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Acurex Project 7280

PARTICULATE MATTER EMISSION TESTS FOR NO. I COKE BATTERY COMBUSTION STACK AT REPUBLIC STEEL, CLEVELAND, OHIO

Ralph Pape and Jim Steiner

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May 1980

ACUREX FINAL REPORT 80-60/EE

Prepared for
EPA Project Officer — John R. Busik
EPA Task Officer — Larry Kertcher

Enforcement Division
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60606

Contract 68-01-4142
Task 19

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SUMMARY

Particulate mass tests were performed on the no. 1 coke battery combustion stack of Republic Steel located in Cleveland, Ohio.

Test results show that particulate mass emission rates (2.4 to 3.5 lbs/hr) were lower when there were many ovens (5-7) being pushed and charged. Test results obtained while only a few ovens (0-2) were being pushed and charged were higher (4.7 to 7.5 lbs/hr). The same trend was noted for condensible organic emission rates. Condensible inorganic and condensible sulfate emission rates were grouped closely for tests performed with a few ovens being pushed and charged. However, those emission rates varied widely for those tests performed while many ovens were being charged and pushed.

SECTION 1

INTRODUCTION

At the request of the Enforcement Division of EPA Region V, the Energy & Environmental Division of Acurex Corporation undertook a test program at the no. 1 coke oven combustion stack of Republic Steel located in Cleveland, Ohio to determine particulate mass emission rates.

Particulate mass measurements were made on July 16 and 17, 1979 using an EPA Method 5 sampler. Simultaneous to the mass tests, opacity readings were made by a certified opacity reader. In addition, the impinger catch was evaluated for condensible inorganics, organics, and sulfates.

Section 2 of this report provides a summary of the coke plant operation; Sections 3 and 4 describe the sampling and analysis procedures used during the tests, while Section 5 presents the results of the tests. Appendices A, B and C describe the sampling equipment used to collect the samples, the pretest preparation and the equipment calibration procedures. Appendix D of this report presents the raw data collected during the test program.

SECTION 2

PROCESS DESCRIPTION

This section of the report summarizes the operating characteristics of the no. 1 coke battery at the Republic Steel plant in Cleveland, Ohio.

Republic Steel operates a 51 oven coke battery at its Cleveland works in Ohio. This battery has been in operation since January 20, 1977. The gas collecting system is made up of two offtakes, one located at each end of the oven. The volatile products liberated during the coking process pass through the battery's dual collecting main, the coke byproducts plant and are used to heat the ovens in the battery. The products of combustion then leave the battery via the waste gas stack. There are no pollution control devices serving the stack. Naturally induced stack draft is used to keep the pressure in the collecting main at -23 mm of H_2O on the push side and -22 mm of H_2O on the coke side. The stack draft draws air required for combustion through an air box at the bottom of the regenerator chambers.

The coal (approximately 0.9 to 1.2 percent sulfur) used for the coking operation is charged through three openings in the top of the oven. Each oven is charged with approximately 15 tons of coal. A leveling bar on the pusher is used to level the piles before the coking operation begins. The coke ovens are fired with coke oven gas (not desulfurized) (Table 2-1) with the firing taking place from either the

Table 2-1. Average Fuel Gas Flow to Battery

Date	Time	Push Side (cfm)	Coke Side (cfm)
7/16/79	0800	240,000	245,000
	1100	235,000	235,000
	1230	235,000	240,000
	1300	240,000	235,000
	1400	240,000	245,000
7/17/79	0800	235,000	240,000
	1300	235,000	245,000
	1500	235,000	245,000

coke side or the push side. More gas is fired on the coke side of the oven since it is approximately 3 inches wider and hence, contains more coke to heat up than the pusher side of the oven. Firing of the coke ovens is reversed every 30 minutes to keep the ovens operating within the safe temperature range of the silica refractories. The coking operation is complete when the skin temperature of the coke is at 1900^{o}F to 2000^{o}F. This usually takes from 17 to 18 hours.

Once the charge has been fully coked the oven is ready to be pushed. The coke guide and the quench car are moved into place and the doors of the oven are removed. The pusher then pushes the coke out of the oven, through the coke guide and into the quenching car for transportation to the quench tower where the coke is cooled for use.

Particulate mass tests were conducted on the waste gas stack. Each test was 96 minutes long and traversed 48 points in the stack. During each of the 4 tests, firing of the coke ovens was reversed and several

ovens were pushed and charged (see Table 2-2). The H_2S concentration in the coke oven gas was 353 grains/100 ft^3 and 381 grains/100 ft^3 on July 16, 1979 and July 17, 1979. The organic sulfur content was 20 grains/100 ft^3.

Table 2-2. Plant Operating Data

Test No.	Date	Time	Oven No.	Time Pushed	Time Charged
60	7/16/79	0824-1109	194	0823	0837
			204	0845	0859
			214	0912	0926
			224	0934	0948
			176	0945	1003
			196	1000	1018
			206	1045	1130
61	7/16/79	1211-1412	*	*	*
62	7/17/79	0748-0958	178	0725	0818
			198	0752	0845
			208	0812	0915
			218	0835	0930
			171	0905	0943
63	7/17/79	1053-1243	221	1050	1215
			173	1225	1240

*No oven charged or pushed

SECTION 3

SAMPLING PROCEDURES

This section of the report describes the procedures used by Acurex personnel to conduct the particulate mass and volumetric flowrate determinations.

3.1 PRELIMINARY MEASUREMENTS

Before conducting particulate mass or volumetric gas flowrate determinations, preliminary measurements were made to determine:

- Sampling site location and number of sampling points to be used
- The velocity, temperature, pressure, composition and moisture content of the gases to be sampled.

This information was used to select the proper nozzle site for isokinetic sampling. EPA Methods 1 through 4 were used to conduct the preliminary measurements.

3.2 SAMPLING SITE AND SAMPLING POINT LOCATIONS

The sampling ports in the no. 1 coke battery combustion stack were located approximately 6 diameters downstream of an elbow and approximately 11 diameters upstream of the stack exit (Figure 3-1). The maximum number of sampling points (according to EPA Method 1) was chosen to give the most representative sample. Figure 3-2 gives the sampling point locations. Sample points 1 through 5 were relocated to point 6 because the sample ports extended 13 inches into the stack from the inside wall.

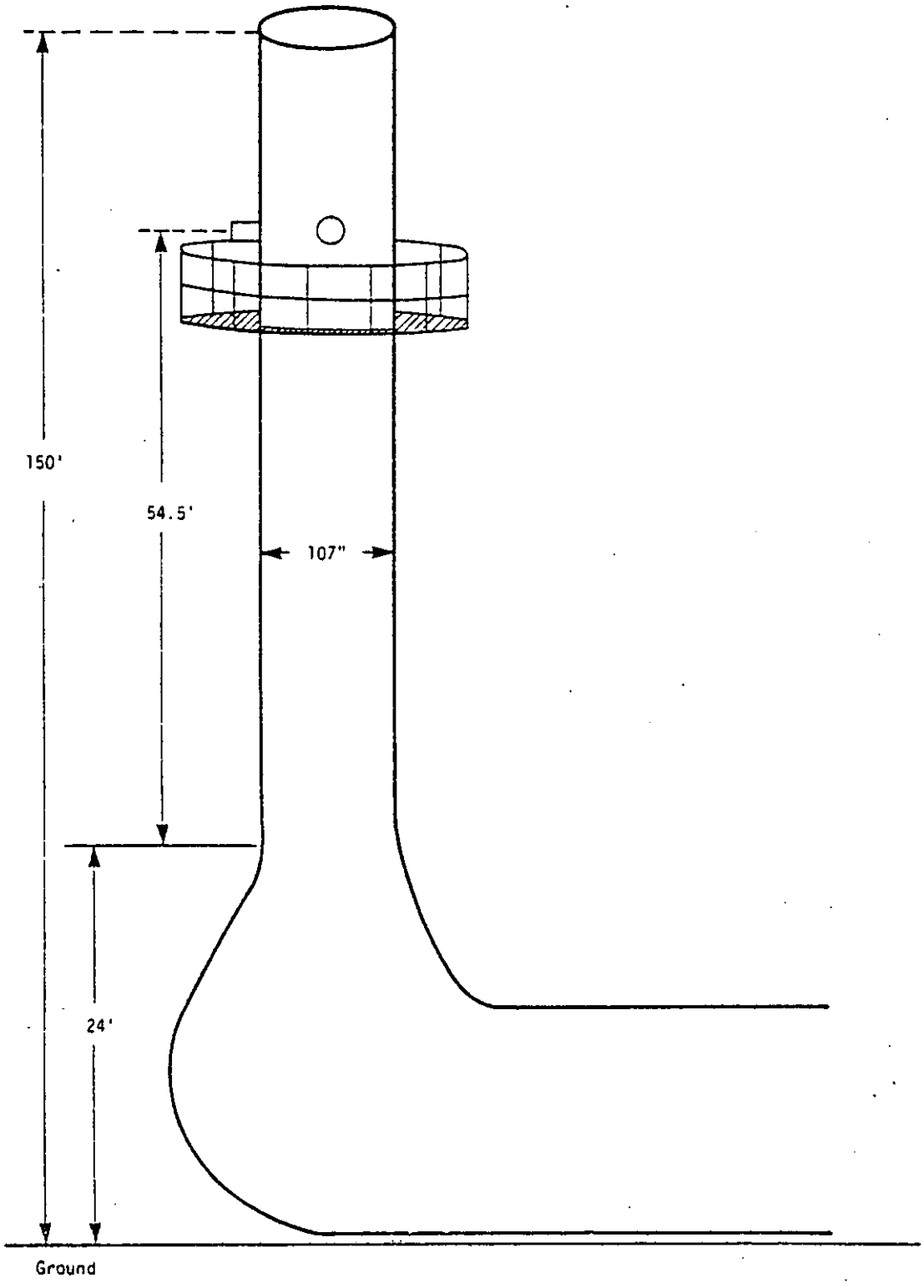
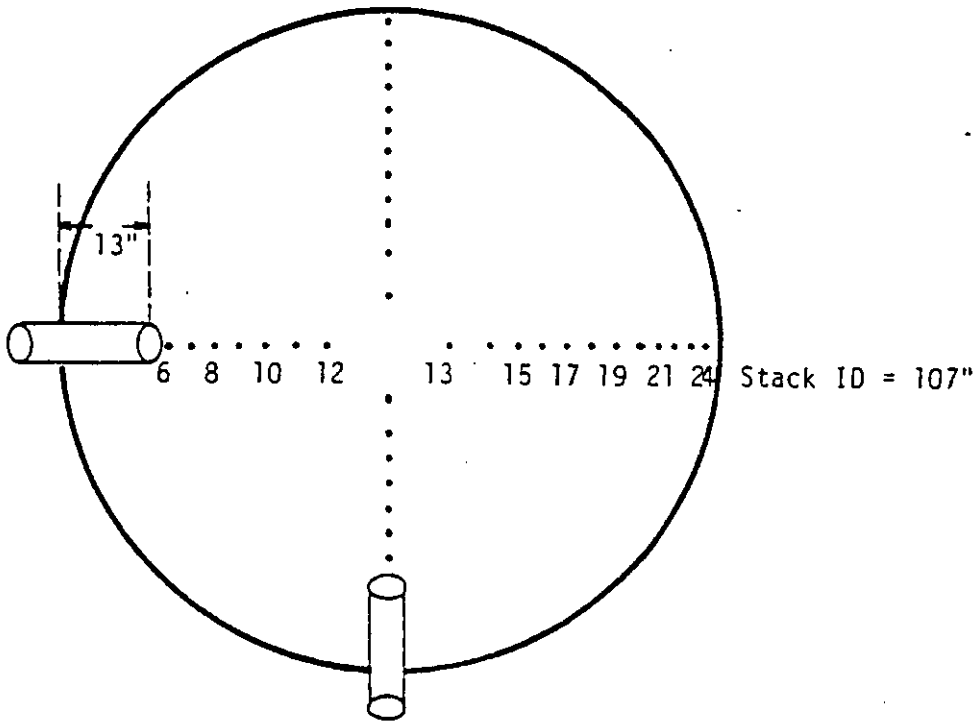


Figure 3-1. No. 1 Coke Oven combustion stack sampling site.



Sample Point	Location from Inside Wall	Sample Point	Location from Inside Wall
1	1.2" - 14.1"	13	64.4"
2	3.4" - 14.1"	14	72.4"
3	5.9" - 14.1"	15	77.9"
4	8.5" - 14.1"	16	82.4"
5	11.2"- 14.1"	17	86.2"
6	14.1"	18	89.8"
7	17.2"	19	92.9"
8	20.8"	20	95.8"
9	24.6"	21	98.5"
10	29.1"	22	101.1"
11	34.6"	23	103.6"
12	42.6"	24	105.8"

Figure 3-2. Sampling point locations.

The sample ports were situated at 90° angles to each other and the stack was traversed in both directions for each test.

3.3 PREPARATION AND SAMPLING PROCEDURES FOR PARTICULATE MASS TESTS

Prior to conducting a particulate mass measurement, the sampling train was thoroughly cleaned in the Mobile Emission Monitoring van situated outside the BOF shop and set up using the procedures outlined in Figure 3-3.

The prepared sampling train components were then transported to the sampling site, assembled and leak checked according to EPA Method 5 procedures. Figure 3-4 outlines the procedures used by the test crew to conduct particulate mass tests on the no. 1 coke oven combustion stack.

Upon receiving direction from the process observer, the particulate mass tests were started. At the same time opacity observations were being made from a location near the Republic Steel offices, approximately 750 feet northeast of the combustion stack. Opacity readings were taken every 15 seconds during the testing period.

During the test periods, the process observer monitored the following process data:

- Average fuel gas flow during test period
- Stack draft
- Time and number of ovens charged
- Time and number of ovens pushed
- Average quantjty of coal charged per oven

3.4 SAMPLE RECOVERY PROCEDURES

After the completion of a particulate mass test, the sampling train was disassembled at the sampling site and those components from which a sample was to be recovered were sealed and transported to the mobile van

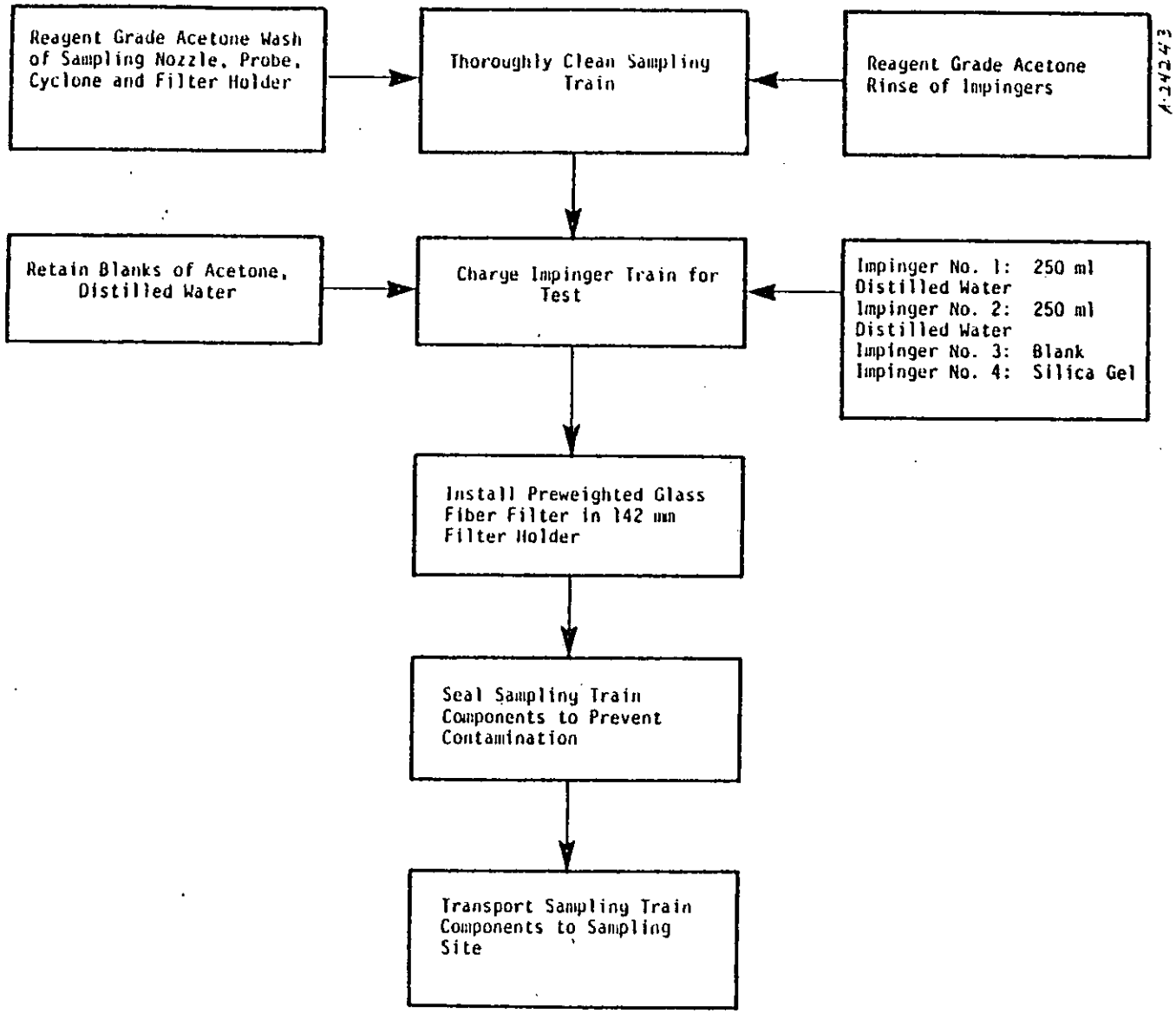


Figure 3-3. Preparation procedures for a particulate mass sampling train.

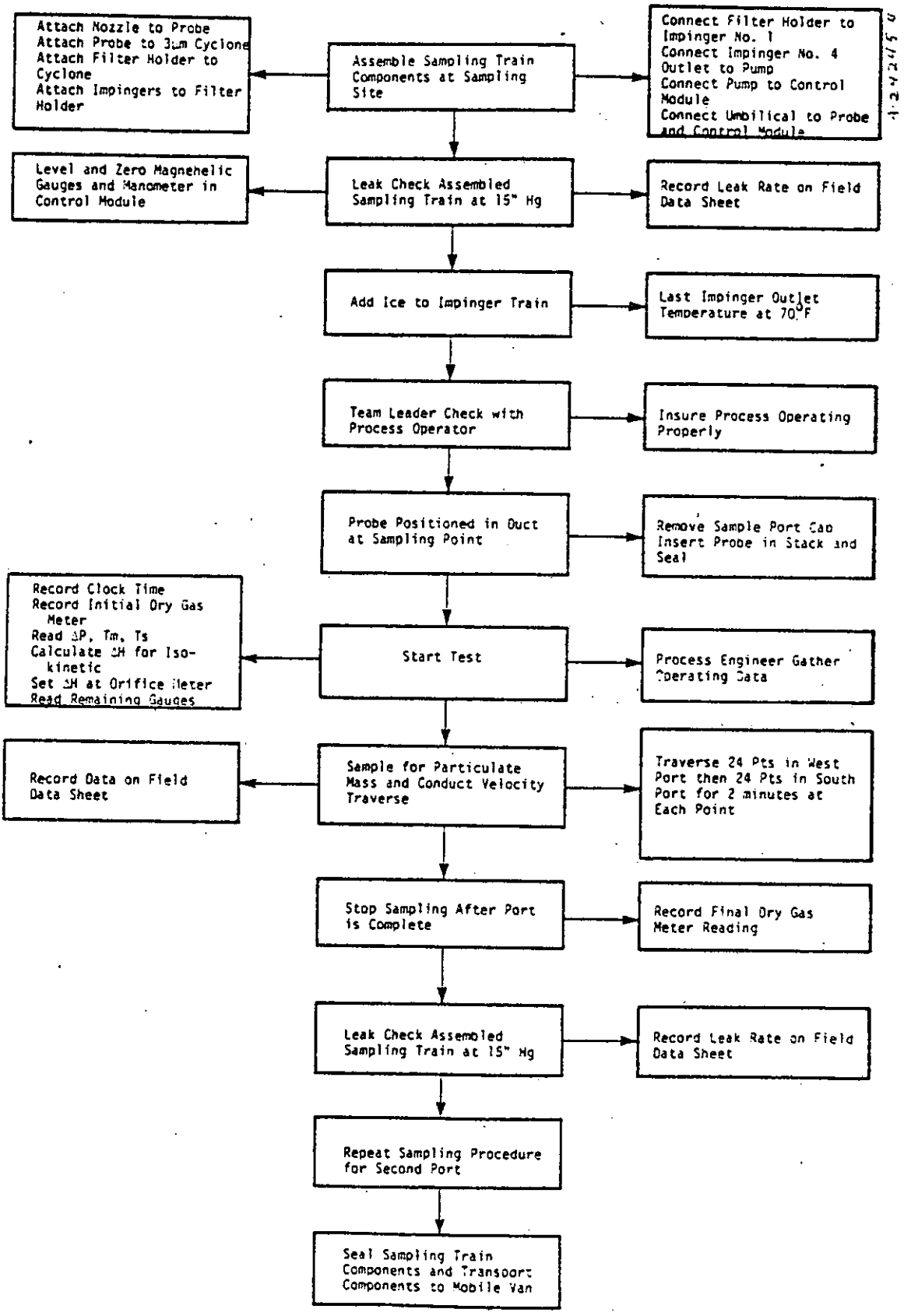


Figure 3-4. Sampling procedures for particulate mass tests performed on the No. 1 coke oven combination stack.

for recovery and analysis. Figure 3-5 illustrates the sample recovery procedures employed for the particulate mass sampling train. The collected samples were sealed in labeled plastic (solids) and amber glass (liquids) containers.

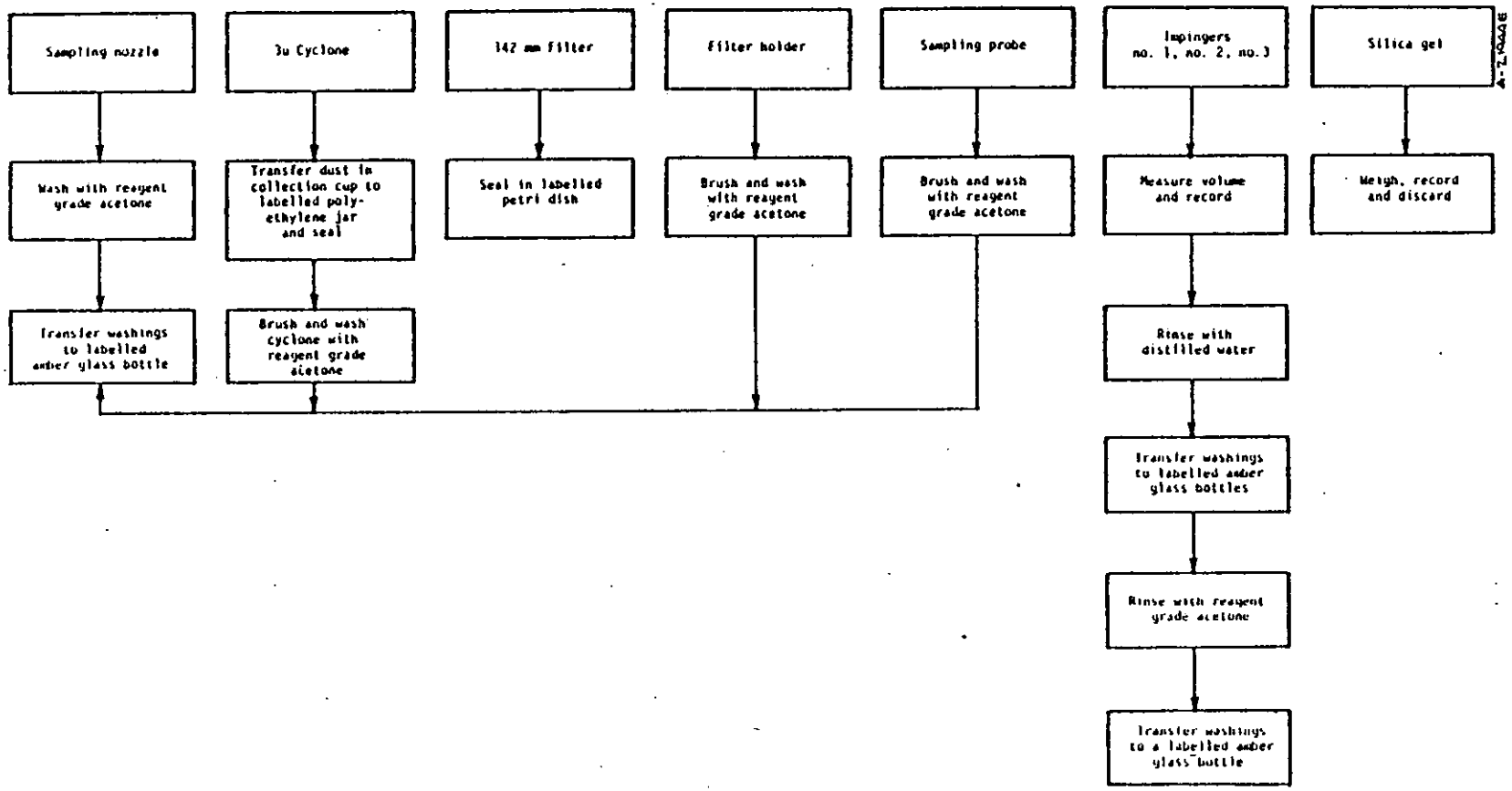


Figure 3-5. Sample recovery procedures for particulate sampling train.

SECTION 4

SAMPLE ANALYSIS PROCEDURES

This section of the report describes the procedures used to analyze the samples collected from the Republic Steel coke battery in Cleveland, Ohio. Analysis was performed on site in the Acurex mobile lab facilities which was stationed outside the BOF shop. Figure 4-1 illustrates the mobile lab.

4.1 ANALYSIS OF THE PARTICULATE SAMPLES

Figure 4-2 is a flowchart illustrating the step by step procedures used to analyze the entire catch of the particulate mass sampling train. The procedure used to evaluate the back half catch of the mass train was obtained from EPA Region V. Deviation from this procedure included performing analysis immediately on site in the mobile lab and addition of cyclone dust catches to cyclone acetone washes to minimize the number of particulate mass samples to be analyzed. Due to rapid changes in particulate mass filter weights caused by the presence of H_2SO_4, final filter weights were extrapolated from time versus weight curves. These curves can be found in Appendix D.

Sulfate analysis was done by the EPA barium-thorin titration method. All samples and blanks were filtered through ion-exchange columns containing Dowex Resin 50W-X8 100 to 200 mesh to remove any interferents.

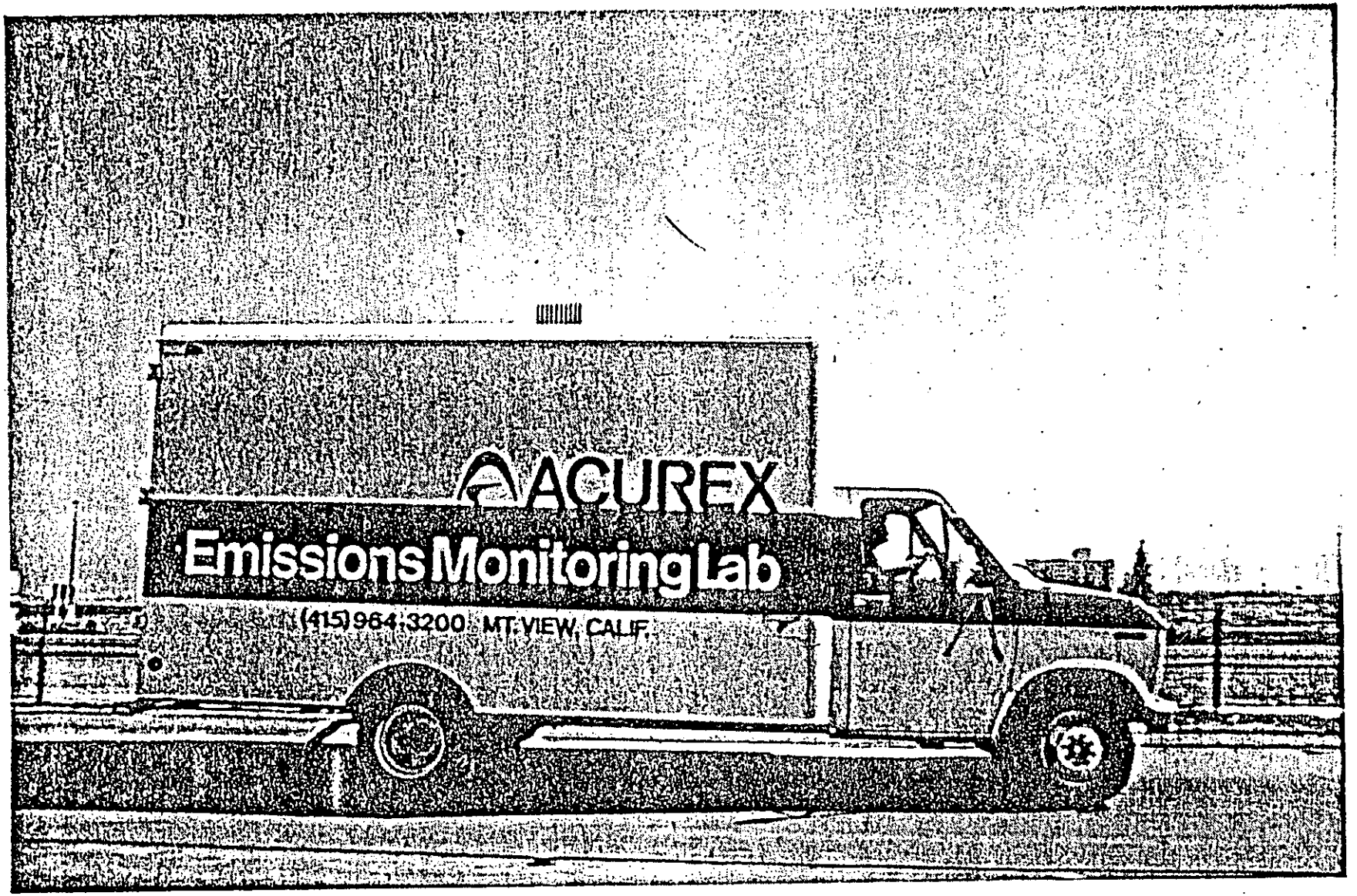


Figure 4-1. Acurex mobile emission monitoring laboratory.

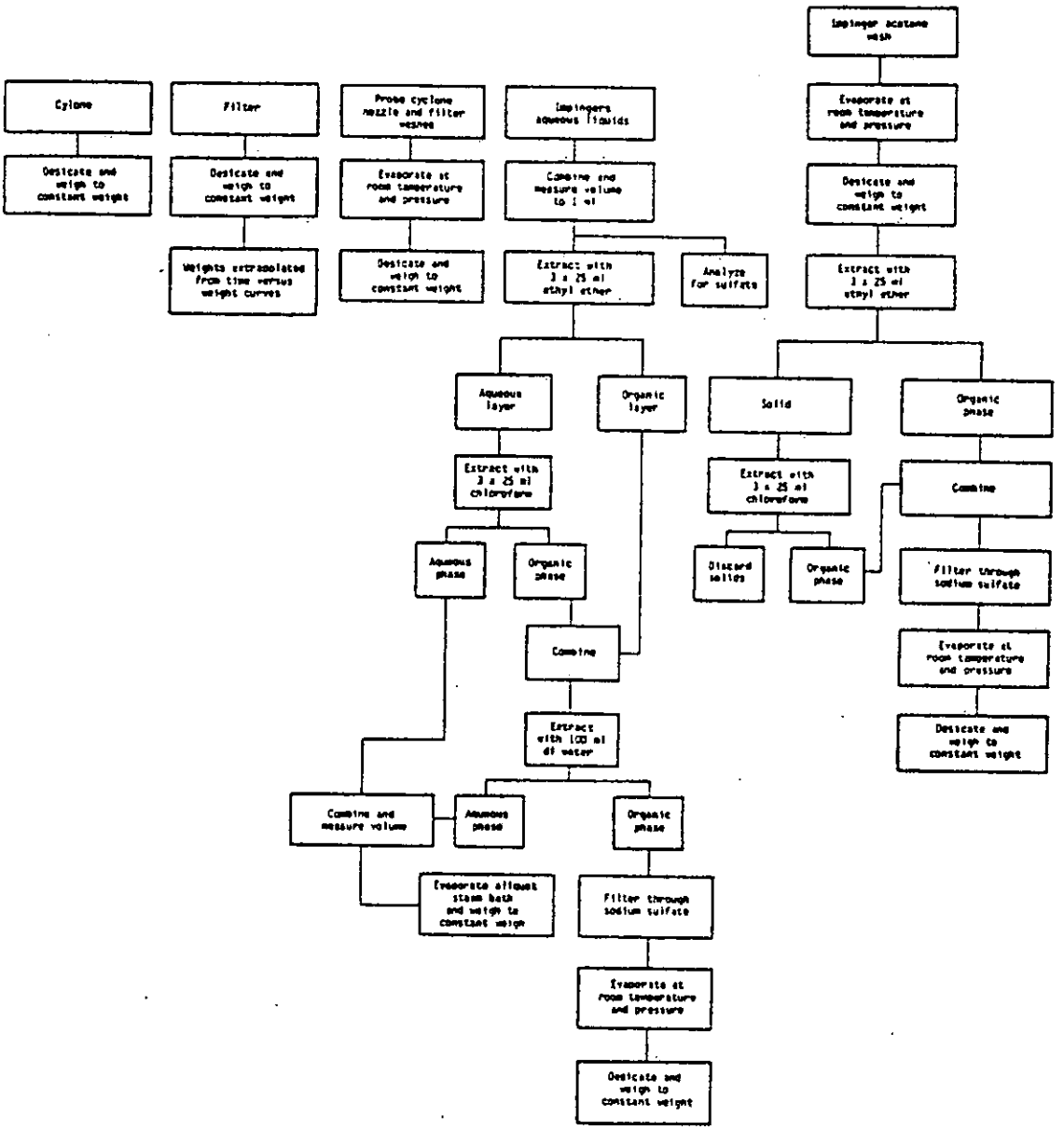


Figure 4-2. Sample analysis scheme for particulate mass train.

Barium perchlorate was standardized daily against 0.0100 N H_2SO_4. All samples were assigned an I.D. number in a log book for chain of custody.

4.2 QUALITY ASSURANCE

Field analysis performed fell largely into two categories -- sulfate analysis using the barium thorin titration method, and particulate quantification of various samples (i.e., impinger catches, acetone washes, organic extracts etc.). A quality control program was made part of the sulfate analysis and quality assurance program monitored the latter analysis. The aluminum weighing tins used in quantification were baked at 350°F for 3 hours to drive off oils left on the aluminum by the manufacturing process. After baking, the tins were dessicated and then tarred to $\pm$0.1 mg. After dessicating for 24 hours, the tins were weighed on a Mettler Model H51AR analytical balance. The tins were then redessicated for 24 hours before being weighed a second time. The maximum weight difference was required to be 0.3 mg. This process was repeated every 24 hours until the weight difference met tolerance.

All solvents used were nanograde including the solvents used for glassware rinsing. Blank acetone samples were taken daily from the acetone squeeze bottles in use.

All water used, including that used for glassware washing, was deionized and provided by Republic's laboratory. Blanks of this water were taken daily from the main storage container.

Filters were visually inspected for imperfections prior to original tare. Like the tins, original tare tolerance was $\pm$0.1 mg. Final weights of the particulate mass filters changed too rapidly (due to presence of H_2SO_4) for normal tare procedures. Filter weights were extrapolated from time versus weight curves. Blank filters were carried with and run

along with the sample filters, through the drying and weighing processes to ±0.3 mg.

A quality control program, including duplicates and spikes, was added to the quality assurance program for the sulfate analysis. Analyses of samples collected from the four particulate mass tests conducted at the No. 1 coke oven combustion stack were analyzed along with samples collected from 42 mass tests conducted at the BOF shop. Duplicates of samples were run -- a minimum of one in seven samples. Titrant was required to agree within ±0.5 ml of original. These same samples were then spiked with approximately 150 percent of their original concentration, with a required percent recovery of 100 ± 5 percent. All blanks were analyzed in the same manner as their corresponding samples (i.e., through ion-exchange columns etc.). The results are summarized in Table 4-1.

Table 4-1. Quality Assurance Results

Date	Duplicate Percent	Recovery Percent
7-09-79	±0.0	101.0
7-04-79	±0.0	101.0
7-05-79	±0.0	98.4
7-19-79	±0.0	104.0
7-19-79	±0.0	102.0
7-19-79	±0.0	100.9

SECTION 5

STACK TEST RESULTS

This section of the report summarizes the results of the particulate mass emission tests conducted on the no. 1 coke battery combustion stack.

Tables 5-1 and 5-2 summarize the particulate mass data obtained for the coke plant test program. Table 5-1 presents pertinent flue gas data such as volumetric flowrate, oxygen and carbon dioxide concentration, stack gas velocity and stack gas temperature. Table 5-2 presents the particulate and condensible emission rates. All four tests were conducted within the $\pm$10 percent isokinetic sampling guideline required by EPA Method 5. Upon completion of each test each filter was visibly inspected; all filters for all four tests were intact, were not torn, and showed no signs of penetration. The average sampling probe and filter temperatures were within the 248 $\pm 25^{\circ}$F criteria required by EPA Method 5.

Particulate test results (Table 5-2) show that particulate mass emission rates for tests 60 and 62 were lower than particulate mass emission rates for tests 61 and 63. Plant operating data (Table 2-2) shows that during test 60 there were 7 ovens pushed and 6 ovens charged and during test 62 there were 4 ovens pushed and 5 ovens charged. Approximately 10 tons of coke are pushed from each oven. During test 61 there were no ovens charged or pushed and during test 63 there were 2

Table 5-1. Particulate Mass Test Sampling Data

Test No.	Date	Start Test	Test Time (min)	Stack Gas Moisture (%)	Oxygen Concentration (%)	Carbon Dioxide Concentration Temp (%)	Stack Gas Temp (°F)	Stack Gas Pressure (in. Hg)	Average Velocity (fps)	Stack Gas Volumetric Flowrate (dscfm)	Percent Isokinetic
60	7-16	0824	96	8.2	12.4	4.0	576	29.52	23.3	40300	96.9
61	7-16	1211	96	14.0	11.5	4.2	600	29.53	25.3	40100	101.2
62	7-17	0748	96	12.7	13.4	3.5	609	29.60	23.9	38300	100.5
63	7-17	1053	96	13.8	11.3	4.2	610	29.60	24.6	38800	100.9

Table 5-2. Particulate and Condensible Emission Rates

Test No.	Date	Volume of Gas Sampled (dscf)	Particulate Mass (mg)	Particulate[a] Mass Concentration (gr/dscf)	Particulate[a] Mass Emission Rate (lbs/hr)	Condensible Organic Concentration (gr/dscf)	Condensible Organic Emission Rate (lbs/hr)	Condensible Inorganic Concentration (gr/dscf)	Condensible Inorganic Emission Rate (lbs/hr)	Condensible Sulfate Concentration (gr/dscf)	Condensible Sulfate Emission Rate (lbs/hr)	Total[b] Emission Rate (lbs/hr)
60	7-16	40.300	39.7	0.010	3.5	0.0001	0.04	0.0091	3.15	0.0183	6.32	6.69
61	7-16	40.100	56.0	0.014	4.7	0.0042	1.46	0.0685	23.54	0.0526	18.08	29.70
62	7-16	38.300	84.5	0.007	2.4	0.0009	0.29	0.3105	101.91	0.1744	57.23	104.60
63	7-16	38.800	88.2	0.023	7.5	0.0036	1.18	0.0848	28.19	0.0563	18.72	36.87
Average ± Standard Deviation				0.013 ± .007	4.5 ± 2.2	0.0022±0.0020	0.74 ± 0.68	0.1182±0.1322	39.20 ± 43.20	0.0754±0.0682	25.09±22.17	44.47 ±42.11

[a]Front half catch (nozzle, probe, cyclone, filter)
[b]Front half plus back half catch (condensible organic and inorganic)

ovens pushed and 2 ovens charged. This grouping indicates that the particulate mass emission rate is lower when more ovens are pushed and charged. Condensible emission test results are also more variable when there are many ovens being charged and pushed. During these operations the doors to the oven are open and the negative draft will cause in-leakage. The O_2 concentration in Table 5-1 shows that tests 60 and 62 (many ovens being charged) measured from 1 to 2 percent higher O_2 than tests 61 and 63 (few ovens being charged). The variation in the number of ovens pushed and charged during this test program is considered to be typical.

Opacity readings (Table 5-3) were 0 percent throughout the particulate mass test runs except for a 30 second period of 10 percent opacity. This occurred during test 61 which was the only test where no charging or pushing took place.

Table 5-3. Visible Emission Readings

Date	Test No.	Particulate Test Time Interval	Opacity Reading Interval	No. of Opacity Readings	Range of Readings (%)	Average Opacity Readings (%)
7-16-79	60	0824-0912	0823-0912	196	0 - 0	0.0
		1021-1109	1018-1107	196	0 - 0	0.0
7-16-69	61	1211-1259	1207-1257	200	0 - 10	0.1
		1324-1412	1320-1409	196	0 - 0	0.0
7-17-79	62	0748-0836	0748-0836	192	0 - 0	0.0
		0910-0958	0910-0959	196	0 - 0	0.0
7-17-79	63	1053-1141	1053-1142	196	0 - 0	0.0
		1155-1243	1155-1244	196	0 - 0	0.0

APPENDIX A

SAMPLING EQUIPMENT

This section of the report describes the sampling equipment used by Acurex to sample the particulate emissions from the no. 1 coke oven combustion stack.

A.1 PARTICULATE SAMPLING EQUIPMENT

The particulate mass tests were conducted using the following sampling train:

- A 316 stainless steel sampling nozzle properly sized for isokinetic sampling;
- A 316 stainless steel lined sampling probe 10 feet long equipped with a thermocouple to measure probe temperature, a thermocouple to measure stack gas temperature, and an S-type pitot tube to measure velocity pressure;
- A 316 stainless steel 3 μcyclone for large particulate collection;
- A teflon coated stainless steel 142 mm filter holder;
- An impinger train containing four glass bottles to collect moisture and condensible material escaping the filter and cyclone;
- A 10-cfm carbon vane pump modified for very low leakage around the shaft;

- A control module to monitor temperature, pressure, and flowrate throughout the sampling train.

For a list of the specific equipment used for each particular test, refer to Table A-1.

A.1.1 Sampling Probe

A heated 316 stainless steel lined probe 10 feet in length was used to isokinetically extract samples from the ducts. The probe had a closed loop temperature control system to keep the probe temperature at 250°F as required by EPA Method 5. The probe was equipped with an S-type pitot tube to measure the stack gas velocity pressure and a thermocouple to measure the stack gas temperature.

A.1.2 Cyclone and Filter Holder

For the particulate mass tests, a 316 stainless steel cyclone with a 3 μ aerodynamic diameter cut point was used to capture large particulates (Figure A-1). A 316 stainless steel, teflon coated 142 mm filter holder containing a glass fiber filter was used to capture the particulates escaping the cyclone. The oven has its own closed loop temperature control system to maintain the cyclone and filter temperature at 250°F.

Table A-1. Sampling Equipment Used During Particulate Mass Tests

Test No.	Date	Probe Length (ft.)	Probe Liner	Pitot Coeff.	Nozzle Dia. (in.)	Orifice Coeff. (K_o)	Control Unit No.
60	7/16/79	10	ss	.786	.429	.708	0039
61	7/16/79	10	ss	.786	.429	.708	0039
62	7/17/79	10	ss	.786	.745	1.787	0039
63	7/17/79	10	ss	.786	.429	.708	0039

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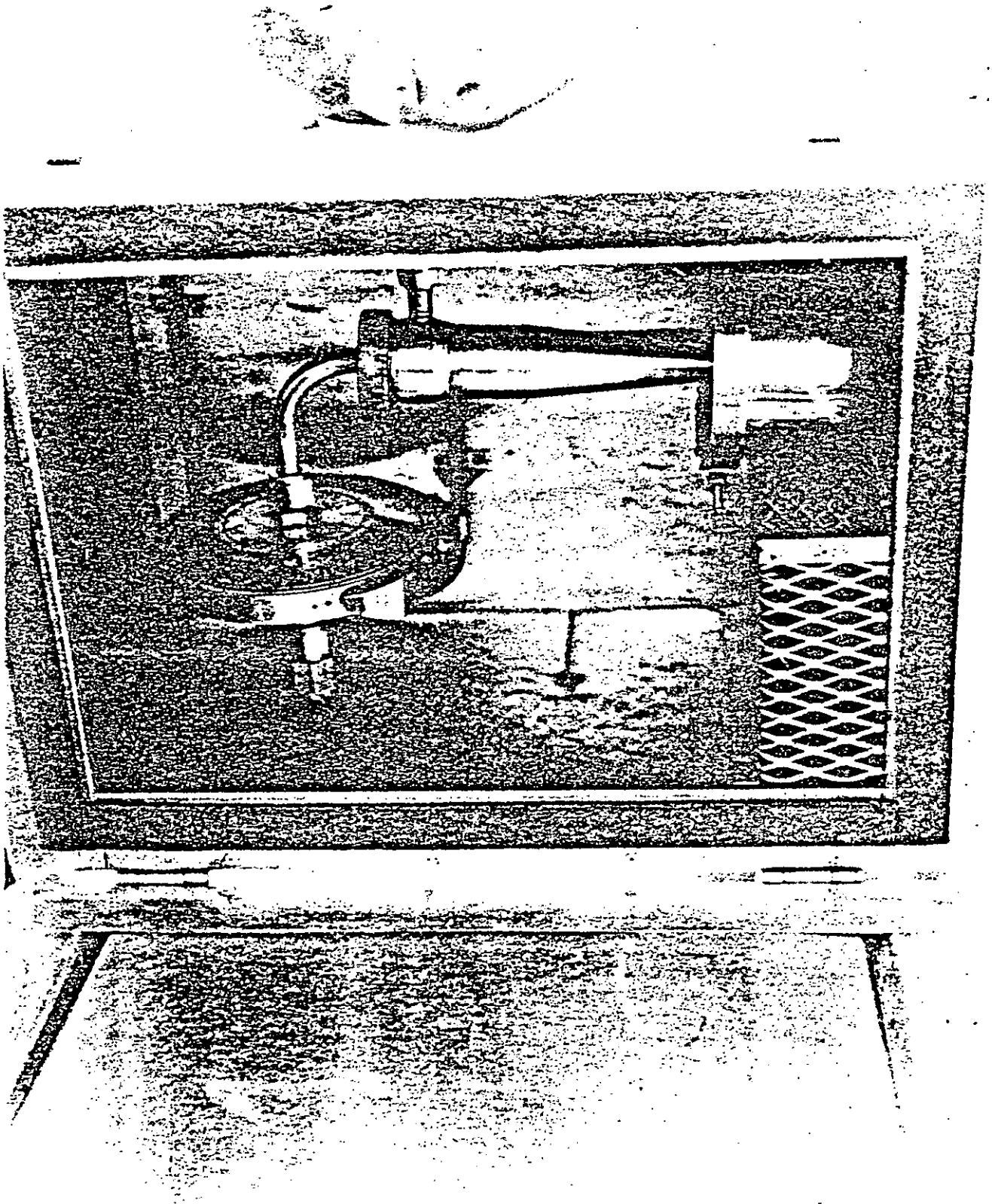

Figure A-1. One cyclone and filter in oven for particle mass tests.

The oven contains a fan to insure the uniform distribution of heat in the oven.

A.1.3 Impinger Train

The impinger train for the particulate mass tests was immersed in an icebath and consisted of four glass impinger bottles equipped with teflon caps and 316 stainless steel stems, connector tubes and fittings. The first two bottles contained 250 ml of distilled water, the third bottle was blank, and the fourth contained a known amount of silica gel. The temperature of the gases leaving the last impinger was monitored with a thermocouple. The impingers were used to collect moisture and condensible material (inorganic and organic) that escaped collection by the cyclone and filter.

A.1.4 Control Module

The control module monitors the temperatures, pressures and flowrates throughout the sampling train. For these tests, the orifice ΔH was indicated on a 0-6" magnehelic gauge whose smallest division was 0.1" H_2O. The velocity pressure of the stack gases is indicated on a 0-0.5" or a 0-4" magnehelic.

The control module contained a Rockwell Model 415 dry gas meter to measure the total volume of gas sampled to the nearest 0.005 ft^3. An orifice meter (after the dry gas meter) was used to measure the instantaneous flowrate through the sampling train to insure sampling was being done isokinetically.

Finally, the control module had an 8-position thermocouple switch to measure temperatures throughout the sampling train. Figure A-2 illustrates all the aforementioned components of the Acurex High Volume Stack Sampler used for conducting the test program at the no. 1 coke oven combination stack.

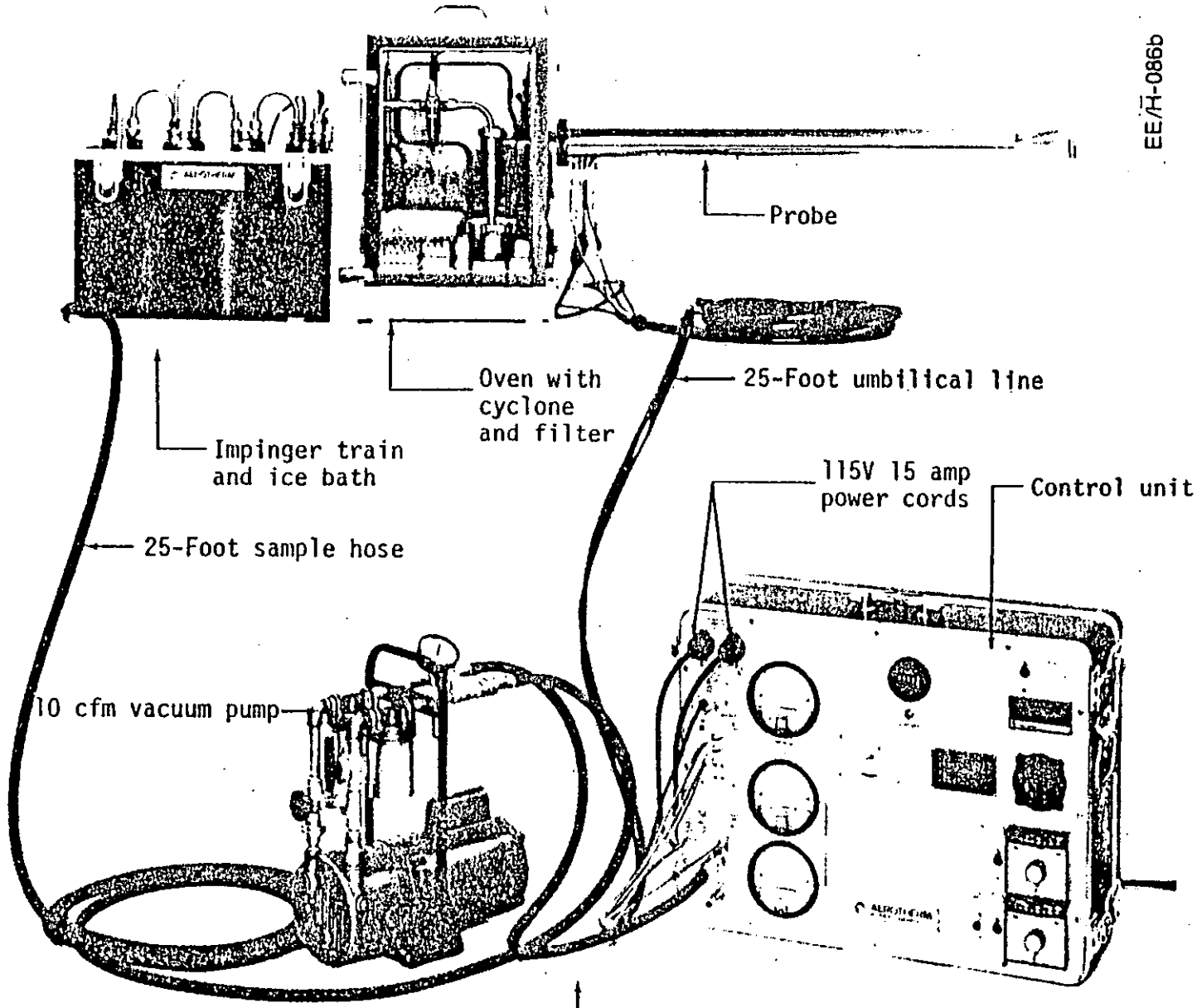

Figure A-2. Acurex high volume stack sampler.

APPENDIX B

PREPARATION OF THE SAMPLING EQUIPMENT

Before stack tests in the field can be conducted, sampling equipment must be carefully prepared to make reliable field measurements and to minimize costly delays due to equipment breakdown. This section of the report describes the preparations made by Acurex personnel prior to conducting the field tests at Republic Steel, Cleveland.

B.1 SAMPLING NOZZLES

All sampling nozzles to be used in the field tests were inspected and sharpened if necessary to minimize both gas streamflow disturbances and particulate impacting on the edge of the nozzle. Those nozzles which had been nicked or damaged were sharpened. The internal diameters of the sampling nozzles were measured with a micrometer to insure accurate values for the nozzle diameter when calculating the isokinetic sampling rates for the particulate tests.

B.2 SAMPLING PROBE

A heated 316 stainless steel lined sampling probe was used during the test program.

B.3 PROBE HEATER AND OVEN HEATER

Before the equipment was packed, and the probe and oven heaters and their temperature controllers were checked out in the laboratory by setting the temperature controllers at 250^{o}F and turning the heaters

on. The system was left on for approximately 5 minutes to make sure that the heaters were working and the temperature controllers were holding the temperatures at 250°F.

B.4 UMBILICAL CORD

The umbilical cord which connects the probe to the control module was inspected and the polyflow tubing inside the umbilical cord checked for cracks and leaks. The quick disconnects were also inspected and checked to make sure they were operating properly.

B.5 IMPINGER ASSEMBLY

The impinger sampling train consisted of four glass impinger bottles (in place of the Lexan bottles normally used). All parts were inspected before they were shipped to the site. All the glassware was cleaned in a chromic acid bath. Replacement impinger bottles were taken in case of breakage.

B.6 VACUUM PUMP

The vacuum pumps were operated in the laboratory to measure their free flow capacity and leak rate at maximum vacuum. The vacuum pumps were found to be leak tight.

B.7 GLASS FIBER FILTERS

The glass fiber filters were obtained from Schleicher and Schuell and were equivalent to the MSA 1106 BH glass fiber filters specified by EPA Method 5. The filters were placed into individual plastic petri dishes and put in a dessiccator for conditioning over silica gel for at least 24 hours. The filters were then taken to the balance room and weighed to the nearest 0.01 milligram on a Mettler Model H51AR analytical balance. After weighing, each filter was returned to the plastic petri

dish, which was sealed with masking tape and labeled with the filter number. This information was also recorded in the filter record book.

B.8 CHEMICALS

Several types of chemicals were purchased for the field tests. Analytical reagent grade acetone from J. T. Baker (Resi-Analyzed) and Mallinckrodt (Nanograde) was used to rinse the front half and back half of the sampling train. Deionized water from Republic Steel's laboratory was used in the impinger train and was also used to rinse the impinger train for sample recovery (followed by acetone rinse). Chloroform and ether were analytical reagent grade chemicals.

Silica gel grade Type 4, from MC/B Company, was used to dry the sample gases. Silica gel is equivalent to Drierite, the desiccant specified by EPA Method 5.

B.9 FILTER HOLDER ASSEMBLY

The two filter holder assemblies were cleaned and inspected to insure the teflon gaskets were in good shape. Each assembly was equipped with new gaskets if required and tested for leaks before they were sent to the site. The filter halves had recently been teflon coated so that the internal surfaces were smooth and resistant to chemical attack.

APPENDIX C

CALIBRATION PROCEDURES

After the sampling equipment was inspected and prepared, various pieces of the sampling train were calibrated. This section describes these calibration procedures.

C.1 DIGITAL TEMPERATURE INDICATOR AND THERMOCOUPLES

The Acurex High Volume Stack Sampler uses a digital temperature indicator with an 8-point thermocouple selector switch. The selector switch permits temperature to be monitored at each of the following locations: stack gas, probe, oven, impinger train outlet, gas meter inlet, gas meter outlet, and two spare locations. The digital temperature indicator operates over a range of $0^{o}F$ to $1500^{o}F$ with an accuracy of $\pm 4^{o}F$. All temperatures in the sampling train are measured by chromel-alumel thermocouples.

The digital temperature indicator for the control module was checked in two ways. For the first check, a thermocouple was immersed in an ice bath at $32^{o}F$ and the leads from the thermocouple connected to one of the spare locations on the control module. The reading on the digital temperature indicator was then observed and compared with that of the ice bath. For the second check, the oven controller was set at $250^{o}F$. The temperature of the oven was then displayed by the digital temperature indicator and compared to the temperature measured by a mercury-in-glass

thermometer. The zero and span of the digital temperature indicator was adjusted if the readings disagreed with either the ice bath or the oven temperature.

C.2 MAGNEHELIC GAUGES

Normally, magnehelic gauges are used in the control module to display the velocity pressure in the stack and the pressure drop across the orifice meter. These magnehelic gauges were calibrated against the Dwyer inclined manometer described in Section C.4.

The calibration procedure was a simple one. First the Dwyer inclined manometer and the magnehelic gauge to be calibrated were zeroed and leveled in the control module. Tee taps were installed in both the high-pressure and low-pressure sides of the magnehelic gauge. One side of the tee tap was connected to the orifice meter and the other side connected to the inclined manometer. A constant volume of gas was pumped through the orifice meter in the control module, and the readings on the magnehelic gauge and the Dwyer inclined manometer were observed. If the readings differed, the magnehelic gauge was adjusted and the calibration was repeated until the readings agreed. The calibration procedure was repeated at several different flowrates.

C.3 DRY GAS METER AND ORIFICE METER

The control module of the sampling train contains a dry gas meter and an orifice meter. The dry gas meter measures the total volume of gas sampled during the test. The orifice meter is used to measure the rate at which the stack gas is sampled.

A Rockwell Model 415 gas meter (illustrated in Figure C-1) is used to simultaneously calibrate the dry gas meter and orifice meter in the control module. This calibration standard is the same type of meter that

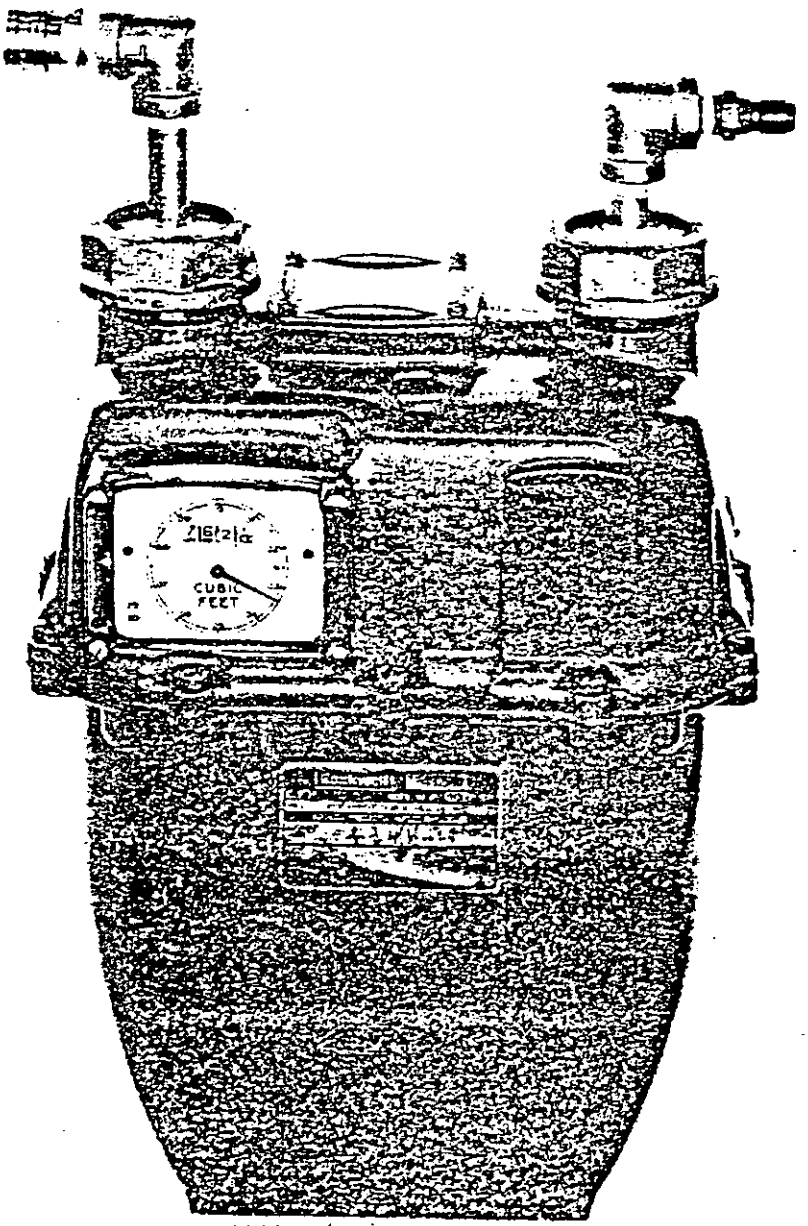

Figure C-1. Rockwell Model 415 gas meter calibration standard.

is used in the control module of the sampling train. The accuracy of this Rockwell meter has been verified against a National Bureau of Standards traceable bell prover maintained by the Pacific Gas & Electric Company.

Before performing a calibration, the Rockwell gas meter and the control module to be calibrated were left overnight in the Laboratory to come to thermal equilibrium. The next day, the magnehelic gauges in the control module were zeroed and leveled and the following components were arranged in series: the calibration standard, a vacuum pump, and the control module to be calibrated. Calibration information and the initial readings on the calibration standard gas meter and the gas meter in the control module were recorded on the data sheet shown in Figure C-2.

The vacuum pump was then turned on with the valves closed. Next, the valves were opened, the ΔH across the orifice magnehelic gauge was set at a particular value, and the timer in the control module was started. The initial inlet and outlet temperatures at the calibration standard meter were measured with chromel-alumel thermocouples. The inlet and outlet temperatures of the dry gas meter in the control module were measured by thermocouples installed in the meter and the temperatures were displayed on the digital temperature indicator. The flowrate through the assembled components was maintained at a constant rate (as indicated by the reading on the orifice magnehelic gauge) for a known length of time, ranging from 2 to 4 minutes, until at least 10 cubic feet of air had passed through the system.

At the completion of a calibration run, the final dry gas meter readings and the final inlet and outlet dry gas meter temperatures were recorded. The same procedure was repeated at four different flowrates to calibrate the orifice meter over its entire useful range. The data from

Date 5/23/75		Orifice Meter	C039, .358	Operator	P. Scezmiller
Time	[illegible]	Orifice Magnehelic		Wet Bulb Temperature	
Barometric Pressure	30.2[illegible]	Primary Calibration Meter			
Ambient Temperature	74 °F	Control Module	0039		

METER CALIBRATION DATA

Orifice Manometer ΔH_{ref} (in. wg.)	Orifice Magnehelic ΔH_0 (in. wg.)	Primary Meter ΔH_p (in. wg.)	Dry Test Meter P_{dg} (in. wg.)	Gas Volume Primary Meter V_p (ft.³)	Gas Volume Dry Test Meter V_d (ft.³)	Temperature – Primary Meter – Inlet, T_{pi} (°F)	Primary Meter – Outlet, T_{po} (°F)	Primary Meter – Avg., T_{pa} (°F)	Dry Test Meter – Inlet, T_{di} (°F)	Dry Test Meter – Outlet, T_{do} (°F)	Dry Test Meter – Avg., T_{da} (°F)	Time t (min.)	a	K_0
	0.2													
	0.4													
	0.6													
.54	0.8			[illegible]	[illegible]	73 73	[illegible]	73.5	75 [illegible]	73 73	74.25	3.5	[illegible]	[illegible]
	1.0													
	1.2													
	1.4													
	1.6													
1.55	1.8			[illegible]	[illegible]	73 73	74 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2.0													
	2.2													
	2.4													
	2.6													
[illegible]	[illegible]			[illegible]	[illegible]	73 73	[illegible]	73.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	3.0													
	3.2													
	3.4													
	3.6													
3.82	3.8			[illegible]	432.415 [illegible]	73 73	74 74	73.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	4.0													
	4.2													
	4.4													
	4.6													
	4.8													
	5.0													

Average	
[illegible]	[illegible]

Figure C-2. Meter Calibration Data Sheet

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these calibrations were then used to calculate the calibration constants for the dry gas meter and the orifice meter in the control module.

The formula used to calculate the calibration constant for the dry gas meter is as follows:

$$\alpha = \frac{V_d \left(P_{bar} + \frac{\Delta H_o}{13.6}\right)\left(\frac{T_{pi} + T_{po}}{2} + 460\right)}{V_p P_{bar}\left(\frac{T_{di} + T_{do}}{2} + 460\right)}$$

where

α = calibration constant for dry gas meter in the control module

V_d = total volume of gas passing through the dry gas meter in the control module, ft^3

V_p = total volume of gas passing through the calibration standard meter, ft^3

P_b = barometric pressure, inches Hg

ΔH_o = pressure drop across the orifice meter in the control module, inches H_2O

13.6 = conversion factor, inches H_2O/inches Hg

T_{di} = inlet temperature of dry gas meter in the control module, ^oF

T_{do} = outlet temperature of dry gas meter in the control module, ^oF

T_{pi} = inlet temperature of calibration standard meter, ^oF

T_{po} = outlet temperature of calibration standard meter, ^oF

460 = conversion factor, ^oF to ^oR

The meter readings obtained during the field tests were divided by α to obtain the true volume.

The calibration constant for the orifice meter was determined using the following formula:

$$K_o = \frac{V_p}{t \left(\frac{T_{do}\, \Delta H_o}{P_{bar}\, M_m} \right)^{1/2}}$$

where

K_o = calibration constant for the orifice meter in the control module

V_p = total volume of gas passing through the calibration standard meter, ft^3

T_{do} = outlet temperature of dry gas meter in the control module, ^oR

t = calibration time, minutes

ΔH_o = pressure drop across the orifice meter in the control module, inches H_2O

P_{bar} = barometric pressure, inches Hg

M_m = molecular weight of the air, 28.96 lb/lb-mole

An average calibration constant was determined for the dry gas meter and orifice meter in the control module by averaging the individual test results. The calibration data for the control module used during the field tests is presented in Figure C-2.

C.4 S-TYPE PITOT TUBE

The S-type pitot tube attached to the sampling probe measures the volumetric stack gas flowrate and the velocity at each sampling point so that an isokinetic sampling rate can be determined. Before being taken into the field, the S-type tube for the sampling train was calibrated in the Acurex Wind Tunnel illustrated in Figure C-3 using the United Sensor

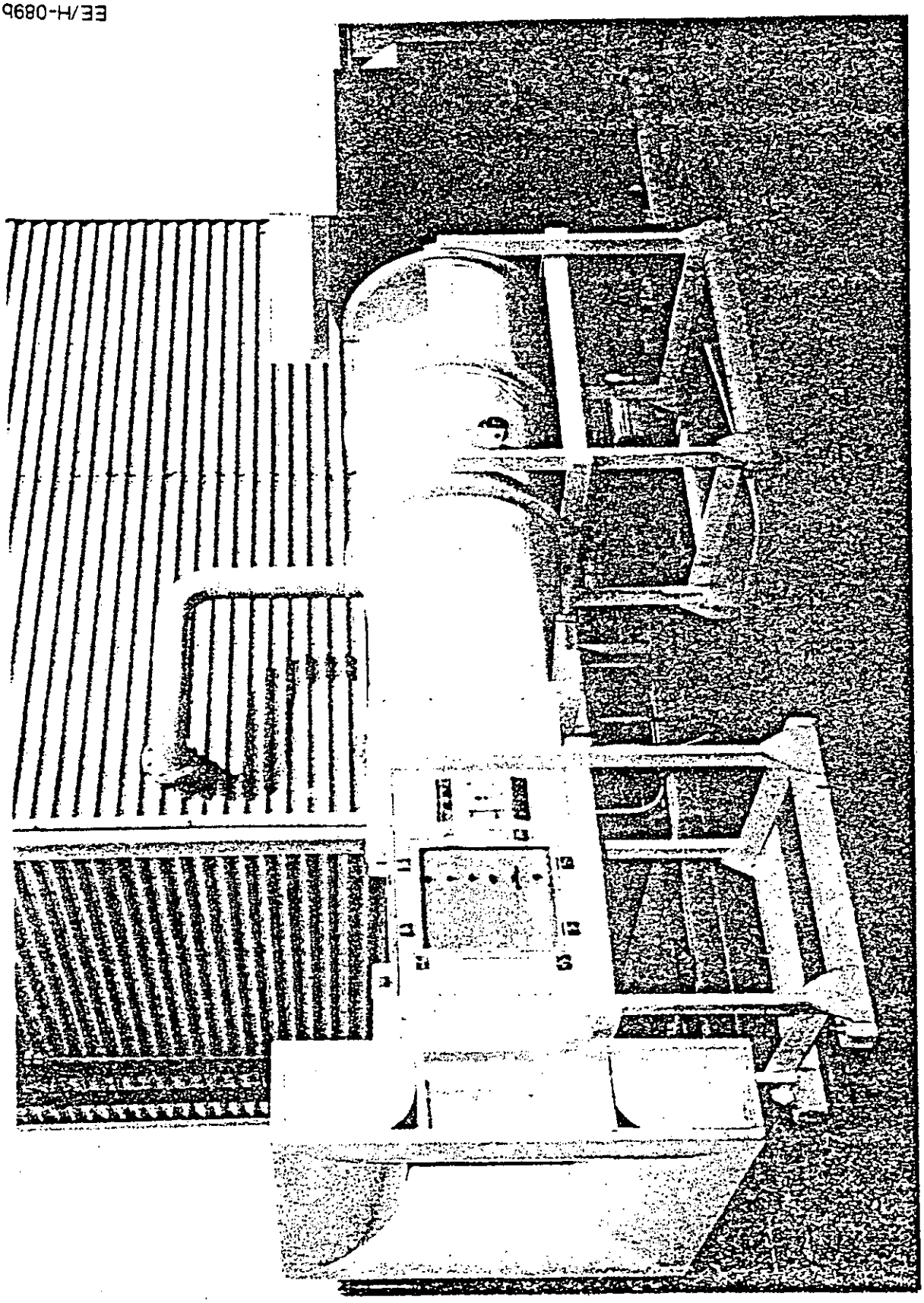

Figure C-3. Acurex calibration wind tunnel.

Hemispherical nose standard pitot tube shown in Figure C-4. The coefficient for this standard pitot tube is 0.99.

The velocity pressure sensed by the standard pitot tube was indicated on the Dwyer inclined manometer shown in Figure C-5. This manometer has a full scale range of 0 to 4 inches of water and can measure differences as small as 0.01 inch of water. In addition, the inclined manometer is equipped with a valve system which allows the operator to change from the standard pitot tube to the S-type tube being calibrated without disconnecting any tubes, thereby eliminating any unnecessary movement of the manometer. The valve system on the manometer also has a vent position which allows the manometer to be zeroed at any time. The manometer has a built-in level gauge so that the operator can check the level at any time.

The following steps were taken in calibrating the S-type pitot tube. First, the wind tunnel was leveled to ensure that the test section was horizontal. The wind tunnel fan was then turned on and the outlet dampers were adjusted to provide the desired velocity in the wind tunnel. The inclined manometer was positioned on a box near the wind tunnel and the standard pitot tube was connected to the inclined manometer with tygon tubing. At the same time, the S-type pitot tube was connected to the manometer using polyflow tubing and quick disconnects. Both the tygon and polyflow lines were inspected to make sure there were no leaks or cracks. The inclined manometer was then zeroed and leveled. Before beginning the actual calibration run, the data at the top of the pitot tube calibration data sheet, Figure C-6, was recorded.

The standard pitot tube was inserted into the wind tunnel through holes on the far side of the tunnel, as shown in Figure C-3, with the nose

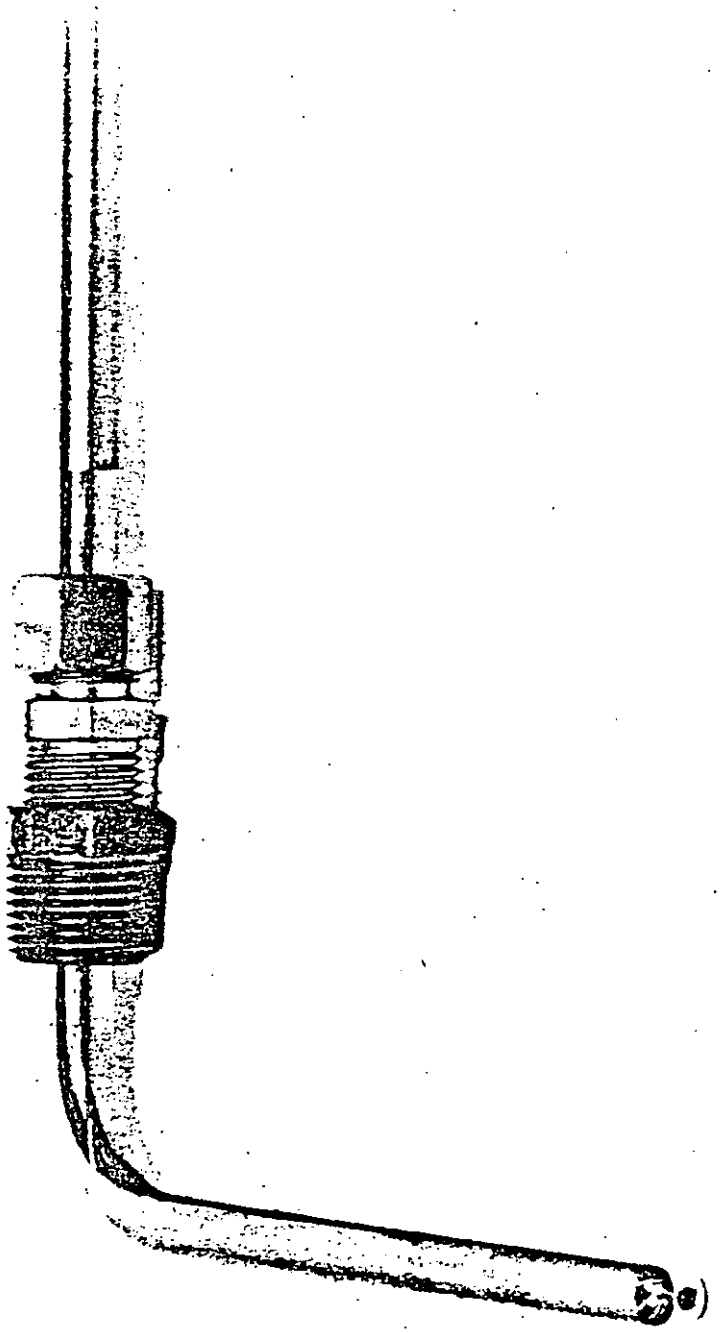

Figure C-4. United sensor hemispherical nose standard pitot tube.

EE/H-1016

Figure C-5. Dwyer inclined manometer.

DATE 6/1/79
TIME 810
BAROMETRIC PRESSURE 30.05
AMBIENT TEMP 68°F

TEST PITOT TUBE P-11
STANDARD PITOT TUBE United Sensor
TEST SECTION LOCATION Aerotherm Wind Tunnel
OPERATORS Gilchrist, Kaufman

NOZZLE SIZE 1/2"
NOZZLE-PITOT SPACING
PITOT-TC SPACING

PITOT TUBE CALIBRATION DATA

Test Pitot Tube ΔP (in. wg.)		Standard Pitot Tube	C_p	Static Pressure	Gas Temp	Wet Bulb Temp	Test Section Velocity
Upper Leg	Lower Leg	ΔP (in. wg.)		(in. wg.)	(°F)	(°F)	(fps)
.22	.22	.14					
.795	.798						
.54	.54	.33					
.782	.782						
.85	.84	.52					
.782	.787						
1.20	1.19	.75					
.783	.786						
1.50	1.49	.93					
.780	.782						

A-17406

Average C_p upper = .785 Average C_p lower = .787
C_p Avg. = .786

Figure C-6. Pitot tube calibration data sheet.

of the pitot tube positioned at the centerline of the wind tunnel facing directly into the gas streamlines. The operator could look through a plexiglass window to ensure that the pitot tube was pointed in the proper direction at all times. With the standard pitot tube properly positioned in the test section, the valve system on the inclined manometer was opened. The velocity pressure measured by the standard pitot tube and indicated on the inclined manometer was recorded and the standard pitot tube was withdrawn from the wind tunnel.

The S-type pitot tube, attached to the sampling probe with the sampling nozzle and thermocouple in place, was then inserted through the near side of the wind tunnel so that the S-type tube tip was at the centerline of the wind tunnel. Inserting the sampling probe assembly into the wind tunnel was made easier by a bracket adjacent to the plexiglass window, as shown in Figure C-3. The bracket was clamped tightly around the sampling probe to ensure that the assembly did not move in the wind tunnel. The bracket also made a seal with the inside of the wind tunnel wall so that the surfaces were flush and no flow disturbance was created at the wall. The tips of the S-type pitot tube were aligned and pointed directly into the gas streamlines, with the operator observing the position of the tips through the plexiglass window.

The valve system on the inclined manometer was then switched to the S-type pitot tube, and the velocity pressure measured by the lower leg of the S-type pitot tube and indicated by the inclined manometer, was recorded. This procedure was repeated several times in order to calibrate the S-type pitot tube over a wide range of velocities.

The formula used to calculate the coefficient for the S-type pitot tube for each sampling probe is as follows:

$$C_{P_{S\text{-type}}} = 0.99 \left(\frac{P_{std}}{P_{S\text{-type}}} \right)^{1/2}$$

where

$C_{P_{S\text{-type}}}$ = coefficient of the S-type pitot tube

P_{std} = velocity pressure measured by the standard pitot tube, inches H_2O

$P_{S\text{-type}}$ = velocity pressure measured by the S-type pitot tube, inches H_2O

0.99 = coefficient of the standard pitot tube

The average coefficients for the upper and lower legs of the S-type pitot tube were calculated by averaging the individual coefficients of each calibration run. These average values were recorded on the calibration data sheet. The 10 foot 316 ss lined probe used during the field tests was calibrated in accordance with the aforementioned procedures. Figure C-6 shows the calibration data for the S-type pitot tube and sampling probe that was used during the field test program.

C.5 METTLER ANALYTICAL BALANCE

A Mettler Model H51AR balance, which can be read to 0.01 mg, was used to weigh the glass fiber filters and the chemicals used to prepare solutions. This balance is checked twice a year by the Mettler Instrument Corporation against National Bureau of Standards weights to ensure its accuracy. In addition, a set of Class S National Bureau of Standards weights were brought into the field to check the accuracy of this balance periodically.

APPENDIX D

RAW DATA SHEETS

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

Plant Republic Steel | Barometric Pressure 29.61 | Nozzle Size & Number .429

Date 7/16/79 | Static Pressure -1.2 | Molecular Weight

Test Location Coke oven | Stack Pressure 29.52 | BWO

Run Number #60 | Probe Number 10' | FILTER DATA

Stack Diameter inches 107.1 | Pitot Coefficient 0.786

NUMBER	TARE	FINAL WT

Duct Dimensions in. x in. | Pitot Number P11

Start Time 0824 | Meter Box Number 0039

Operator JARMAN | Orifice Coefficient .708

IMPINGER VOLUMES	TIME	CO_2	O_2	CO
113.7	10:20	4%	12%	0%
	10:50	4%	12%	0%
SILICA GEL				

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in wg	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in. Hg	$\sqrt{\Delta P}$	Leak Rate .11 @15kg
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
4S	0	.05	.78	543.147	450	256	72		260	88	88		.22	
5	2.0	.06	.95	EST	425	260	66		267	87	88		.24	
5	4.0	.05	.78	543.112	450	260	66		267	87	88		.22	
4S	6.0	.075	1.08	546.21	452	254	63		267	87	88		.26	
5	8.0	.06	1.10	547.58	307	253	63		267	87	88		.24	
6	10.0	.06	1.10	548.88	314	254	63		268	86	88		.24	
7	12.0	.075	1.02	549.81	574	260	64		267	86	88		.27	
8	14.0	.075	.99	550.96	609	258	64		267	86	88		.27	
9	16.0	.08	1.05	552.11	616	258	64		268	87	88		.28	
10	18.0	.09	1.17	553.25	622	264	65		267	87	88		.3	
11	20.0	.09	1.17	554.43	624	267	66		268	87	88		.3	
12	22.0	.09	1.17	555.62	628	267	67		268	86	88		.3	
13	24.0	.11	1.42	556.87	634	268	68		268	86	88		.33	
14	26.0	.13	1.67	558.19	640	267	69		268	87	88		.36	
15	28.0	.14	1.79	559.64	642	266	68		268	87	88		.37	
16	30.0	.14	1.79	561.17	645	267	69		268	87	88		.37	
17	32.0	.14	1.79	562.72	648	269	67		267	87	88		.37	
18	34.0	.145	1.84	564.27	652	270	69		267	87	88		.38	
19	36.0	.14	1.79	565.82	654	269	68		267	87	88		.37	
20	38.0	.14	1.84	567.37	603	270	67		268	87	88		.37	
AVG/TOTAL														

25,771

Form EED-03 [illegible]79

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D-3

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ACUREX Corporation

Pg. 2 of 3

PARTICULATE TEST FIELD DATA SHEET

Plant REPUBLIC STEEL — Barometric Pressure ____

Date 2/16/79 — Static Pressure ____

Test Location COKE STACK #1 — Stack Pressure ____

Run Number 60 — Probe Number ____

Stack Diameter inches 107 — Pitot Coefficient ____

Duct Dimensions in x in ⌒ — Pitot Number ____

Start Time ____ — Meter Box Number ____

Operator JARMAN — Orifice Coefficient ____

Nozzle Size & Number ____

Molecular Weight ____

BWO ____

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg.	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in Hg	$\sqrt{\Delta P}$
21	40	.15	1.98	568.89	609	264	68		269	87	88		.39
22	42	.14	1.84	570.48	613	264	68		268	87	88		.37
23	44	.13	1.67	572.0	616	267	69		268	87	88		.36
24	46	.115	1.51	573.48	617	268	68		268	87	88		.34
	48			574.871									
				31.724									
5	0	.04	.56	574.871	550	265	68		270	88	89		.2
5	2	.035	.49	575.71	555	259	69		260	89	89		.19
5	4	.035	.49	576.54	559	259	68		250	88	88		.19
5	6	.035	.49	577.36	560	265	69		255	88	88		.19
5	8	.03	.42	578.15	560	267	68		257	88	88		.17
6	10	.10	1.38	578.92	561	265	69		264	88	88		.32
7	12	.11	1.62	580.11	563	267	69		267	88	88		.33
8	14	.115	1.54	581.57	598	263	70		261	88	89		.34
9	16	.12	1.58	582.93	610	260	69		261	88	89		.35
10	18	.126	1.64	584.41	616	265	69		260	88	89		.35
11	20	.13	1.70	585.84	618	263			263	88	89		.36
AVG/TOTAL													

E

D-4

S

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Form EED-021 1 79

ACUREX Corporation

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PARTICULATE TEST FIELD DATA SHEET

Plant Republic Steel | Barometric Pressure
Date 7/16/79 | Static Pressure
Test Location Coke Stk #1 | Stack Pressure
Run Number #20 | Probe Number
Stack Diameter inches | Pitot Coefficient
Duct Dimensions in. x in | Pitot Number
Start Time | Meter Box Number
Operator JARMAN | Orifice Coefficient

Nozzle Size & Number
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg.	ORIFICE METER ΔH in. wg	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in. Hg	$\sqrt{\Delta P}$	
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
12	22	.12	1.56	587.33	622	261	70		261	88	89		.35	
13	24	.12	1.56	588.74	627	264	69		260	88	89		.35	
14	26	.12	1.55	590.15	630	267	69		264	88	89		.35	
15	28	.12	1.55	591.59	634	260	69		264	88	89		.35	
16	30	.125	1.60	593.04	637	262	69		263	88	89		.35	
17	32	.125	1.60	594.47	639	265	68		265	88	89		.35	
18	34	.12	1.56	595.94	641	267	69		268	88	89		.35	
19	36	.115	1.47	597.32	646	267	69		267	88	89		.34	
20	38	.115	1.47	598.128	647	265	70		269	88	89		.34	
21	40	.10	1.27	599.45	650	265	69		268	88	89		.32	
22	42	.10	1.33	601.35	600	267	69		264	89	89		.32	
23	44	.105	1.39	602.45	604	268	68		267	89	89		.32	
24	46	.10	1.32	603.99	608	269	69		268	89	89		.32	
	48			605.327										
				30.456										
												LEAK RATE		
												.009 @ 15 kg		
AVG/TOTAL	96		1.34	62.180	576	263.85 ±4.39			265.23 ±4.10	88			0.311	

D-5

2

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Form EED 021 1 79

ACUREX Corporation

Pg 1 of 3

PARTICULATE TEST FIELD DATA SHEET

1/3

Plant Republic Steel Cleveland | Barometric Pressure 29.01

Date 7-16-79 | Static Pressure -1.1

Test Location Coke Stack | Stack Pressure 29.529

Run Number #61 | Probe Number 10 ft.

Stack Diameter inches 107" | Pitot Coefficient 0.786

Duct Dimensions in. x in. — | Pitot Number P11

Start Time 1211 | Meter Box Number 0039

Operator JARMAN | Orifice Coefficient 0.708

Nozzle Size & Number 0.429

Molecular Weight

BWO

FILTER DATA

NUMBER	TARE	FINAL WT.

IMPINGER VOLUMES	TIME	CO_2	O_2	CO
		4.3	11.4	0
		4.0	11.5	0
	215.8			
SILICA GEL		4.2	11.5	0

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in Hg	√ΔP	
S 5	0	.05	.70	605.845	560	259	69		263	96	96		.22	Leak Check
5	2	.045	.63	606.84	561	262	70		262	98	97		.21	.014 | 15" Hg
5	4	.05	.70	607.77	561	263	68		264	98	97		.22	
5	6	.05	.70	608.71	560	265	68		262	97	97		.22	Pitot OK
5	8	.045	.63	609.68	567	264	68		262	98	97		.21	
6	10	.11	1.54	610.61	568	266	69		263	98	97		.33	
7	12	.14	1.95	611.94	568	267	69		263	98	97		.37	
8	14	.14	1.91	612.37	~~598~~ 593	269	69		264	98	97		.37	
9	16	.145	1.9	615.17	637	263	68		262	97	97		.38	
10	18	.134	1.82	616.54	644	265	68		263	97	97		.37	
11	20	.145	1.88	618.07	647	267	68		264	97	97		.38	
12	22	.13	1.76	619.61	600	265	68		267	97	98		.36	
13	24	.13	1.74	621.12	610	266	69		267	97	98		.36	
14	26	.13	1.74	622.60	612	267	69		266	97	98		.36	
15	28	.125	1.67	624.08	617	263	69		263	97	98		.35	
16	30	.12	1.59	625.52	621	264	68		266	97	98		.34	
17	32	.125	1.65	626.94	624	265	69		263	97	98		.35	
18	34	.125	1.65	628.40	627	264	69		265	97	98		.35	
19	36	.115	1.51	629.83	630	266	69		267	97	98		.34	
20	38	.115	1.51	631.23	633	267	69		268	97	98		.34	
AVG/TOTAL	96		1.51	65.738	600					98			.33	

25.771

D-6

5108.78

Form EED-021 1-79

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

2 of 3

Plant Republic Steel Cleveland
Date 7-16-79
Test Location Coke Stack
Run Number #61
Stack Diameter inches
Duct Dimensions in. x in.
Start Time
Operator JARMAN

Barometric Pressure
Static Pressure
Stack Pressure
Probe Number
Pitot Coefficient
Pitot Number
Meter Box Number
Orifice Coefficient

Nozzle Size & Number
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in wg	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in Hg	$\sqrt{\Delta P}$	
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
21	40	.12	1.57	632.61	636	267	70		269	97	98		.35	
22	42	.13	1.7	634.01	638	267	70		263	97	98		.36	
23	44	.11	1.43	635.47	642	265	71		264	96	98		.33	
24	46	.11	1.43	636.81	642	267	70		267	96	98		.33	
end	48			638.211										
					490									
5	48	.07	1.06	638.211	~~257~~	257	72		273	98	99		.26	
5	50	.065	.98	639.11	491	265	70		269	98	99		.25	
5	52	.08	1.2	640.51	495	266	69		268	98	99		.28	
5	54	.075	1.13	641.79	500	265	68		263	98	99		.27	
5	56	.075	1.13	642.99	503	262	68		263	98	99		.27	
6	58	.08	1.19	644.21	509	265	69		261	98	99		.28	
7	60	.08	1.14	645.48	550	266	69		262	98	99		.28	
8	62	.085	1.15	646.69	605	267	69		263	98	99		.29	
9	64	.09	1.2	647.17	613	267	69		263	98	99		.3	
10	66	.10	1.34	649.23	615	269	68		267	98	99		.31	
11	68	.10	1.35	650.45	618	267	68		269	98	99		.31	
12	70	.105	1.4	651.77	623	267	69		267	98	99		.32	
13	72	.115	1.52	653.10	628	265	69		265	99	99		.34	
14	74	.125	1.65	654.59	633	266	70		265	99	99		35	
AVG/TOTAL														

Form EEC-

5103.7

ACUREX Corporation

3 of 3

PARTICULATE TEST FIELD DATA SHEET 3

3

Plant Republic Steel / Cleveland

Date 7-16-79

Test Location Coke Stack

Run Number #61

Stack Diameter inches

Duct Dimensions in

Start Time

Operator JARMAN

Barometric Pressure

Static Pressure

Stack Pressure

Probe Number

Pitot Coefficient

Pitot Number

Meter Box Number

Orifice Coefficient

Nozzle Size & Number

Molecular Weight

BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in Hg	$\sqrt{\Delta P}$	
15	76	.14	1.84	655.94	637	267	69		269	99	99		.37	
16	78	.15	1.96	657.47	640	270	69		270	99	99		.39	
17	80	.155	2.02	659.04	643	269	70		266	99	99		.39	
18	82	.15	1.95	660.61	647	263	69		262	99	99		.39	
19	84	.155	2.14	662.20	~~579~~ 650	269	69		267	99	99		.39	
20	86	.16	2.07	663.81	652	266	70		267	99	99		.4	
21	88	.15	2.0	665.42	6595	270	70		269	100	100		.39	
22	90	.15	2.03	667.0	604	266	69		263	100	100		.39	
23	92	.14	1.89	668.61	608	267	70		269	100	100		.37	
24	94	.12	1.68	670.00	610	269	69		268	100	100		.34	
end	96			671.583										
AVG/TOTAL						265.69 ±2.54			265.31 ±2.78					

Leak Rate .11 @ 15 Hg

E

D-8

510378

Form EED 021 1/79

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET 1/3

Plant Republic Steel
Date 7/17/79
Test Location Coke Stack #1
Run Number 62
Stack Diameter inches 107
Duct Dimensions in. x in.
Start Time 0748
Operator JARMAN

Barometric Pressure 29.76
Static Pressure -1.3" H_2O
Stack Pressure —
Probe Number 10'
Pitot Coefficient 0.786
Pitot Number P11
Meter Box Number 0039
Orifice Coefficient 1.787

Nozzle Size & Number .745
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES	TIME	CO_2	O_2	CO
	7:58	3.7	13.2	0
553.1	9:35	3.3	13.6	0
SILICA GEL				

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in. wg	GAS METER VOLUME FT³	TEMPERATURES °F STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in. Hg	√ΔP	Leak Rate .12 @ 15 lg
5	0	.03	~~.59~~	671.772	550	260	70		~~268~~	84	85		.17	
5	2	.035	.49	674.29	553	256	64		263	84	85		.18	
5	4	.04	.79	676.32	557	262	63		260	84	85		.2	
5	6	.07	1.37	679.21	561	264	67		258	84	85		.26	
5	8	.07	1.36	682.14	567	268	66		262	84	85		.26	
6	10	.09	1.72	685.43	569	277	67		268	85	87		.3	
7	12	.09	1.36	688.91	585	272	67		266	88	85		.26	
8	14	.095	1.79	692.60	602	267	68		266	89	85		.30	
9	16	.10	1.89	696.31	606	266	68		268	89	85		.31	
10	18	.11	2.08	700.13	609	267	69		266	92	86		.33	
11	20	.11	2.07	704.01	613	264	69		267	93	86		.33	
12	22	.11	2.07	707.91	618	271	69		267	94	86		.33	
13	24	.13	2.43	711.89	622	269	69		269	94	86		.36	
14	26	.125	2.33	716.12	627	269	68		267	94	86		.35	
15	28	.14	2.62	720.37	631	270	68		267	97	87		.37	
16	30	.14	2.61	724.77	633	272	69		267	98	88		.37	
17	32	.135	2.53	729.12	636	272	69		267	100	88		.36	
18	34	.13	1.42	733.67	640	269	68		269	100	88		.38	
19	36	.14	2.6	738.01	643	270	69		267	100	89		.37	
20	38	.14	2.6	742.41	646	269	69		268	101	89		.37	
AVG/TOTAL														

30.685

W D-9

5103179

Form EED [illegible] 79

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

2/3

Plant Republic Steel — Barometric Pressure

Date 7/17/79 — Static Pressure

Test Location Coke Stack #1 — Stack Pressure

Run Number 62 — Probe Number

Stack Diameter inches — Pitot Coefficient

Duct Dimensions in. x in — Pitot Number

Start Time — Meter Box Number

Operator JARMAN — Orifice Coefficient

Nozzle Size & Number

Molecular Weight

BWO

FILTER DATA

NUMBER	TARE	FINAL WT.

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in. wg	GAS METER VOLUME FT³	TEMPERATURES °F: STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in Hg	$\sqrt{\Delta P}$	
21	40	.135	2.5	746.85	649	273	70		269	101	90		.36	
22	42	.14	2.7	751.32	610	270	69		268	102	91		.37	
23	44	.13	2.5	755.12	607	270	69		268	102	91		.36	
24	46	.135	2.4	760.15	613	271	69		269	102	92			
END	48			784.327										
				92.555										
			LEAK	Rate .11	@15lg									
5	0	.07	1.39	764.327	557	259	70		264	90	91		.26	
5	2	.085	1.68	767.54	560	261	69		264	88	91		.29	
5	4	.07	1.38	771.13	562	263	69		266	89	91		.26	
5	6	.08	1.57	774.46	565	260	70		271	90	91		.28	
5	8	.07	1.37	777.94	567	265	69		269	90	91		.26	
6	10	.07	1.37	781.24	569	267	68		270	90	91		.26	
7	12	.09	1.7	784.46	613	265	69		269	91	91		.3	
8	14	.09	1.7	787.41	632	267	70		276	91	91		.3	
9	16	.095	1.75	791.78	638	272	71		278	91	91		.31	
10	18	.11	2.01	795.46	644	269	71		276	91	91		.33	
11	20	.12	2.3	799.43	597	272	70		280	92	91		.35	
12	22	.115	2.18	803.55	609	266	70		283	93	91		.34	
13	24	.115	2.17	807.64	615	265	69		280	94	91		.34	
AVG/TOTAL														

W

8:30

0-10

S

0910

510380

Form EED 021

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

Plant Republic Steel — Barometric Pressure
Date 7/17/79 — Static Pressure
Test Location Coke Stack #1 — Stack Pressure
Run Number #62 — Probe Number
Stack Diameter inches — Pitot Coefficient
Duct Dimensions in. x in — Pitot Number
Start Time — Meter Box Number
Operator JARMAN — Orifice Coefficient

Nozzle Size & Number
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

3/3

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg.	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in Hg	$\sqrt{\Delta P}$	
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
14	26	.115	2.160	811.69	618	266	69		281	95	91		.34	
15	28	.12	2.24	815.70	623	271	68		282	95	91			
16	30	.115	2.14	819.85	624	280	69		282	96	91		.34	
17	32	.115	2.15	823.92	630	280	70		282	96	91		.34	
18	34	.10	1.87	827.93	632	274	70		282	95	91		.31	
19	36	.11	2.12	831.97	634	276	70		283	95	91		.33	
20	38	.125	2.32	835.17	639	275	70		282	95	91		.35	
21	40	.11	2.03	839.93	642	279	71		282	95	91		.33	
22	42	.10	1.85	843.92	643	280	72		282	95	91		.31	
23	44	.09	1.65	847.79	647	280	72		283	95	91		.3	
24	46	.09	1.65	851.37	646	280	72		284	95	91		.3	
END	48			854.958										
				90.631										
											Leak Rate			
											.12 @ 15 lg			
										91.1				
AVG/TOTAL	96		1.932	183.186	609	261.38 ±5.96			271.77 ± 7.44				0.312	

S

D-11

9:38

510381

Form LEO-021

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET 1/3

Plant Republic Steel Cleveland | Barometric Pressure 29.07
Date 7-17-79 | Static Pressure -1.3
Test Location Coke Stack | Stack Pressure
Run Number #63 | Probe Number 10ft
Stack Diameter inches 107 | Pitot Coefficient .786
Duct Dimensions in x in | Pitot Number P11
Start Time 1053 | Meter Box Number 0039
Operator JARMAN | Orifice Coefficient .708

Nozzle Size & Number .429
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES	TIME	CO_2	O_2	CO
705				
SILICA GEL				

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg.	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in. Hg	$\sqrt{\Delta P}$	
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
5	0	.03	.41	855.273	567	255	72		280	86	86		.17	Leak Check
5	2	.03	.41	856.04	570	257	71		281	85	86		.17	.008 / 16" Hg
5	4	.035	.48	856.77	573	267	70		281	85	86		.19	
5	6	.035	.47	857.54	576	267	70		281	85	86		.19	
5	8	.035	.47	858.34	579	261	69		273	85	86		.19	
6	10	.08	1.08	859.14	581	262	68		266	84	86		.28	
7	12	.09	1.21	860.25	583	272	68		271	84	86		.3	
8	14	.095	1.27	861.45	585	266	69		273	84	86		.31	
9	16	.11	1.44	862.98	611	268	69		268	84	86		.33	
10	18	.12	1.58	864.05	608	270	70		266	84	86		.35	
11	20	.125	1.63	865.45	619	270	69		266	84	86		.35	
12	22	.12	1.55	866.89	623	269	69		269	85	86		.35	
13	24	.125	1.61	868.30	628	273	70		267	85	86		.35	
14	26	.125	1.60	869.69	631	272	69		267	86	86		.35	
15	28	.13	1.67	871.10	635	269	68		268	86	86		.36	
16	30	.135	1.73	872.55	638	268	69		268	86	86		.37	
17	32	.14	1.77	874.0	641	270	69		268	87	86		.37	
18	34	.14	1.8	875.48	644	270	69		268	87	86		.37	
19	36	.13	1.67	876.99	647	277	68		268	87	87		.36	
20	38	.12	1.58	877.13	607	279	69		269	87	87		.35	
AVG/TOTAL			~~1.77~~ 1.67		~~607~~ 644					~~85~~ 86	~~86~~ 86		.30	

25.697

Form EPD-021 1-79

D-12

510382

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

2/3

Plant Republic Steel Cleveland

Date 7-17-79

Test Location Coke Stack

Run Number #63

Stack Diameter inches

Duct Dimensions in x in

Start Time

Operator JARMAN

Barometric Pressure

Static Pressure

Stack Pressure

Probe Number

Pitot Coefficient

Pitot Number

Meter Box Number

Orifice Coefficient

Nozzle Size & Number

Molecular Weight

BWO

FILTER DATA

NUMBER	TARE	FINAL WT.

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg	ORIFICE METER ΔH in. wg.	GAS METER VOLUME FT³	TEMPERATURES °F STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT	PUMP VACUUM in. Hg	$\sqrt{\Delta P}$	
21	40	.12	1.57	879.86	610	270	69		267	87	87		.35	
22	42	.105	1.37	881.27	613	269	70		268	87	87		.32	
23	44	.10	1.30	882.58	617	270	70		272	86	87		.31	
24	46	.095	1.23	883.87	620	269	70		269	86	87		.31	
end	48			885.124										
11:59 5	0	.06	.82	885.124	572	266	71		275	88	88		.24	
5	2	.065	.88	886.15	575	272	70		268	87	88		.25	
5	4	.06	.81	887.22	579	269	70		264	87	88		.24	
5	6	.065	.88	888.29	581	265	69		265	88	88		.25	
5	8	.065	.88	889.34	584	270	68		267	88	88		.25	
6	10	.07	.94	890.41	587	272	67		267	89	88		.26	
7	12	.085	1.13	891.51	596	271	67		265	89	89		.29	
8	14	.09	1.18	892.61	609	271	68		265	89	89		.3	
9	16	.095	1.25	893.99	614	272	68		267	90	89		.31	
10	18	.10	1.31	895.14	616	267	69		266	90	89		.32	
11	20	.115	1.5	896.42	619	268	69		266	91	90		.34	
12	22	.12	1.56	897.79	624	265	69		266	91	90		.35	
13	24	.12	1.56	899.21	629	270	70		265	91	90		.35	
14	26	.14	1.81	900.0	633	272	69		266	92	91		.37	
AVG/TOTAL			1.22		[illegible] 604					89	88		.27	

Form EED 021 1-79

510383

ACUREX Corporation

PARTICULATE TEST FIELD DATA SHEET

Plant Republic Steel Cleveland
Date 7-17-79
Test Location Coke Stack
Run Number #63
Stack Diameter inches
Duct Dimensions in. x in.
Start Time
Operator JARMAN

Barometric Pressure
Static Pressure
Stack Pressure
Probe Number
Pilot Coefficient
Pilot Number
Meter Box Number
Orifice Coefficient

Nozzle Size & Number
Molecular Weight
BWO

FILTER DATA

NUMBER	TARE	FINAL WT

IMPINGER VOLUMES		TIME	CO_2	O_2	CO
SILICA GEL					

3/3

SAMPLE POINT	CLOCK TIME	VELOCITY HEAD ΔP in. wg.	ORIFICE METER ΔH in. wg	GAS METER VOLUME FT³	TEMPERATURES °F							PUMP VACUUM in Hg	$\sqrt{\Delta P}$	
					STACK	PROBE	IMPINGER	ORGANIC MODULE	OVEN	GAS METER IN	GAS METER OUT			
15	28	.14	1.81	902.07	637	267	69		266	92	91		.37	
16	30	.15	1.93	903.71	640	266	69		269	92	91		.39	
17	32	.14	1.8	905.15	644	267	68		271	92	92		.37	
18	34	.14	1.8	906.62	646	267	68		273	92	92		.37	
19	36	.15	2.0	908.16	598	270	69		272	92	91		.39	
20	38	.155	2.05	909.73	609	268	70		269	93	92		.39	
21	40	.15	1.97	911.29	615	268	70		270	94	92		.39	
22	42	.145	1.90	912.88	619	271	71		267	94	93		.38	
23	44	.14	1.83	914.41	623	271	70		267	94	94		.37	
24	46	.135	1.76	915.94	626	269	70		267	95	95		.36	
end	48			917.375										
			1.89		626					93	92		.38	Leak Check .010 / 15"Hg
			1.38											
			~~1.46~~	62.102	612					88			.32	
AVG/TOTAL			~~1.89~~		~~626~~	268.63 ± 4.11			268.10 ± 4.30	~~93~~	~~92~~		~~.38~~	

Form EED-021

D-14

5103884

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company Republic Steel

Date 7/16/79 Time First Sighted Plume

Time Start 0823 Time Stop 0912

Air Temperature 79°F Relative Humidity 75%

Wind Speed 5-7 MPH Wind Direction at of West

Sky Condition Clear Background Blue Sky

Plume Characteristics: Continuous: ☐ Yes ☒ No

Color _____ Dispersion Description _____

Stack Height 150 (ft) Observer Location 750 (ft) NE of stack

Sun Location: ☐ Back of Observer ☒ Left Shoulder
● Right Shoulder ☐ Other _____

Emission Point ~~Stack of Abt.~~ Combustion Stack No. 1 Coke Battery

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				

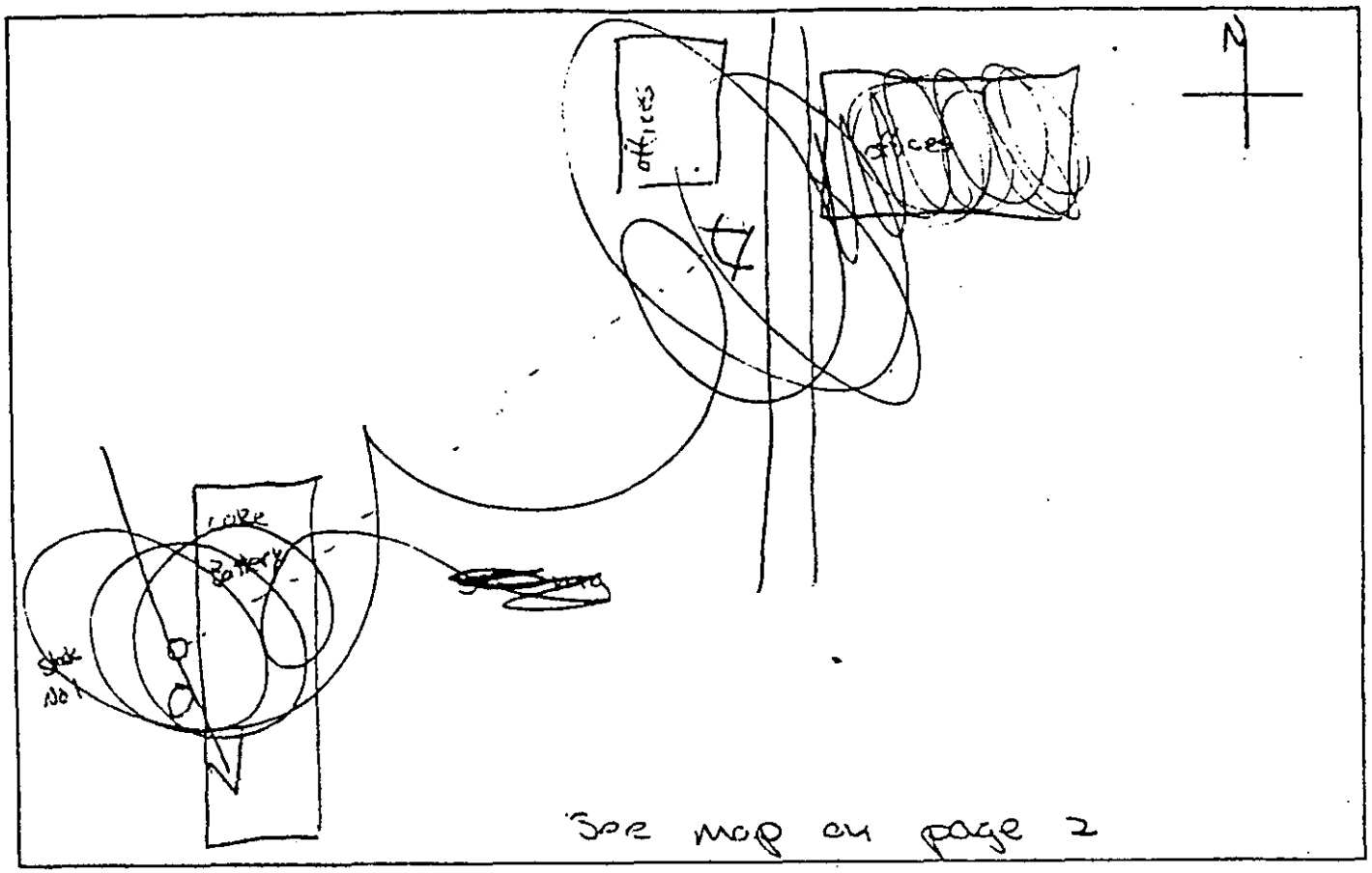
NOTES Test 60

Inspector [signature] Date 7/16/79

Form EED-044 3-79

510385

MAP



Symbols

Sun = ☼

Plume direction = ⟶

Point where plume observed = ...

Observer = X

Water Vapor Condensate None

Photographs: ☐ File ☐ Enclosed ☒ None

Comments

Signature Rita Kaufmann Date 7/16/79

510386

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company _____

Date _____ Time First Sighted Plume _____

Time Start 1018 Time Stop 1107

Air Temperature _____ Relative Humidity _____

Wind Speed _____ Wind Direction _____

Sky Condition _____ Background _____

Plume Characteristics: Continuous: ☐ Yes ☐ No

Color _____ Dispersion Description _____

Stack Height _____ (ft) Observer Location _____ (ft) _____ of stack

Sun Location: ☐ Back of Observer ☐ Left Shoulder ☐ Right Shoulder ☐ Other _____

Emission Point _____

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

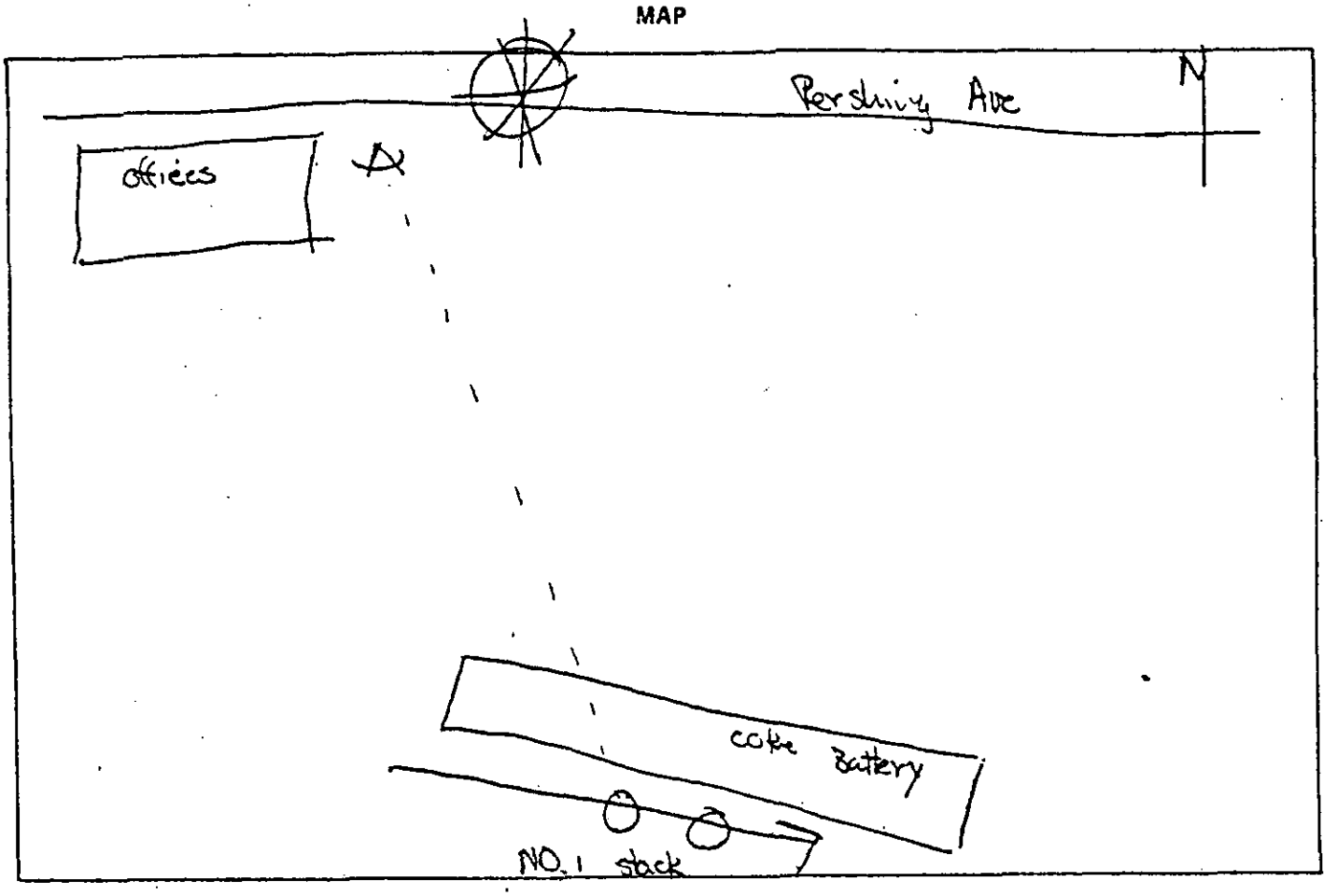
Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				

NOTES Test 60 continued

Inspector Bill Kaufmann Date 7/16/79

MAP



Symbols

Sun = ✳

Plume direction = ⟶

Point where plume observed = ...

Observer = X

Water Vapor Condensate .....

Photographs: ☐ File ☐ Enclosed ☐ None

Comments .....

Signature Peter Kaufmann Date 7/16/79

510388

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company Republic Steel

Date 7/16/79 Time First Sighted Plume 1211

Time Start 1207 Time Stop ~~1247~~ 1257

Air Temperature 84°F Relative Humidity 70%

Wind Speed 3-7 MPH Wind Direction out of NW

Sky Condition clear Background blue sky

Plume Characteristics: Continuous: ☐ Yes ☐ No

Color Black Dispersion Description lofting

Stack Height 150 (ft) Observer Location 750 (ft) NE of stack

Sun Location: ☐ Back of Observer ☐ Left Shoulder ☐ Right Shoulder ☒ Other ax head

Emission Point No. 1 stack - coke Battery

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	10	10
05	0	0	0	0
06	0	0	0	0
07	0	0	5	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50	0	0	0	0
51				
52				
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58				
59				
60				

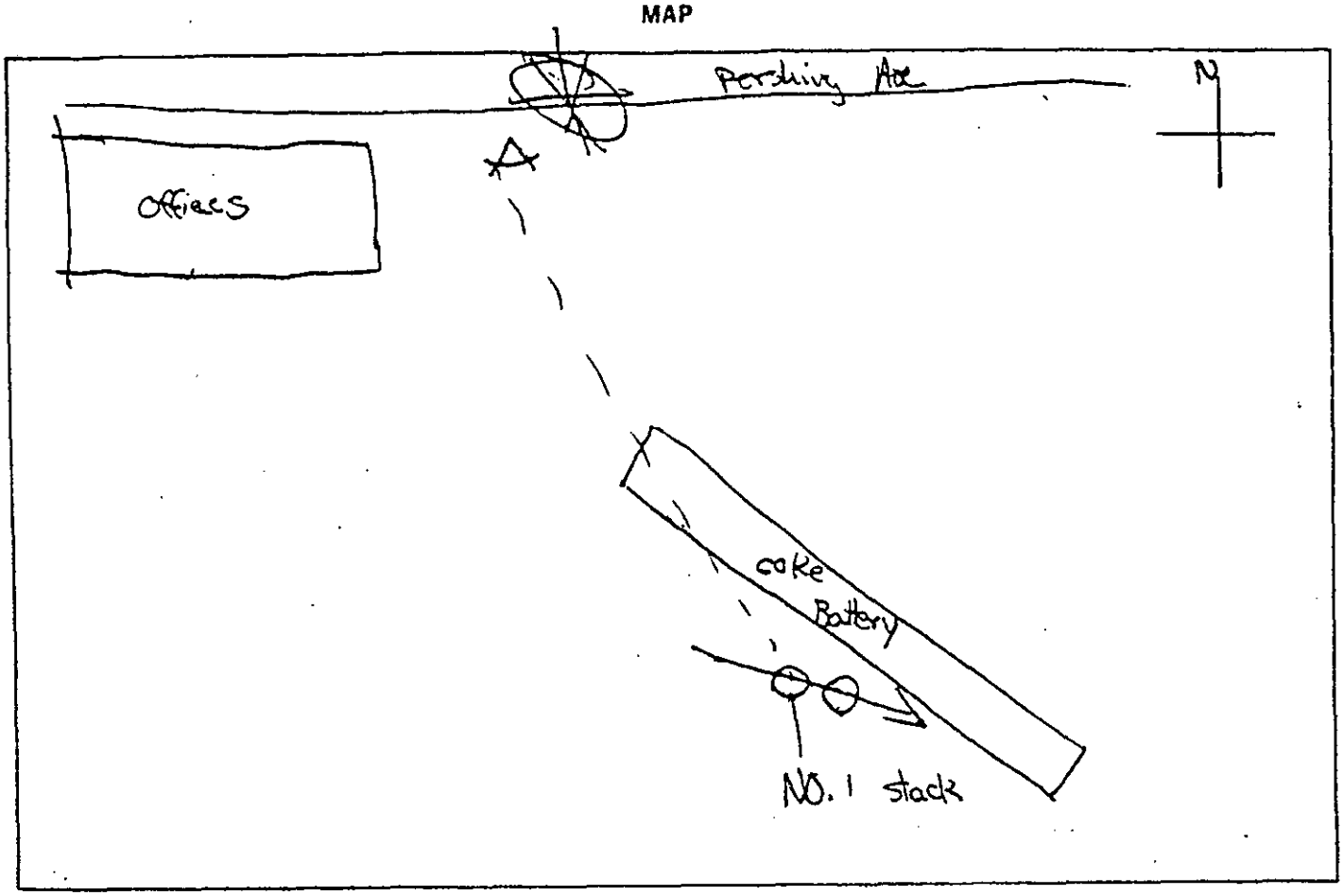
NOTES TCT 61

Inspector Bill Kaufmann Date 7/16/79

Form EFD-044 3-79

510389

MAP



Symbols

Sun = ✳

Plume direction = ⟶

Point where plume observed = ...

Observer = X

Water Vapor Condensate None

Photographs: ☐ File ☐ Enclosed ☒ None

Comments

Signature Ruth Kaufmann Date 7/16/79

510390

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company

Date | Time First Sighted Plume

Time Start 1320 | Time Stop 1409

Air Temperature | Relative Humidity

Wind Speed | Wind Direction

Sky Condition | Background

Plume Characteristics: Continuous: ☐ Yes ☐ No

Color | Dispersion Description

Stack Height (ft) | Observer Location (ft) of stack

Sun Location: ☐ Back of Observer ☐ Left Shoulder ☐ Right Shoulder ☒ Other

Emission Point

Min	0	15	30	45	Min	0	15	30	45	Min	0	15	30	45
01	0	0	0	0	21	0	0	0	0	41	0	0	0	0
02	0	0	0	0	22	0	0	0	0	42	0	0	0	0
03	0	0	0	0	23	0	0	0	0	43	0	0	0	0
04	0	0	0	0	24	0	0	0	0	44	0	0	0	0
05	0	0	0	0	25	0	0	0	0	45	0	0	0	0
06	0	0	0	0	26	0	0	0	0	46	0	0	0	0
07	0	0	0	0	27	0	0	0	0	47	0	0	0	0
08	0	0	0	0	28	0	0	0	0	48	0	0	0	0
09	0	0	0	0	29	0	0	0	0	49	0	0	0	0
10	0	0	0	0	30	0	0	0	0	50				
11	0	0	0	0	31	0	0	0	0	51				
12	0	0	0	0	32	0	0	0	0	52				
13	0	0	0	0	33	0	0	0	0	53				
14	0	0	0	0	34	0	0	0	0	54				
15	0	0	0	0	35	0	0	0	0	55				
16	0	0	0	0	36	0	0	0	0	56				
17	0	0	0	0	37	0	0	0	0	57				
18	0	0	0	0	38	0	0	0	0	58				
19	0	0	0	0	39	0	0	0	0	59				
20	0	0	0	0	40	0	0	0	0	60				

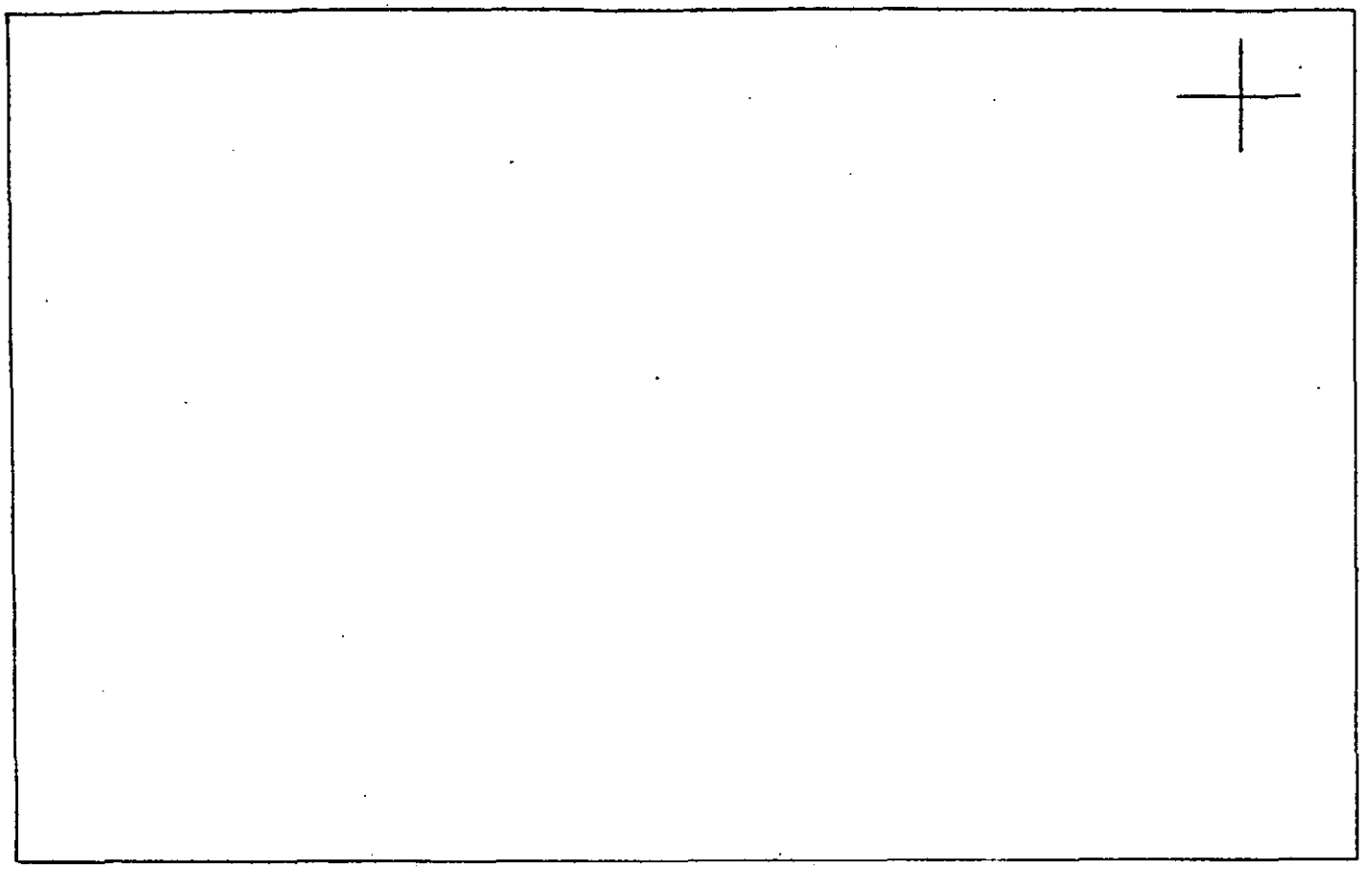
NOTES Test 61 continued

Inspector Rita Kaufman Date 7/16/79

Form LFD 044

510391

MAP



Symbols

Sun = 

Plume direction = ⟶

Point where plume observed = ...

Observer = 

Water Vapor Condensate _____

Photographs: ☐ File ☐ Enclosed ☐ None

Comments _____

Signature Peter Kaufmann Date 7/16/79

510392

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company Republic Steel

Date 7/17/79 Time First Sighted Plume

Time Start 0748 Time Stop 0836

Air Temperature 71°F Relative Humidity 70%

Wind Speed 0-5 MPH Wind Direction out of NE

Sky Condition Partly Cloudy Background Blue Sky (sometimes white cloud)

Plume Characteristics: Continuous: ☐ Yes ☒ No

Color Dispersion Description

Stack Height 150 (ft) Observer Location 750 (ft) N of stack

Sun Location: ☐ Back of Observer ☒ Left Shoulder ☐ Right Shoulder ☐ Other

Emission Point No. 1 stack Coke Battery

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0			
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				

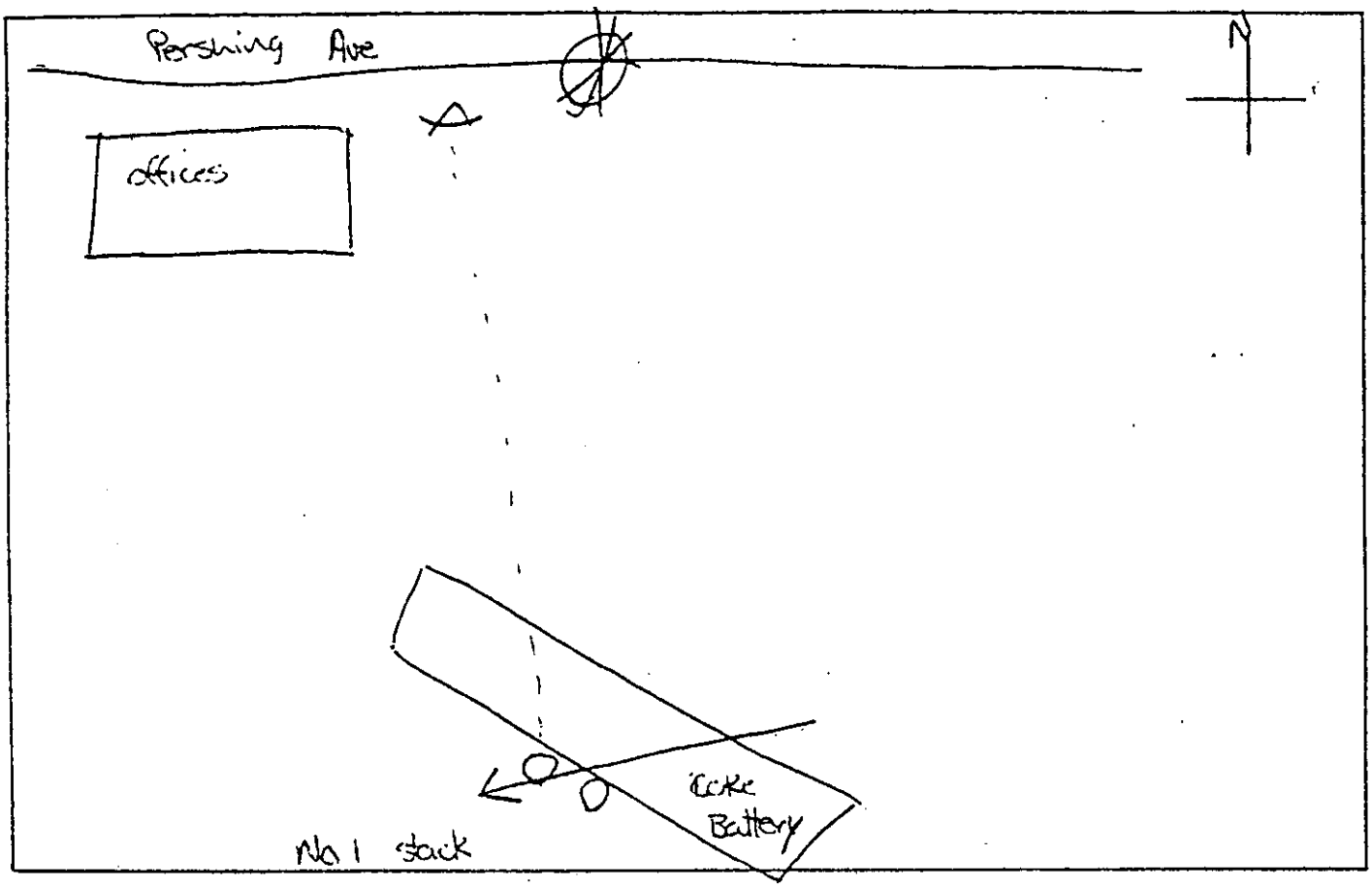
NOTES Test 62

Inspector [signature] Date 7/17/79

Form EED 044 3/79

510393

MAP



Symbols

Sun = ✳

Plume direction = ⟶

Point where plume observed = ...

Observer = 🧍

Water Vapor Condensate None

Photographs: ☐ File ☐ Enclosed ☒ None

Comments _____

Signature Rita Kaufmann Date 7/17/79

510394

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company

Date _____ Time First Sighted Plume _____

Time Start 0910 Time Stop 0959

Air Temperature _____ Relative Humidity _____

Wind Speed _____ Wind Direction _____

Sky Condition _____ Background _____

Plume Characteristics: Continuous: ☐ Yes ☐ No

Color _____ Dispersion Description _____

Stack Height _____ (ft) Observer Location _____ (ft) _____ of stack

Sun Location: ☐ Back of Observer ☐ Left Shoulder
☐ Right Shoulder ☐ Other _____

Emission Point

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				

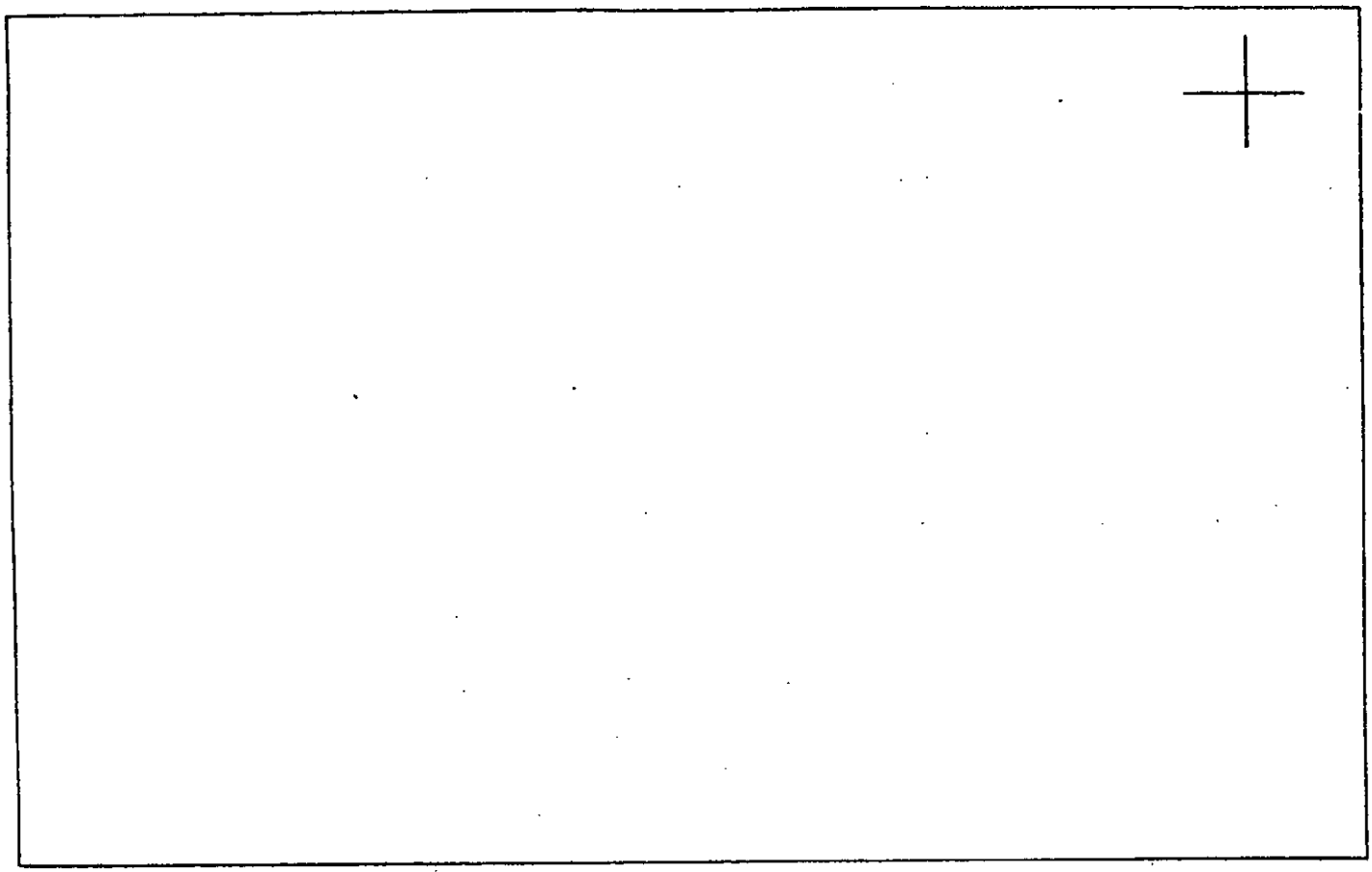
NOTES Test 62 continued

Inspector Rita Kenyon

Date 7/17/19

510395

MAP



Symbols

Sun = 

Plume direction = ⟶

Point where plume observed = ...

Observer = 

Water Vapor Condensate .....

Photographs: ☐ File ☐ Enclosed ☐ None

Comments

Signature Rita Kaufmann Date 7/17/71

510396

ACUREX Aerotherm

VISIBLE EMISSION OBSERVATION RECORD

Company Republic Steel

Date 7/17/79 Time First Sighted Plume

Time Start 1053 Time Stop 1142

Air Temperature 76° F Relative Humidity 6090

Wind Speed 0-5 MPH Wind Direction Out of N E

Sky Condition Partly cloudy Background Blue sky occasional cloud

Plume Characteristics: Continuous: ☐ Yes ☒ No

Color Dispersion Description

Stack Height 150 (ft) Observer Location 750 (ft) N of stack

Sun Location: ☐ Back of Observer ☒ Left Shoulder ☐ Right Shoulder ☐ Other

Emission Point No. 1 Stack Coke Battery

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50				
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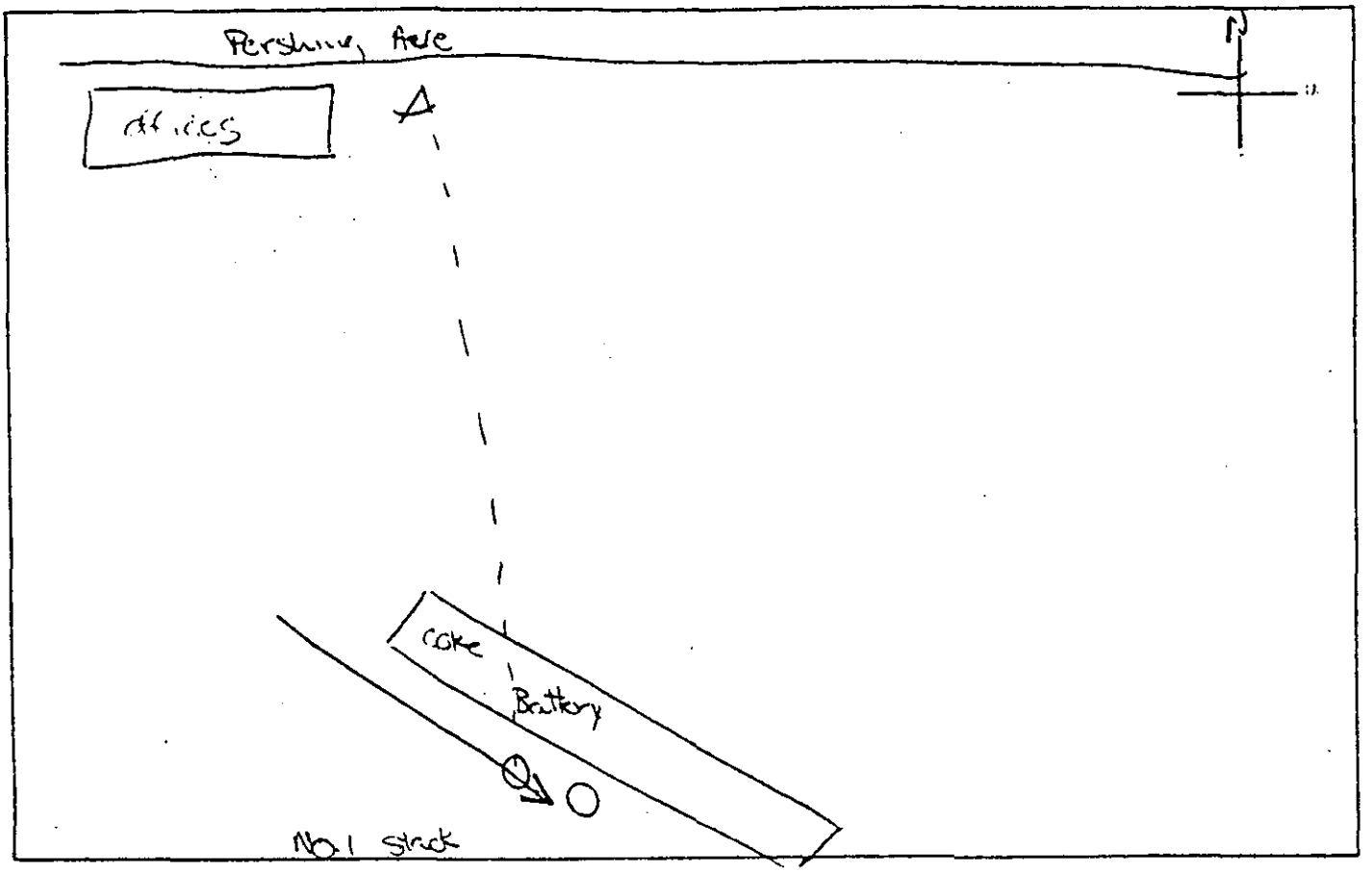
56				
57				
58				
59				
60				

NOTES Test 63

Inspector Rita Carfagno Date 7/17/79

MAP



Symbols

Sun = ☼

Plume direction = ⟶

Point where plume observed = ...

Observer = 🧍

Water Vapor Condensate None

Photographs: ☐ File ☐ Enclosed ☒ None

Comments

Signature Bill Kuykendall Date 7/17/79

510398

ACUREX
Aerotherm

Page 2 of 2

VISIBLE EMISSION OBSERVATION RECORD

Company _____

Date _____ Time First Sighted Plume _____

Time Start 1155 Time Stop 1244

Air Temperature _____ Relative Humidity _____

Wind Speed _____ Wind Direction _____

Sky Condition _____ Background _____

Plume Characteristics: Continuous: ☐ Yes ☐ No

Color _____ Dispersion Description _____

Stack Height _____ (ft) Observer Location _____ (ft) _____ of stack

Sun Location: ☐ Back of Observer ☐ Left Shoulder
☐ Right Shoulder ☐ Other _____

Emission Point _____

Min	0	15	30	45
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	0	0	0	0
05	0	0	0	0
06	0	0	0	0
07	0	0	0	0
08	0	0	0	0
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0

Min	0	15	30	45
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Min	0	15	30	45
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50				
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56				
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58				
59				
60				

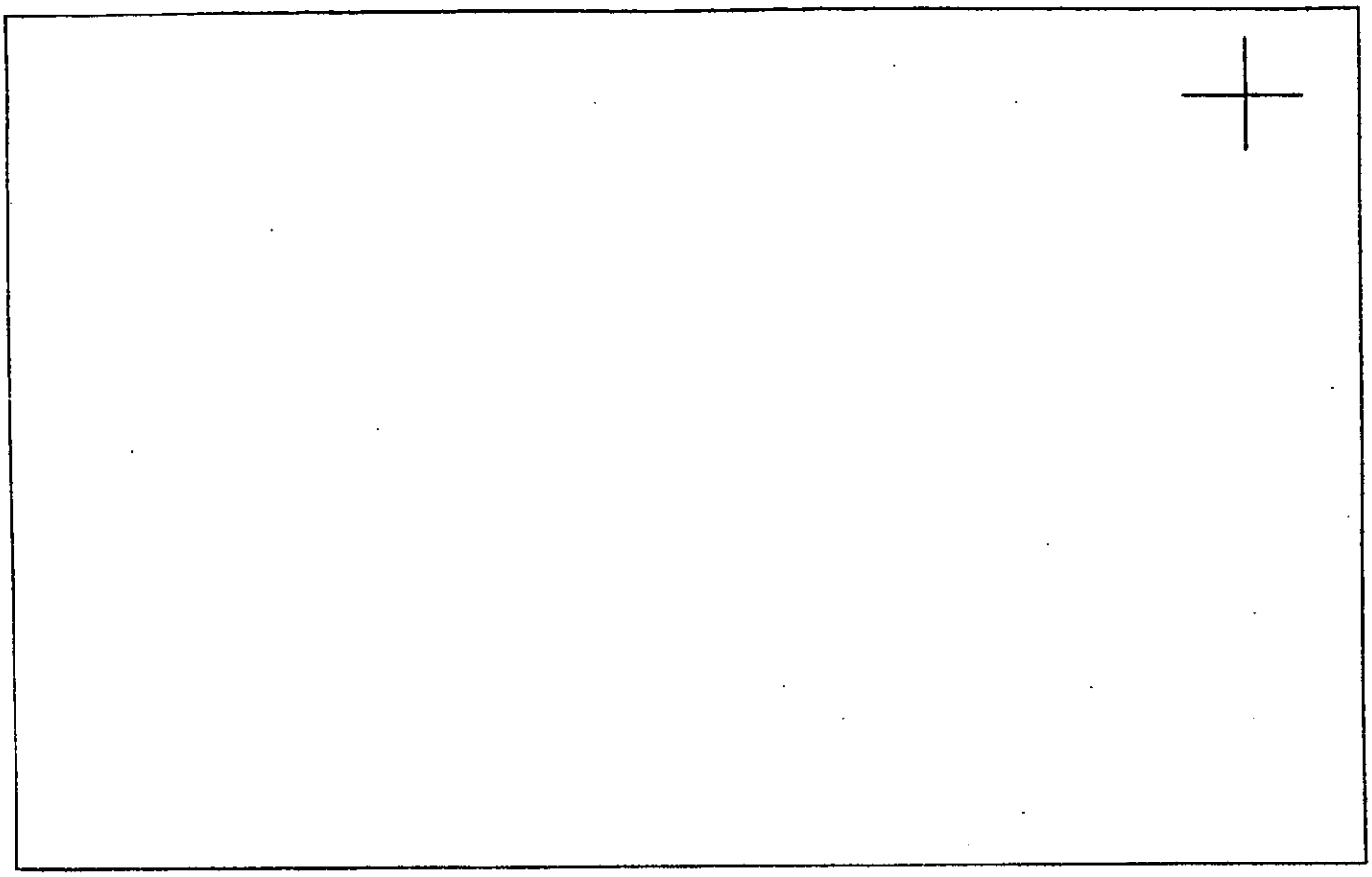
NOTES Test 63 continued

Inspector [signature] Date 7/17/79

Form EED-044 7/79

510399

MAP



Symbols

Sun = ☼

Plume direction = ⟶

Point where plume observed = ...

Observer = X

Water Vapor Condensate .....

Photographs: ☐ File ☐ Enclosed ☐ None

Comments _____

Signature [redacted] Pete Kaufmann Date 7/17/79

510400

Cleveland, Ohio

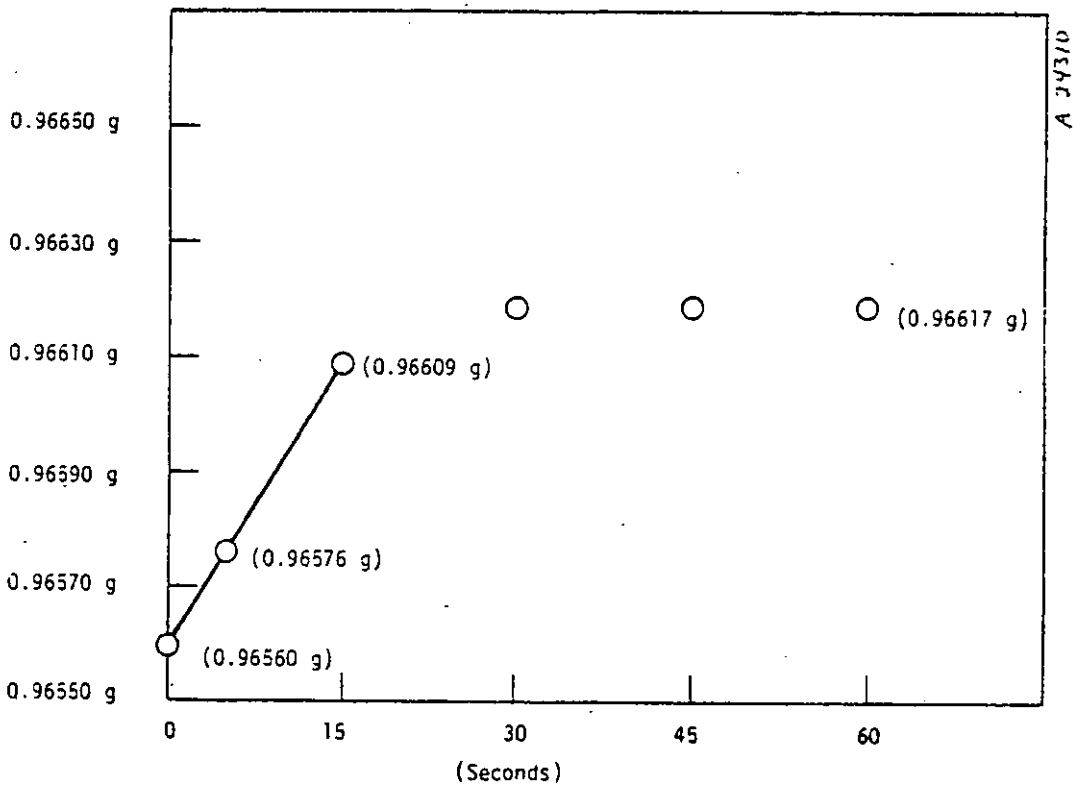
FRONT HALF RESULTS (Particle Mass Test)

RUN #	"FILTERS" UNCORRECTED	"FILTERS" BLANK CORRECTED	"Cyclone Catch" UNCORRECTED	"Cyclone Catch" FRONT HALF WASH BLANK-CORRECTED	REMARKS
#60	30.5 mg *	30.5 mg *	10.1 mg	9.2 mg	
#61	45.5 mg *	45.5 mg *	11.4 mg	10.5 mg	
#62	56.0 mg *	56.0 mg *	29.3 mg	28.5 mg	
#63	49.5 mg *	49.5 mg *	39.4 mg	38.7 mg	
*	Filter particulate weight extrapolated by graph. (graphs included)				

REPUBLIC IRON & STEEL

Test #60 "Coke Stack"
Filter #JMC 522102

Original tare = 0.93510 g
Blank weight = <0.1 mg
Particulate loading = 30.5 mg

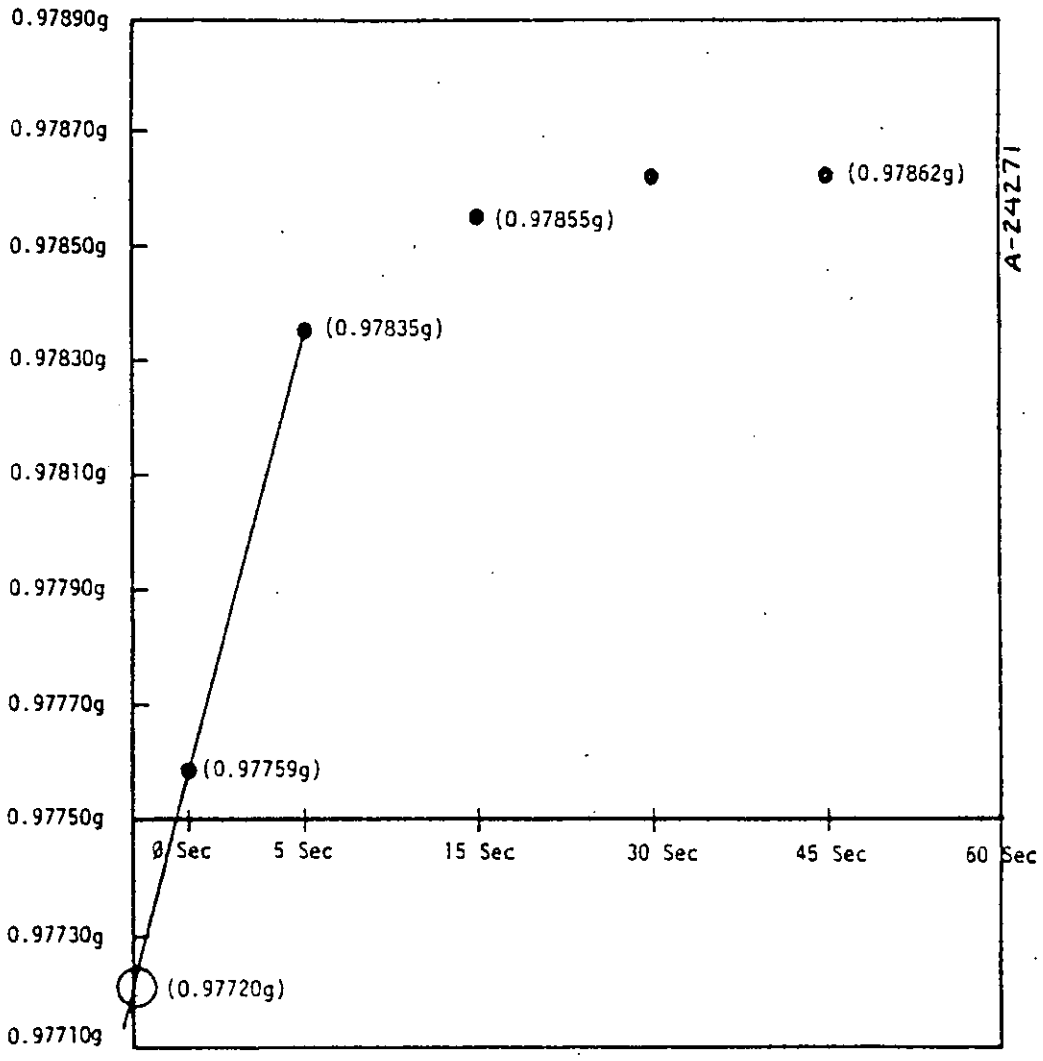


510402

REPUBLIC IRON & STEEL

Test #61
Filter #JMC 52241

Original tare = 0.93170g
Blank weight = <0.1 mg
Particulate loading = 45.5 mg

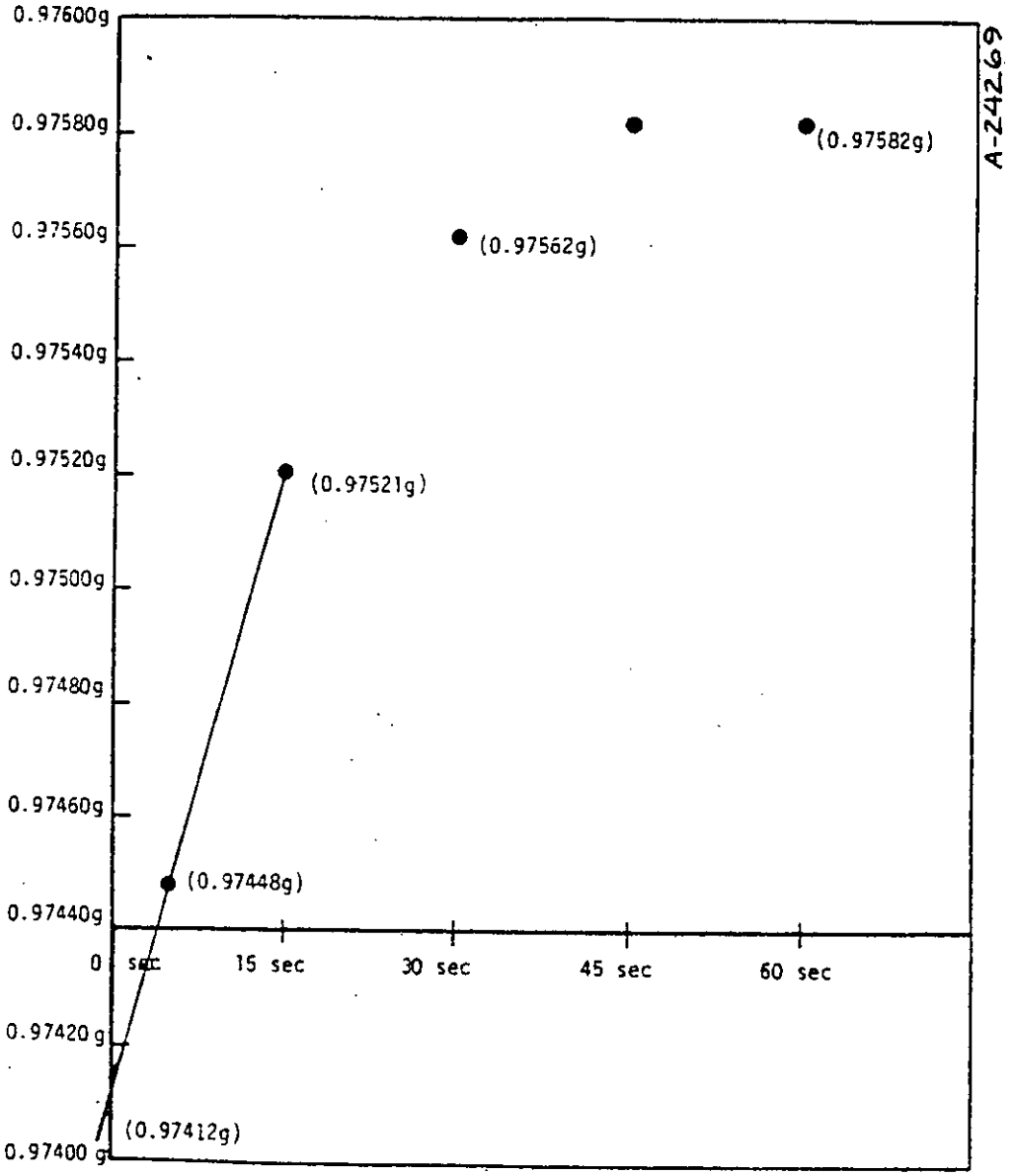


510403

REPUBLIC IRON & STEEL

Test #62 "Coke Stack"
Filter #JMC 52246

Original tare = 0.91810g
Blank weight = <0.1 mg
Particulate loading = 560 mg

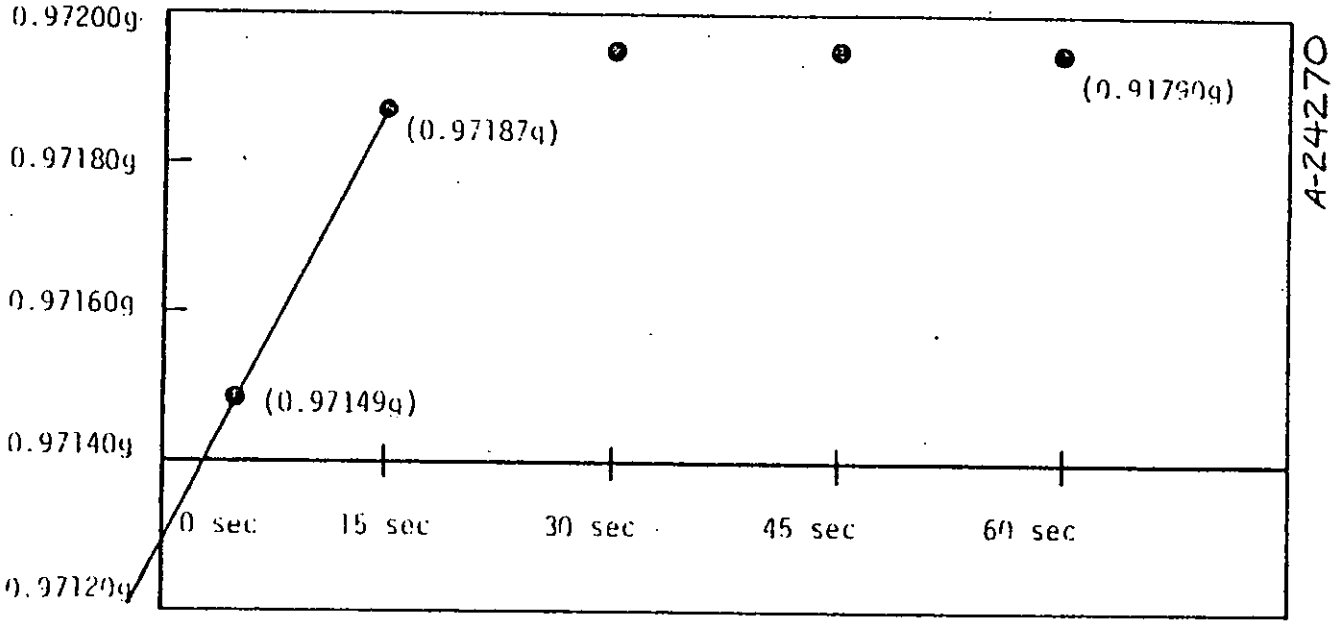


510404

REPUBLIC IRON & STEEL

Test #63 "Coke Stack"
Filter #JMC 52263

Original tare = 0.92180g
Blank weight = <0.1 mg
Particulate loading = 49.5 mg



A-24270

BACK HALF RESULTS. (Particle Mass Tests)

Run #	Acetone Impinger Wash Organic Extractables		H_2O Impinger Catch Organic Extractables		IKL Pkg.
	Uncorrected	Blank Corrected	Uncorrected	Blank Corrected	
Test #60	1,0 mg	Ø,3 mg	Ø,6 mg	Ø,2 mg	
Test #61	Ø,7 mg	<Ø,1 mg	17,6 mg	17,2 mg	
Test #62	Ø,7 mg	<Ø,1 mg	10,5 mg	10,1 mg	
Test #63	Ø,5 mg	<Ø,1 mg	14,3 mg	13,9 mg	

Republic Steel
Back half Inorganic condensable particulate

RUN #	Uncorrected	Blank Corrected
Test 46	120.3	<0.1
47	112.6	<0.1
48	69.4	<0.1
49	106.8	<0.1
50	69.6	<0.1
51	70.9	<0.1
52	16.0	<0.1
54	120.8	10.4
55	131.7	20.4
56	14.6	<0.1
57	21.4	<0.1
58	11.0	<0.1
60	194.8	35.6
61	453.3	277.8
62	3833.2	3596.8
63	5112.2	331.6

REPUBLIC IRON & STEEL

"SULFATE ANALYSIS [illegible]"

RUN #	SULFATES UNCORRECTED	SULFATES VOLUME CORRECTED	REMARKS
Test #60	.1050 mg/ml	71.40mg	
Test #61	.2845mg/ml	213.38mg	
Test #62	2.000 mg/ml	2020.00mg	Sample diluted to 100 ml
Test #63	.2446mg/ml	220.14mg	

510408

TEST 60

PARTICULATE CALCULATIONS

1. Volume of dry gas sampled at standard conditions, 68°F, 29.92 inch Hg (scf)

$$Vm_{std} = 17.64 \frac{Vm}{\alpha} \frac{P_b + \frac{\Delta H}{13.6}}{Tm + 460}$$

$$60.247 = 17.64\left(\frac{62.180}{.987}\right)\left(\frac{29.61 + \frac{1.34}{13.6}}{88 + 460}\right)$$

2. Stack gas moisture condensed at standard conditions (scf)

$$Vw_{std} = 0.04707\ Vl_c$$

$$5.352 = 0.04707(113.7)$$

3. Stack gas proportion of water vapor, by volume

$$B_{wo} = \frac{Vw_{std}}{Vw_{std} + Vm_{std}} \qquad \frac{5.352}{5.352 + 60.247}$$

$$0.082 =$$

4. Stack gas dry molecular weight (lb/lb-mole)

$$MW_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

$$29.14 = 0.44(4) + 0.32(12.4) + 0.28(83.6)$$

5. Stack gas molecular weight (lb/lb-mole)

$$MW_s = MW_d\ (1 - B_{wo}) + 18\ (B_{wo})$$

$$28.23 = 29.14\ (1 - .082) + 18(.082)$$

6. Pressure stack, in. Hg

$$P_s = P_b + \frac{P_{st}}{13.6}$$

$$29.52 = 29.61 + \frac{-1.2}{13.6}$$

7. Stack gas velocity at stack conditions (ft/sec)

$$V_s = 85.49 \left(C_p\right)\left(\sqrt{\Delta P}\right)_{avg} \sqrt{\frac{T_{s,avg} + 460}{P_s \, MW_s}}$$

$$23.30 = 85.49\,(0.786)(0.311)\sqrt{\frac{1036}{29.52\,(28.23)}}$$

8. Stack gas volume at standard conditions (scfm)

$$Q_s = 60\left(1 - B_{wo}\right) Vs_{avg} \, A_s \left(\frac{528}{T_{s\ avg} + 460}\right)\left(\frac{Ps}{29.92}\right)$$

$$40{,}300 = 60(1 - 0.082)(23.30)\left(\frac{\pi\, 8.92^2}{4}\right)\left(\frac{528}{1036}\right)\left(\frac{29.52}{29.92}\right)$$

$$\left(\frac{\pi\, 8.92^2}{4}\right) = 62.49$$

9. Test percent isokinetic

$$\%I = \frac{17.33 \left(T_s + 460\right)\left[0.04707 \left(Vl_c\right) + Vm_{std}\right]}{\theta \quad V_s \quad P_s \quad D_n^2}$$

$$96.9 = \frac{17.33\,(1036)(5.352 + 60.247)}{96\,(23.30)(29.52)\,(0.429)^2}$$

10. Particulate matter concentration, gr/scf

$$C_s = 15.432 \frac{M_p}{Vm_{std}}$$

$$0.010 = 15.432 \frac{0.0397}{60.247}$$

11. Emission rate of particulate matter, lb/hr

$$ER = 0.00857 \left(Q_s\right) C_s$$

$$3.512 = 0.00857(40{,}300)(0.010)$$

12. Percent excess air at sampling point

$$\%\ EA = \frac{100\left[\%O_2 - 0.5\ (\%CO)\right]}{0.264\left[\%N_2 - (\%O_2 - 0.5 \times \%CO)\right]}$$

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