as per Container No. 4.

DD H<sub>2</sub>O Blank - 50 ml were treated as per Container No. 4.

#### 5.1.4 Calculations

Calculations to determine inorganic arsenic concentrations and emissions were in accordance with EPA Method 108 as presented in Appendix A. The amount of arsenic (As) collected in each sample fraction was calculated as follows:

$$M_n = C_a F_d V_{\text{SOLN}} \quad \text{Eq. 108-7}$$

where:  $M_n$  = Total mass of arsenic collected ( $\mu\text{g}$ )

$C_a$  = Concentration of As from standard curve ( $\mu\text{g/ml}$ )

$F_d$  = Dilution factor of sample

$V_{\text{SOLN}}$  = Volume of solution (ml)

and the total arsenic collected is:

$$M_t = M_n (\text{filter}) + M_n (\text{probe}) + M_n (\text{impingers}) \\ - M_n (\text{filter blank}) - M_n (\text{NaOH}) - M_n (\text{H}_2\text{O}) \quad \text{Eq. 108-8}$$

The total arsenic concentration in the stack gas was calculated as follows:

$$C_s = 10^{-6} \text{ g}/\mu\text{g} \frac{M_t}{V_m (\text{std})}$$

where:  $C_s$  = As concentration in stack gas

$V_m$  = Volume of dry gas meter at STP

All other calculations were performed in accordance with EPA Methods 1 through 5 and 108. All calculations were performed utilizing a Texas Instruments TI 59 programmable calculator with printer.

## 5.2 Secondary Testing/Arsenic

Following the completion of each set of three primary tests performed in accordance with Method 108 (modified), the second phase of the test program began. Three sets of two simultaneous, single point, 90-minute tests were performed at the ESP Inlet utilizing two different filtered gas stream temperatures under each batch condition (three tests with arsenic trioxide and three tests with arsenic acid). Sample recovery and analysis were as described in Section 5.1. These tests were performed in order to determine the effect of filter temperature on the degree of arsenic control feasible, since a significant part of arsenic emissions from glass furnaces exhibit significant vapor pressures at elevated temperatures. During each pair of secondary Method 108 arsenic emission tests performed at the ESP Inlet, one Method 5A - Particulate/Condensable Organic Emission test was performed at the ESP Outlet.

### 5.2.1 Sample Collection

Two separate arsenic sampling trains simultaneously sampled two separate traverse points of approximately equal flow rates and temperatures for 90 minutes. The sampling trains were basically the same as that described in Section 5.1.1. The differences were the use of heated stainless steel thimble filter holders with glass fiber filters (to accommodate higher temperatures), two distinct probe and filter outlet temperatures, replacing the Teflon sample line with a short length of stainless steel tubing, and the monitoring of the

gas stream temperature at the outlet of the first impinger. The filter temperatures were:

1. Train 1: As per Method 108 ( $230^{\circ}$ - $275^{\circ}$ F)
2. Train 2: Actual stack temperature ( $550^{\circ} \pm 25^{\circ}$ F)

The impinger train and sample train operational specifications are outlined in Section 5.1.1. Data was recorded at 5-minute intervals.

#### 5.2.2 Sample Recovery

Sample recovery was performed at the location and in the same manner as discussed in Section 5.1.2.

#### 5.2.3 Sample Analyses

Sample analyses was performed at the location and in the same manner as discussed in Section 5.1.3.

#### 5.2.4 Calculations

Calculations will be performed in the same manner as described in Section 5.1.4.

### 5.3 Secondary Testing/Particulate

During the secondary phase of the test program, testing was performed at the ESP exhaust to determine emissions of particulate and condensible organic matter in accordance with EPA Method 5A.



### 5.3.1 Sample Collection

The particulate/condensable organic sampling train was identical to the one described in Section 5.1.1 used for the primary test. Sampling train operations were identical, with probe and filter outlet temperatures at 250° ±25° F.

### 5.3.2 Particulate/Condensable Organic Compounds - Sample Recovery and Preparation

At the conclusion of each test run, separate sample fractions were collected from the Method 5A sampling train by a three-person clean-up crew. The liquid samples were placed in glass sample jars with Teflon-lined lids, while the filters were placed in inert petri dishes and sealed. The sample fractions collected are as follows:

Container No. 1 - 4-1/2 in. glass-fiber filter.

Container No. 2 - Acetone wash of nozzle, probe and front half of the 4-1/2 in. filter holder.

Container No. 3 - Contaminated impinger solution from impingers 1, 2 and 3 and D.D. H<sub>2</sub>O wash of impingers, connectors, Teflon sample line, back half of 4-1/2 in. filter holder and front half of 2-1/2 in. filter holder.

Container No. 4 - Acetone wash of first three impingers, connectors, Teflon sample line, back half of 4-1/2 in. filter holder, and front half of 2-1/2 in. filter holder.

Container No. 5 - Silica Gel.

Sample recovery was according to EPA Method 5A as presented in Appendix A. The probe and nozzle was brushed and rinsed three times with acetone which was deposited in Container 2. The front half of the 4-1/2 in. filter holder was also rinsed with acetone, which was deposited in Container 2.

The Teflon sample line was drained into the impinger train. The Teflon sample line was not brushed as the particulate catch there was considered to

be insignificant. Impinger contents were weighed to determine moisture catch and deposited in Container 3. The Teflon sample line, impingers, connectors and the back half of the 4-1/2 in. filter holder were rinsed three times with D.D. H<sub>2</sub>O into Container 3, and then rinsed three times with acetone into Container 4.

The filter was removed from its holder and deposited into a petri dish (Container No. 1). Filter residue on the filter holder was scraped and deposited into the same acetone rinse container as the front half of the filter holder. The stainless steel filter frits used in the filter holders were not rinsed during sample recovery, as any organic compounds on the frits would be insignificant.

Silica gel samples were weighed immediately upon the conclusion of each test and the weights recorded by the clean-up crew. All Method 5A samples were packed in shock-proof containers and driven to the TRC Environmental laboratory in East Hartford for analysis upon the conclusion of the test program.

Sample recovery data was recorded on the sample recovery log, sample handling log, chain of custody and analytical data forms as presented in Appendix D of this report.

### 5.3.3 Particulate/Condensable Organic Compounds - Sample Analysis

All analyses were according to EPA Method 5A, as presented in Appendix A and as approved by EPA-EMB. The sample fractions were analyzed as follows:

Container No. 1 - (4-1/2 in. glass-fiber filter) - dessicate and weigh after 24 hours, then weigh to constant weight.

Container No. 2 - (acetone probe rinse) - evaporate, dessicate and weigh after 24 hours, then weigh to constant weight.

Container No. 3 - (impinger water solution and D.D. H<sub>2</sub>O rinse) - extract, dessicate, and weigh.

Container No. 4 - (impinger acetone wash) - evaporate, dessicate, and weigh.

Container No. 5 - (Silica gel) - weigh.

Silica gel samples were weighed at the test site on a triple beam balance upon the conclusion of each test by the Method 5A sample recovery crew. The weight gain of the silica gel were determined to the nearest 0.5 g and recorded.

#### 5.4 CO<sub>2</sub> and O<sub>2</sub> Determination

Concentrations of CO<sub>2</sub> and O<sub>2</sub> was determined according to EPA Method 3 as presented in Appendix A to determine the molecular weight of the gas stream. An integrated gas sample was taken simultaneously with each emission sample through a stainless steel probe that is integral with the Method 5/108 probe. The sample was drawn through the probe, a flexible sample line and into a Tedlar sample bag with an approximate volume of 1 ft<sup>3</sup> in an evacuated chamber by a diaphragm pump at a rate of approximately 0.5 liters per minute. Data was recorded at the prescribed intervals.

Immediately upon the completion of the each test run, the integrated bag sample was analyzed according to Method 3. An Orsat analyzer manufactured by A.H. Thomas of Philadelphia was used to determine concentrations of CO<sub>2</sub> and O<sub>2</sub> to the nearest 0.1 percent. Analysis was performed according to the Method, using 3 passes through each absorbing bubbler to assure complete absorption. Analyses were performed in triplicate.

### 5.5 Preliminary Moisture Determination

Preliminary moisture tests were performed at each sampling location prior to emissions testing. Testing was performed according to EPA Method 4 as described in Appendix A.

### 5.6 Preliminary Velocity Determination

Preliminary velocity measurements were made according to EPA Methods 1 and 2 at each sampling location prior to emissions testing. Data was recorded in accordance with the field data sheets.

### 5.7 Visible Emissions

Visible emissions observations were conducted concurrently with each particulate/arsenic test to determine the relationship between measured and visible emissions. Observations were made according to EPA Method 9 as presented in Appendix A. Plume opacity was recorded to the nearest 5 percent at 15-second intervals. Six-minute average opacity values were calculated from each set of 24 consecutive observations. Visible emissions evaluation began at least ten minutes prior to the commencement of each test and concluded at least fifteen minutes after the conclusion of that test.

Opacity readings were recorded by a certified observer on the Record of Visible Emissions form presented in Appendix C.

### 5.8 Product Samples

Three samples (1 set) of the product were taken during each test performed (one each at the beginning, middle, and end of the test). The samples were crushed and composited for analysis. The twelve composite

samples were analyzed for arsenic content in accordance with ASTM Methods C169-75 and C196-80 as presented in Appendix A.

#### 5.9 Ambient Air Samples

Ambient air at each sampling location was drawn through a 37 mm cellulose acetate membrane filter with a personnel sampling pump at approximately 1.5 liters per minute during each test performed. A total of twenty-four tests were performed. Samples were analyzed for arsenic and lead by atomic absorption spectrophotometry in accordance with NIOSH Method P+CAM 173 as presented in Appendix A.

## 6.0 QUALITY ASSURANCE

The TRC quality assurance program was designed to ensure that emission measurement work is performed by qualified people using proper equipment following written procedures in order to provide accurate, defensible data. This program is based upon the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III (EPA-600/4-7-027b).

At the beginning of each day, a meeting was held to orient personnel to the activities scheduled for that day and to discuss results from the previous day, and to determine if any special considerations were appropriate for the day's work.

### 6.1 Methods 1, 2, 4, 5, and 108

TRC's measurement devices, including pitot tubes, dry gas meters, thermocouples, probes and nozzles, are uniquely identified and calibrated with documented procedures and acceptance criteria before and after each field effort. Records of all calibration data are maintained in TRC files. These calibration forms are presented in Appendix E.

All Method 5 and 108 sampling was 100  $\pm$ 10 percent isokinetic. Probe and filter outlet temperatures were maintained within 25°F of the temperatures specified. Deviations from these criteria were reported to the EPA/EMB task manager to decide whether a test run should be repeated or continued.

Prior to the field test program, full clean-up evaluations of the sampling equipment were performed. In addition, spiked samples were analyzed. This procedure ensured the accuracy of the method. Audit samples were not available.

A single clean-up evaluation test was performed on each initial set (collector train) of glassware prior to collecting field samples. The tests

were performed in the field sample recovery area and observed by the EPA task manager. The sets of glassware, including the probes, were prepared and precleaned before conducting the clean-up evaluation tests. The impingers were precharged as specified in the actual test program. Afterward the sample collectors, including probes, were cleaned and the blank samples recovered and analyzed as specified in the actual test program. Results are presented in Section 2 of this report.

In summary, the evaluation tests were designed to precondition the sample collectors, to establish blank background values, and to educate the clean-up personnel in specific sample recovery procedures.

All reagents were analyzed by TRC prior to field use. Residue data from this preliminary analysis was evaluated to assess suitability for use during the test program. In addition, three blank samples of each reagent and 4-1/2 inch filters were collected for background analysis. All clean-up evaluation and blank samples were analyzed in conjunction with the actual test samples.

All sample recovery was performed by a three-person clean-up crew. Appropriate sample recovery data was recorded on the sample identification log, sample handling log, chain-of-custody form, and analytical data forms as presented in Appendix D.

Recovered samples were secured in shock-proof, metal containers in a locked room prior to shipment for analysis.

All preparation and analysis of samples were performed at the TRC environmental laboratories. Standards of quality assurance set forth in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III (EPA-600/4-7-/027b) and the Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA-600/4-79-019, March 1979) are adhered to.

## 6.2 Method 3

All Method 3 analyses were performed in triplicate, with three passes being performed through each absorbing bubbler to ensure complete absorption. The analyzer was leak-checked according to the method prior to any analysis. Samples were analyzed immediately upon completion of the sampling.

## 6.3 Method 9

The TRC observer was certified within the past 6 months to perform visible emission evaluations. Documentation verifying the observer's certification is provided in Appendix E.