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Ammonium Nitrate

Emission Test Report Cominco American, Inc. Beatrice, Nebraska

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United States Environmental Protection Agency
Emission Measurement Branch
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EMISSION TEST PROGRAM: AMMONIUM NITRATE MANUFACTURING PLANT

Conducted at
Cominco American
Homestead Plant
Route 7
Beatrice, Nebraska 68310

Contract Number 68-02-2819
Work Assignment 10
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PREFACE

The work reported herein was conducted by personnel from the York Research Corporation (YRC), the GCA/Technology Division (GCA), and the U.S. Environmental Protection Agency (EPA).

The scope of work issued under EPA Contract No. 68-02-2819, Work Assignment No. 10 was under the supervision of the YRC Project Director, Mr. James Davison. Mr. Roger Kniskern of YRC served as Project Manager and was responsible for summarizing the test and analytical data in this report. Analyses of the samples were performed at the YRC lab located in Stamford, Connecticut under the direction of Ms. Kay Wahl and at the Cominco, Beatrice, Nebraska field lab under the direction of Mr. Michael Horowitz.

Mr. Stephen V. Capone and Mr. William Battye of GCA were responsible for monitoring the process operations during the testing program. GCA personnel were also responsible for writing the Process Description and Operations Section along with Appendix 6.8 of this report.

Members of Cominco American, Beatrice, Nebraska whose assistance and guidance contributed greatly to the accomplishment of the test program, include Mr. Gary Carstens, Plant Manager, Mr. Larry Wood, Production Supervisor, Mr. Ken Schoenhofer, Operating Superintendent, and Mr. Ken Brockman, Plant Chemist.

Mr. Eric A. Noble, Office of Air Quality Planning and Standards, Industrial Studies Branch, EPA, served as Test Process Project Engineer and was responsible for coordinating the process operations monitoring.

Mr. Clyde E. Riley, Office of Air Quality Planning and Standards, Emission Measurement Branch, EPA, served as Technical Manager and was responsible for coordinating the emission test program.

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1.0 INTRODUCTION

Section 111 of the Clean Air Act of 1970 charges the Administrator of the U.S. Environmental Protection Agency (EPA) with the responsibility of establishing Federal standards of performance for new stationary sources which may significantly contribute to air pollution. When promulgated, these standards of performance for new stationary sources (SPNSS) are to reflect the degree of emission limitation achievable through application of the best demonstrated emission control technology. To assemble this background information, EPA utilizes emission data obtained from controlled sources involved in the particular industry under consideration.

Based on the above criteria, EPA's Office of Air Quality Planning and Standards (OAQPS) selected the Cominco American Ammonium Nitrate manufacturing plant at Beatrice, Nebraska as a site for an emission test program. York Research Corporation (YRC), under contract 68-02-2819, was requested by the United States Environmental Protection Agency (USEPA) to conduct an emission test program at the Homestead Plant of Cominco American located in Beatrice, Nebraska. The test program was designed to provide a portion of the emission data base required for SPNSS for the processes associated with the production of ammonium nitrate. This plant is considered to employ process and emission control technology representative of ammonium nitrate granulation facilities. The tests performed at the plant were designed to characterize and quantify uncontrolled and controlled emissions from the solids cooling process as well as determine control equipment efficiency.

The Cominco American manufacturing plant at Beatrice produces granulated ammonium nitrate for use as a fertilizer. The ammonium nitrate granules are manufactured by two rotary drum granulators and are cooled by two rotary drum coolers using countercurrent air flow. The emissions from these units are controlled by Doyle wet impingement scrubbers.

Emission sampling was conducted from November 14 to November 16, 1978 on the No. 1 cooler exhaust emissions. Testing was conducted at the following locations:

- Cooler No. 1 Scrubber Inlet
- Cooler No. 1 Scrubber Outlet

Figure 1-1 shows a schematic of the cooler exhaust gas ducting and control system. Samples were collected and analyzed for particulate, ammonium nitrate, and ammonia. In addition, the inlet location was tested to determine particle size distribution.

EPA engaged YRC to measure ammonium nitrate, insoluble particulate, and ammonia concentrations. All measurements made at this facility were performed during times of normal process operation as described in Section III, "Process Description and Operations".

The measurement program consisted of the following parameters:

Cooler No. 1 Scrubber Inlet, Outlet

1. Insoluble Particulate, Ammonium Nitrate, and Ammonia: Three repetitions of concurrent inlet and outlet test runs were performed in accordance with the prescribed

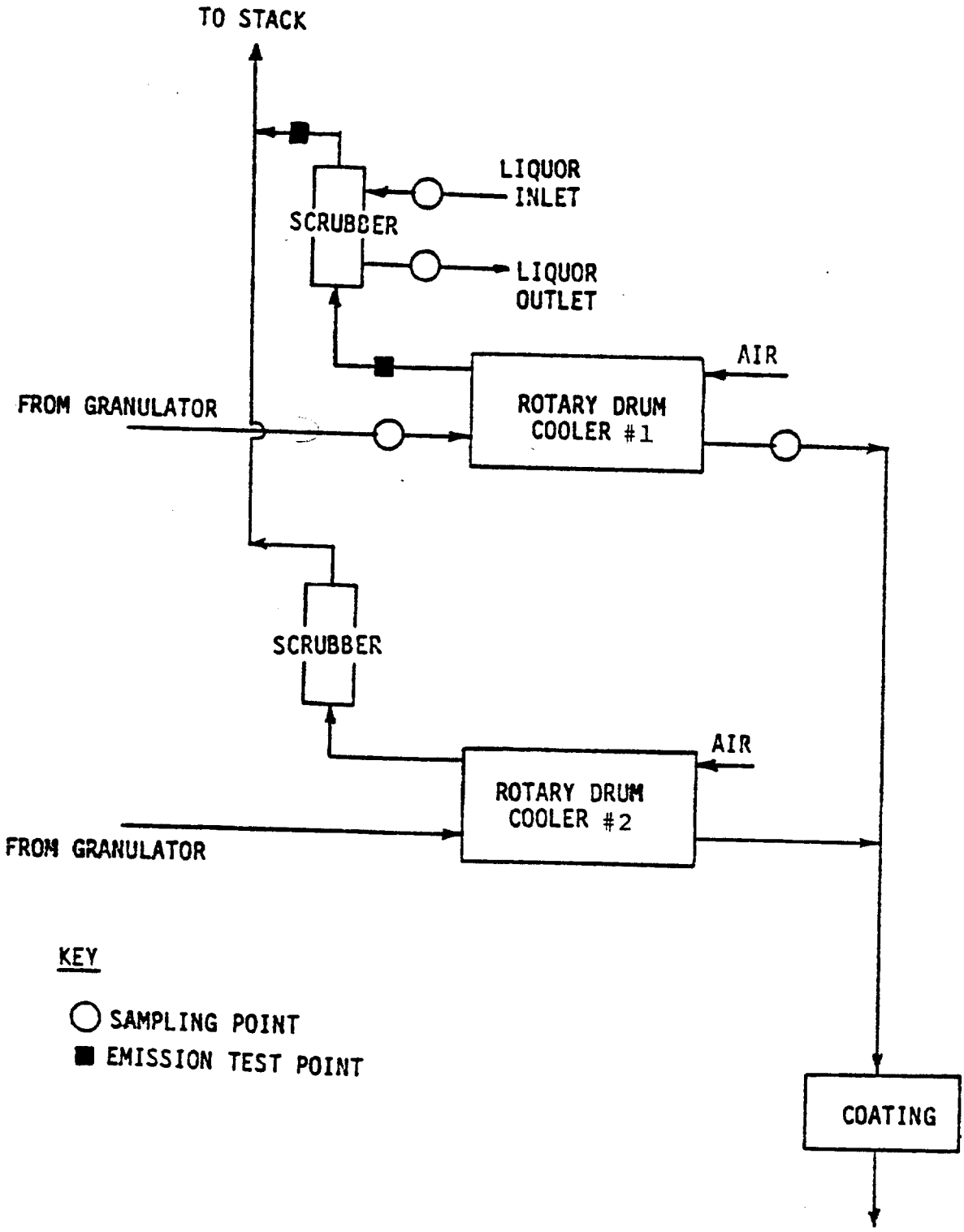


Figure 1.1 Number 1 Solid Formation Line and Sample Point Locations.

EPA method for ammonium nitrate and ammonia. These provided velocity, moisture, nitrate, and ammonia emission data.

2. Particle Size Distribution: Three repetitions of inlet test runs were conducted. The tests were performed using the prescribed procedures as instructed by the manufacturer which are applicable to cascade impactors.

3. Gas Pressure Drop Across Scrubber: Pressure drop measurements were recorded approximately every 15 minutes during the testing periods.

4. Scrubber Aqueous Solutions: pH, temperature, ammonium nitrate, ammonia, and solids content were measured. Samples of inlet and outlet scrubber solutions were collected approximately every 30 minutes during the ammonium nitrate and ammonia testing. The pH and temperature were recorded immediately after collection. Afterward the samples were composited into 3 inlet and 3 outlet samples. These were analyzed for percent nitrates, ammonia, and solids.

5. Ammonium Nitrate and Ammonia Content of Product: Three repetitious collections of granules into and out of the cooler were analyzed for temperature, percent moisture, ammonium nitrate, and ammonia. In addition, sieve analysis along with bulk density determinations were performed on the product samples (procedures presented in Appendix 6.10).

6. Relative Humidity and Ambient Air Measurements: These measurements were recorded at the inlet test

location approximately every 15 minutes during the testing periods.

7. Gas Composition: Measurements of Cooler No. 1 scrubber inlet and outlet gases were made for percent oxygen and percent carbon dioxide. A Fyrite Indicator was used in accordance with EPA Method 3.

YRC personnel were responsible for collecting and measuring the above emission parameters. Simultaneously, GCA was responsible for monitoring and recording necessary process parameters.

Most of the test runs were discontinuous due to excessive loading at the cooler inlet sampling location. These interruptions which also delayed the simultaneous outlet sampling were encountered throughout the test program as indicated in Tables 1-1 through 1-3 (Daily Summary Logs).

The following sections of this report cover the summary and discussion of results, process description and operation, test port locations and sampling point locations, and sampling and analytical procedures. In addition, Appendix 6.11 contains the summary and results of cleanup evaluations performed on the blank sample collectors used for the test program. Detailed descriptions of methods and procedures, field and laboratory data, and calculations are presented in various appendices, as noted.

TABLE 1-1
DAILY SUMMARY LOG FOR NO. 1 COOLER
SAMPLING ON NOVEMBER 14, 1978

Clock Time	Production Rate (Tons/Hour)	Particle Size (Inlet)
1511		Started Run 1
1526	(Data not recorded)	Stopped Switched Ports
1528		Continued
1543		Completed Run 1
1612		Started Run 2
1632		Stopped Switched Ports
1635		Continued
1655		Completed Run 2
		Fyrite Analysis
1130-1235		Inlet
1127-1238		Outlet

TABLE 1-2

DAILY SUMMARY LOG FOR NO. 1 COOLER SAMPLING ON NOVEMBER 15, 1978
AT COMINCO AMERICAN, BEATRICE, NEBRASKA

Clock Time	Production Rate[a] (Tons/Hour)	Ammonium Nitrate Particulate[b]		Particle Size (Inlet)	Scrubber Liquid				Pressure Drop In H2O	Ambient Temp °F	Relative Humidity RH %	Product Material Samples From Cooler[c]	
		Inlet	Outlet		Inlet pH	Inlet Temp. °F	Outlet pH	Outlet Temp. °F				Inlet	Outlet
0906	[d]12.72[e]												
0913	12.66	Started Run 1	Started Run 1										
0918													
0938									13.2	39	66		
0950									13.2	43	63		
0955					1.82	115	1.45	100					
1010									13.2	44	64		
1013		Stopped Continued							13.2	43	63		
1015			Stopped Switched Ports									Grab	
1018													
1026													
1028													
1030			Continued		2.05	115	2.15	100	13.2	44	57		
1032													
1038													
1040									13.2	44	57		
1055													
1115													
1125									13.2	43	64		
1126	12.66	Completed Run 1							13.2	43	64		Grab
1135									13.2	43	57		
1144	12.72				1.90	110	2.10	90					
1205			Completed Run 1										
				Started Run 3									
1238													
				Completed Run 3									
1400	12.41												
1401	12.41	Started Run 2	Started Run 2										
1415													
1430									13.4	46	60		
1445									13.4	49	50		
					1.70	115	1.80	105	13.3	46	60		
1500									13.2	47	54		
1501													
1512									13.1	46	53		
1514		Stopped Switched Ports	Stopped Continued										
1515													
1520													
1530		Continued							13.1	45	65	Grab	Grab
1545					1.74	105	1.75	95					
1600									13.2	46	53		
1615									13.2	46	53		
1620	12.41	Completed Run 2			1.80	115	1.80	105	13.1	44	58		
1626	12.41		Completed Run 2						13.1	44	58		

[a]Average production rate value for each run.
[b]Particulate samples analyzed for insoluble particulate, nitrate and ammonia content.
[c]Product material samples analyzed for nitrate and ammonia content.
[d]Inlet test runs production rates.
[e]Outlet test runs production rates.

TABLE 1-3
DAILY SUMMARY LOG FOR NO. 1 COOLER SAMPLING ON NOVEMBER 16, 1978
AT COMINCO AMERICAN, BEATRICE, NEBRASKA

Clock Time	Production Rate[a] (Tons/Hour)	Ammonium Nitrate Particulate[b]		Scrubber Liquid				Pressure Drop In H2O	Ambient Temp °F	Relative Humidity RH %	Product Material Samples From Cooler[c]	
				Inlet		Outlet						
		Inlet	Outlet	pH	Temp. °F	pH	Temp. °F				Inlet	Outlet
0845	[d]13.05[e]											
0847	13.10	Started Run 3	Started Run 3	1.76	115	1.76	95					
0850												
0900								13.2	41	85		
0915								13.1	41	90		
0930								13.0	42	69		
0940								13.0	43	69		
0945											Grab	Grab
0947								13.1	41	85		
0950		Stopped Switched Ports										
0957			Stopped	1.74	110	1.65	90					
1002			Continued									
1006		Continued										
1015												
1030								13.0	40	85		
1045								13.0	40	76		
1100								13.0	39	84		
1106	13.10			1.76	115	1.74	105					
1114	13.05	Completed Run 3	Completed Run 3									

[a]Average production rate value for each run.
[b]Particulate samples analyzed for insoluble particulate, nitrate and ammonia content.
[c]Product material samples analyzed for nitrate and ammonia content.
[d]Inlet test run production rates.
[e]Outlet test run production rates.

2.0 SUMMARY AND DISCUSSION OF RESULTS

A) Introduction

This section presents the results of a testing program conducted during the week of November 14 through November 16, 1978 at the Cominco American Plant in Beatrice, Nebraska. Testing was performed on the Cooler No. 1 emissions.

The inlet sampling location for Cooler No. 1 was located in the duct venting the exhaust gases from the rotary drum cooler to the Doyle scrubber. The outlet sampling location was located in the header duct venting the Doyle scrubber to the stack.

During testing on the Doyle scrubber, samples of the scrubber effluent were taken from both the inlet and the discharge water. The samples were taken at approximately 30-minute intervals. At the conclusion of each test, the samples from each location were composited and then filtered.

Product samples were collected from the inlet and outlet of the rotary drum cooler for bulk density and sieve analysis.

Particle size distribution was evaluated at the scrubber inlet test location.

Sample analysis was performed at the test site and repeated at YRC's laboratory in Stamford, Connecticut. Field analysis was performed on the train samples for ammonium nitrate and ammonia and on the scrubber liquor for ammonium nitrate.

Tables 2-1 to 2-15 summarize the results of the emission test program. The tables present the emission test results in three categories: insoluble particulate, ammonium nitrate and ammonia.

Tables 2-1 and 2-2 present a summary of particulate emission and ammonium nitrate concentration data. The particulate emission data represent sample train filter dry catch plus the filtered residue from the distilled water and water wash sample. The ammonium nitrate and ammonia emission data represent the water sample; 1.0 N H_2SO_4 sample and the train filter catches.

For test 3, the ammonia nitrate scrubber efficiency could not be calculated from the outlet ammonium nitrate concentration data. During train cleanup on test 3, a residue was noted on the inside of the probe. This residue was not present in tests 1 and 2. The duct work was checked to determine if a residue build up was present on the surfaces; none was found. The outlet sample collected in test 3 was also found to be more acidic than in tests 1 and 2. In the final analysis, the outlet ammonium nitrate concentration was found to be greater than that in the inlet. The specific reason is not apparent, although a scrubber upset condition may have occurred, i.e., entrainment. Entrainment break-through curves are rather sharp and very sensitive to flow fluctuations. Test 3 did have the greatest gas volumetric flow rate. Entrainment would be most critical in the case of ammonium nitrate since it is considered a particulate. In conclusion, the data listed for test 3 are believed to be non-typical of the sampled source and therefore are not represented in the average data.

TABLE 2-1
PARTICULATE AND AMMONIUM NITRATE
CONCENTRATION AND EMISSION DATA SUMMARY IN ENGLISH UNITS

Location	Run 1		Run 2		Run 3[d]		Average[e]	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	11-15-78		11-15-78		11-16-78			
Volume of Gas Sampled--DSCF[a]	91.51	124.23	85.25	126.98	88.53	134.31	88.38	125.61
Percent Moisture by Volume	1.1	3.4	1.5	3.5	0.7	3.1	1.3	3.5
Average Stack Temperature--°F	125	94	133	95	115	95	129	94
Stack Volumetric Flow Rate--DSCFM[b]	15,111	15,471	14,018	16,065	14,968	17,044	14,600	15,768
Percent Isokinetic	104	106	105	105	102	104	105	106
Production Rate--Tons/Hour	12.66	12.72	12.41	12.41	13.10	13.05	12.53	12.56
Insoluble Particulates--Filter Catch and Collection Water Filtrate								
mg	19.32	4.35	16.39	2.04	2.49	6.68	17.86	3.20
gr/DSCF	0.0033	0.00054	0.0030	0.00025	0.0004	0.0007	0.0032	0.00039
lb/hr.	0.427	0.0716	0.360	0.0344	0.0513	0.1022	0.394	0.053
lb/ton	0.034	0.0056	0.029	0.0028	0.0039	0.0078	0.032	0.0042
Collection Efficiency, Percent	83.5		90.3		--		86.9	
Ammonium Nitrate Particulate (Field Analysis[c])								
mg	10,030.00	50.50	9,907.60	48.88	1,108.80	8,173.44	9,968.80	49.64
gr/DSCF	1.688	0.0063	1.790	0.0059	0.1929	0.9371	1.739	0.0061
lb/hr.	218.6	0.835	215.0	0.816	24.74	136.9	216.8	0.826
lb/ton	17.3	0.066	17.3	0.066	1.89	10.5	17.3	0.066
Collection Efficiency, Percent	99.6		99.6		--		99.6	
Total--Particulate Insoluble and Ammonium Nitrate								
mg	10,049.32	54.75	9,923.99	50.92	1,111.29	8,180.12	9,986.66	52.84
gr/DSCF	1.691	0.0068	1.793	0.0062	0.193	0.938	1.742	0.0065
lb/hr.	219.0	0.900	215.4	0.850	24.79	137.0	217.2	0.875
lb/ton	17.3	0.071	17.4	0.069	1.89	10.5	17.4	0.070
Collection Efficiency, Percent	99.6		99.6		--		99.6	

[a]Dry Standard Cubic Feet at 68°F, 29.92 in. Hg.
[b]Dry Standard Cubic Feet Per Minute at 68°F, 29.92 in. Hg.
[c]Analysis Performed at Site Location.
[d]Run 3 Data Questionable As To Being Representative.
[e]Run 3 Data Not Included In Average.

TABLE 2-2

PARTICULATE AND AMMONIUM NITRATE

CONCENTRATION AND EMISSION DATA SUMMARY IN METRIC UNITS

Run Number	Run 1		Run 2		Run 3[d]		Average[e]	
Location	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	11/15/78		11/15/78		11/16/78			
Volume of Gas Sampled--DNM3[a]	2.59	3.52	2.41	3.60	2.51	3.80	2.50	3.56
Percent Moisture by Volume	1.1	3.4	1.5	3.5	0.7	3.1	1.3	3.5
Average Stack Temperature-C[o]	51.7	34.5	55.9	35.0	46.2	34.8	53.8	34.8
Stack Volumetric Flow Rate DNM3/M[b]	428	438	397	455	424	483	413	666
Percent Isokinetic	104	106	105	105	102	104	105	106
Production Rate--mg/Hour	11.48	11.54	11.26	11.26	11.88	11.84	11.37	11.39
Insoluble Particulates -- Filter Catch and Collection Water Filtrate								
mg	19.32	4.35	16.39	2.04	2.49	6.68	17.86	3.20
gm/Normalized Cu. Meters	0.0075	0.0012	0.0068	0.00057	0.0009	0.0017	0.0073	0.00089
Kilograms/Hour	0.19	0.03	0.16	0.02	0.03	0.05	0.18	0.03
kg/Mg of Process Weight	0.017	0.0028	0.0145	0.0014	0.0019	0.0039	0.016	0.0021
Collection Efficiency, Percent	83.5		90.3		-		86.9	
Ammonium Nitrate Particulate -- (Field Analysis)[c]								
mg	10,030.00	50.50	9,907.60	48.88	1,108.80	8,173.44	9,968.80	49.64
gm/Normalized Cu. Meters	3.86	0.014	4.09	0.135	0.441	2.14	3.98	0.014
Kilograms/Hour	99.17	0.38	97.55	0.37	11.23	62.10	98.36	0.38
kg/Mg of Process Weight	8.65	0.033	8.65	0.033	0.945	5.25	8.65	0.033
Collection Efficiency, Percent	99.6		99.6		-		99.6	
Total Particulate -- Insoluble & Ammonium Nitrate								
mg	10,049.32	54.75	9,923.99	50.92	1,111.29	8,180.12	9,986.66	52.84
gm/Normalized Cu. Meters	3.87	0.015	4.10	0.014	0.441	2.15	3.98	0.015
Kilograms/Hour	99.36	0.41	97.71	0.39	11.26	62.15	98.54	0.40
kg/Mg of Process Weight	8.65	0.035	8.70	0.034	0.945	5.25	8.70	0.035
Collection Efficiency Percent	99.6		99.6		-		99.6	

[a] Dry Normal Cubic Meters at 20°C, 760 mm Hg.

[b] Dry Normal Cubic Meters per Minute at 20°C, 760 mm Hg.

[c] Analysis Performed at Site Location

[d] Run 3 Data Questionable as to Being Representative

[e] Run 3 Data Not Included in Average

B) Ammonium Nitrate Results

Tables 2-3 through 2-6 present a summary of the emission test results on ammonium nitrate. The entire ammonium nitrate catch was concentrated in the distilled water sample, i.e., none in the 1.0 N H_2SO_4 sample or on the train filter. The ammonia results for each test showed the greatest concentration of ammonia to be in the distilled water sample. The following percentage breakdown of ammonia was found in the distilled water sample during each test.

- Inlet Test #1 99.88%
- Inlet Test #2 99.75%
- Inlet Test #3 99.99%
- Outlet Test #1 88.87%
- Outlet Test #2 92.48%
- Outlet Test #3 99.99%

For ammonium nitrate, the field analysis compares favorably with the laboratory analysis. This demonstrates that no significant degradation of the sample occurs over time, i.e., from the time the analysis was performed in the field to the time the analysis was performed in the laboratory. Analytically, the nitrate was determined by specific ion probe as nitrate and calculated as ammonium nitrate.

Detailed sampling and analytical procedures along with abstracts are included in Appendix 6.10.

C) Ammonia Results

Tables 2-7 through 2-9 present a summary of the ammonia results.

TABLE 2-3
SUMMARY OF EMISSION TEST RESULTS - COOLER NO. 1
SCRUBBER INLET

Run Number	Run 1		Run 2		Run 3[e]		Average[f]	
Date	11/15/78		11/15/78		11/16/78			
Volume of Gas Sampled--DSCF[a]	91.51		85.25		88.53		88.38	
Percent Moisture by Volume	1.1		1.5		0.7		1.3	
Average Stack Temperature--^{o}F	125		133		115		129	
Stack Volumetric Flow Rate--DSCFM[b]	15,111		14,018		14,968		14,600	
Percent Isokinetic	104		105		108		104	
Production Rate--Tons/Day	303.8		297.8		314.4		300.8	
Insoluble Particulates--Filter Catch and Collection Water Filtrate[c]								
Mg	19.32		16.39		2.49		17.86	
Gr/DSCF	0.0033		0.0030		0.0004		0.0032	
Lb/Hour	0.427		0.360		0.0513		0.394	
Lb/Ton	0.034		0.029		0.0039		0.032	
Ammonium Nitrate Particulate (Analysis Results)[d]	Field	Lab	Field	Lab	Field	Lab	Field	Lab
Mg	10,030	11,635	9,908	8,010	1,109	871.2	9,969	9,823
Gr/DSCF	1,688	1,958	1.790	1.447	0.193	0.152	1.739	1.703
Lb/Hour	218.6	253.6	215.0	173.8	24.74	19.44	216.8	213.7
Lb/Ton	17.3	20.0	17.3	14.0	1.89	1.48	17.3	17.1
Total--Particulate Insoluble & Ammonium Nitrate	Field	Lab	Field	Lab	Field	Lab	Field	Lab
Mg	10,049	11,654	9,924	8,026	1,111	873.7	9,987	9,840
Gr/DSCF	1.691	1.961	1.793	1.450	0.193	0.152	1.742	1.706
Lb/Hour	219	254	215.4	174.2	24.79	19.50	217.2	214.1
Lb/Ton	17.3	20.1	17.4	14.0	1.89	1.49	17.4	17.1

[a] Dry standard cubic feet at 68^{o}F, 29.92 in. Hg.

[b] Dry standard cubic feet per minute at 68^{o}F, 29.92 in. Hg.

[c] Includes train filter, and impinger water filtrate

[d] Field analysis performed at plant site; lab analysis performed at the YRC lab in Stamford.

[e] Run 3 data considered to be non-representative of actual emission. Date to be excluded.

[f] Run 3 data not included in average.

TABLE 2-4
SUMMARY OF EMISSION TEST RESULTS - COOLER NO. 1
SCRUBBER OUTLET

Run Number	Run 1		Run 2		Run 3[e]		Average[f]	
Date	11/15/78		11/15/78		11/16/78			
Volume of Gas Sampled--DSCF[a]	124.23		126.98		134.31		125.61	
Percent Moisture by Volume	3.4		3.5		3.1		3.4	
Average Stack Temperature - ^{o}F	94		95		95		94	
Stack Volumetric Flow Rate--DSCFM[b]	15,471		16,065		17,044		15,768	
Pressure Drop Across Scrubber in H_2O	13.2		13.2		13.1		13.1	
Percent Isokinetic	106		105		104		105	
Production Rate--Tons/Day	305.3		297.8		313.2		301.5	
Insoluble Particulates--Filter Catch and Collection Water Filtrate[c]								
Mg	4.35		2.04		6.68		3.20	
Gr/DSCF	.00054		.00025		.0007		.00039	
Lb/Hour	.0716		.0344		.1022		.053	
Lb/Ton	.0056		.0028		.0078		.0042	
Ammonium Nitrate Particulate (Analysis Results)[d]	Field	Lab	Field	Lab	Field	Lab	Field	Lab
Mg	50.4	41.01	48.88	39.48	8,173	8,669	49.64	40.25
Gr/DSCF	0.0063	0.0051	.00593	.0048	.9371	.9940	.0061	.0050
Lb/Hour	.835	.674	.816	.659	136.9	145.2	.826	.667
Lb/Ton	.066	.053	.066	.053	10.5	11.1	0.066	0.053
Total - Particulate Insoluble and Ammonium Nitrate								
Mg	54.75	45.36	50.92	41.52	8,180	8,676	52.84	43.44
Gr/DSCF	.0068	.0056	.0062	.0050	.938	.995	.0065	.0053
Lb/Hour	.900	.746	.850	.693	137	145.3	.875	.720
Lb/Ton	.071	.059	.069	.056	10.5	11.1	.070	.058

[a] Dry standard cubic feet at $68^{o}F$, 29.92 in. Hg.
[b] Dry standard cubic feet per minute at $68^{o}F$, 29.92 in. Hg.
[c] Includes train filter and impinger water filtrate.
[d] Field analysis performed at plant site; lab analysis performed at the YRC lab in Stamford.
[e] Run 3 data considered to be non-representative of actual emission. Data to be excluded.
[f] Run 3 data not included in average.

TABLE 2-5
RESULTS FOR PARTICULATE, AMMONIUM NITRATE
AND AMMONIUM NITRATE MEASURED AS AMMONIA AT NO. 1 COOLER INLET

Run Number	1	2	3[b]	Average[c]
Date	11-15-78	11-15-78	11-16-78	
Volume of Gas Sampled--DSCF	91.51	85.25	88.53	88.38
Percent Moisture by Volume	1.1	1.5	0.7	1.3
Average Stack Temperature °F	125	133	115	129
Stack Volumetric Flow Rate--DSCFM	15,111	14,018	14,968	14,600
Percent Isokinetic	104	105	108	104
Production Rate--Tons/Hour	12.66	12.41	13.10	12.53
Insoluble Particulates				
Filter Catch and Collection			2.49	17.86
Water Filtrate	19.32	16.39	0.0004	0.0032
mg	0.0033	0.0030	0.0513	0.394
gr./DSCF	0.427	0.360	0.0039	0.032
lb./hr.	0.034	0.029		
lb./ton				

Ammonium Nitrate Particulate[a]	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia
Nitrate and Ammonium Nitrate Measured as Ammonia[d]								
mg	10,030	16,776	9,908	15,911	1,109	17,035	9,969	16,344
gr./DSCF	1.688	2.823	1.790	2.874	0.1929	2.963	1.739	2.848
lb./hr.	218.6	366	215.0	345	24.74	380	216.8	356
lb./ton	17.3	28.9	17.3	27.8	1.89	29.0	17.3	28.4

Total Particulate	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia
Nitrate and Ammonium Nitrate Measured as Ammonia								
mg	10,049	16,795	9,924	15,927	1,111	17,037	9,987	16,362
gr./DSCF	1.691	2.826	1.793	2.877	0.193	2.964	1.742	2.851
lb./hr.	219.0	366.0	215.4	345.7	24.79	380.2	217.2	356.7
lb./ton	17.3	28.9	17.4	27.9	1.89	29.0	17.4	28.5
Percent Insoluble Particulate Catch	0.2	0.1	0.2	0.1	0.2	0.01	0.2	0.1

[a]Field Analysis results used for nitrate data.
[b]Run 3 data non-representative of emissions.
[c]Run 3 data not included in average.
[d]$\frac{\text{Moles } NH_3}{}$ x 80 gms. Ammonium Nitrate/Mole = gms. Ammonium Nitrate.

TABLE 2-6
RESULTS FOR PARTICULATE, AMMONIUM NITRATE
AND AMMONIUM NITRATE MEASURED AS AMMONIA AT NO. 1 COOLER OUTLET

Run Number	1		2		3[b]		Average[c]	
Date	11-15-78		11-15-78		11-16-78			
Volume of Gas Sampled--DSCF	124.23		126.98		134.31		125.61	
Percent Moisture by Volume	3.4		3.5		3.1		3.4	
Average Stack Temperature-°F	94		95		95		94	
Stack Volumetric Flow Rate--DSCFM	15,471		16,065		17,044		15,768	
Percent Isokinetic	106		105		104		105	
Production Rate--Tons/Hour	12.72		12.41		13.05		12.56	
Insoluble Particulates Filter Catch and Collection Water Filtrate								
mg.	4.35		2.04		6.68		3.20	
gr./DSCF	0.00054		0.00025		0.0007		0.00039	
lb./hr.	0.0716		0.0344		0.1022		0.0530	
lb./ton	0.0056		0.0028		0.0078		0.0042	
Ammonium Nitrate Particulate[a] Nitrate and Ammonium Nitrate Measured as Ammonia[d]	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia
mg.	50.4	182.6	48.88	161.5	8,173	8,840	49.64	172.0
gr./DSCF	0.0063	0.0226	0.0059	0.0196	0.9371	1.014	0.0061	0.0211
lb./hr.	0.835	3.00	0.816	2.70	136.9	148	0.826	2.85
lb./ton	0.066	0.236	0.066	0.217	10.5	11.3	0.066	0.227
Total Particulate Nitrate and Ammonium Nitrate Measured as Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia	Measured As Nitrate	Measured As Ammonia
mg.	54.75	186.95	50.92	163.54	8,180	8,847	52.84	175.2
gr./DSCF	0.0068	0.0232	0.0062	0.0198	0.938	1.01	0.0065	0.215
lb./hr.	0.900	3.07	0.850	2.73	137.0	148.2	0.875	2.90
lb./ton	0.071	0.24	0.069	0.22	10.5	11.4	0.070	0.23
Percent Insoluble Particulate Catch	7.9	2.3	4.0	1.2	0.08	0.07	6.0	1.8

[a]Field analysis results used for nitrate data.
[b]Run 3 data non-representative of emission.
[c]Run 3 data not included in average.
[d]Moles NH_3 x 80 gms. ammonium nitrate/mole = gms. ammonium nitrate.

TABLE 2-7
SUMMARY OF AMMONIA AND AMMONIUM NITRATE
EMISSIONS CALCULATED FROM COLLECTED AMMONIA

Location	Run 1		Run 2		Run 3[d]		Average[e]	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	11-15-78		11-15-78		11-16-78			
Volume of Gas Sampled--DSCF[a]	91.51	124.23	85.25	126.98	88.53	134.31	88.38	125.61
Percent Moisture by Volume	1.1	3.4	1.5	3.5	0.7	3.1	1.3	3.4
Average Stack Temperature--°F	125	94	133	95	115	95	129	94
Stack Volumetric Flow Rate--DSCFM[b]	15,111	15,471	14,018	16,065	14,968	17,044	14,600	15,768
Percent Isokinetic	104	106	105	105	108	104	104	105
Production Rate--Tons/Hour	12.66	12.72	12.41	12.41	13.10	13.05	12.53	12.56
Ammonia (Lab Analysis)								
mg.	3,565	38.8	3,381	34.31	3,620	1,878	3,473	36.56
gr./DSCF	0.5999	0.0048	0.6108	0.00416	0.6297	0.2153	0.6054	0.0045
lb./hr.	77.7	0.638	73.4	0.573	80.8	31.5	75.6	0.605
lb./ton	6.14	0.050	5.91	0.0462	6.17	2.41	6.03	0.0481
Collection Efficiency, Percent	99.2		99.2		61.1		99.2	
Ammonium Nitrate Calculated From Moles of Ammonia[c]								
mg.	16,776	182.6	15,911	161.5	17,035	8,840	16,344	172.0
gr./DSCF	2.823	0.023	2.874	0.0196	2.963	1.014	2.848	0.0211
lb./hr.	366	3.00	3.45	2.70	380	148.1	356	2.85
lb./ton	28.9	0.236	27.8	0.217	29.0	11.3	28.4	0.227
Collection Efficiency, Percent	99.2		99.2		61.1		99.2	

[a]Dry standard cubic feet at 68°F, 29.92 in. Hg.
[b]Dry standard cubic feet per minute at 68°, 29.92 in Hg.
[c]$\frac{\text{Moles NH3}}{17}$ x 80 gms. ammonium nitrate/mole = gms. ammonium nitrate.
[d]Run 3 data non-representative of emissions.
[e]Run 3 data not included in average.

TABLE 2-8
SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED EMISSIONS CALCULATED FROM COLLECTED AMMONIA AT THE NO. 1 COOLER SCRUBBER INLET LOCATED AT COMINCO AMERICAN, BEATRICE, NEBRASKA

Run Number	Run 1	Run 2	Run 3[a]	Average[b]
Date	11-15-78	11-15-78	11-16-78	
Volume of Gas Sampled--DSCF	91.51	85.25	88.53	88.38
Stack Volumetric Flow Rate--DSCFM	15,111	14,018	14,968	14,600
Production Rate--Tons/Hour	12.66	12.41	13.10	12.53
Ammonia (As Measured)				
mg.	3,565	3,381	3,620	3,473
gr./DSCF	0.5999	0.6108	0.6297	0.6054
lb./hr.	77.7	73.4	80.8	75.6
lb./ton	6.14	5.91	6.17	6.03
Ammonium Nitrate Calculated From Moles of Ammonia				
mg.	16,776	15,911	17,035	16,344
gr./DSCF	2.823	2.874	2.963	2.848
lb./hr.	366	345	380	356
lb./ton	28.9	27.8	29.0	28.4
Excess Ammonia (Ammonia Not Combined With Ammonium Nitrate)[c]				
mg.	1,434	1,276	3,384	1,355
gr./DSCF	0.2413	0.2305	0.5887	0.2359
lb./hr.	31.3	27.7	75.5	29.5
lb./ton	2.47	2.23	5.76	2.35

[a]Run 3 data suspected to be non-representative of emissions.
[b]Run 3 data not used in average.
[c]Field analysis results used for nitrate data.

TABLE 2-9
SUMMARY OF AMMONIA AND AMMONIUM NITRATE CONTROLLED EMISSIONS CALCULATED FROM COLLECTED AMMONIA AT THE NO. 1 COOLER SCRUBBER OUTLET LOCATED AT COMINCO AMERICAN, BEATRICE, NEBRASKA

Run Number	Run 1	Run 2	Run 3[a]	Average[b]
Date	11-15-78	11-15-78	11-16-78	
Volume of Gas Sampled--DSCF	124.23	126.98	134.31	125.61
Stack Volumetric Flow Rate--DSCFM	15,471	16,065	17,044	15,768
Production Rate--Tons/Hour	12.72	12.41	13.05	12.56
Ammonia (As Measured)				
mg.	38.8	34.31	1,878	36.56
gr./DSCF	0.0048	0.0042	0.2153	0.0045
lb./hr.	0.638	0.573	31.5	0.605
lb./ton	0.050	0.046	2.41	0.048
Ammonium Nitrate Calculated From Moles of Ammonia				
mg.	182.6	161.5	8,840	172.0
gr./DSCF	0.0226	0.0196	1.014	0.0211
lb./hr.	3.00	2.70	148.1	2.85
lb./ton	0.236	0.217	11.3	0.227
Excess Ammonia (Ammonia Not Combined With Ammonium Nitrate)[c]				
mg.	28.05	23.91	142	25.98
gr./DSCF	0.0035	0.0029	0.0163	0.0032
lb./hr.	0.461	0.399	2.38	0.430
lb./ton	0.036	0.032	0.182	0.034

[a]Run 3 data suspected to be non-representative of emissions.
[b]Run 3 data not used in average.
[c]Field analysis results used for nitrate data.

The ammonia field analysis was performed on only the 1.0 N H_2SO_4 sample. As mentioned previously, this sample contained no appreciable ammonia concentration. The water sample which contained the greatest concentration of ammonia was analyzed only in the laboratory. For this reason, only the laboratory emission data may be used for the evaluation of ammonia emissions.

D) Particle Size Test Results

Table 2-10 summarizes the results from the particle sizing tests. Three repetitions of inlet test runs were conducted. Figures 2-2 through 2-4 present graphs of particle size distribution for each test run.

E) Pressure Drop Measurements

Table 2-11 presents a summary of the scrubber pressure drop measurements. Pressure drop measurements were recorded approximately every 15 minutes during the testing periods. The measurements were taken at the inlet location.

F) Scrubber Liquid Results

Table 2-12 presents a summary of the scrubber liquid results.

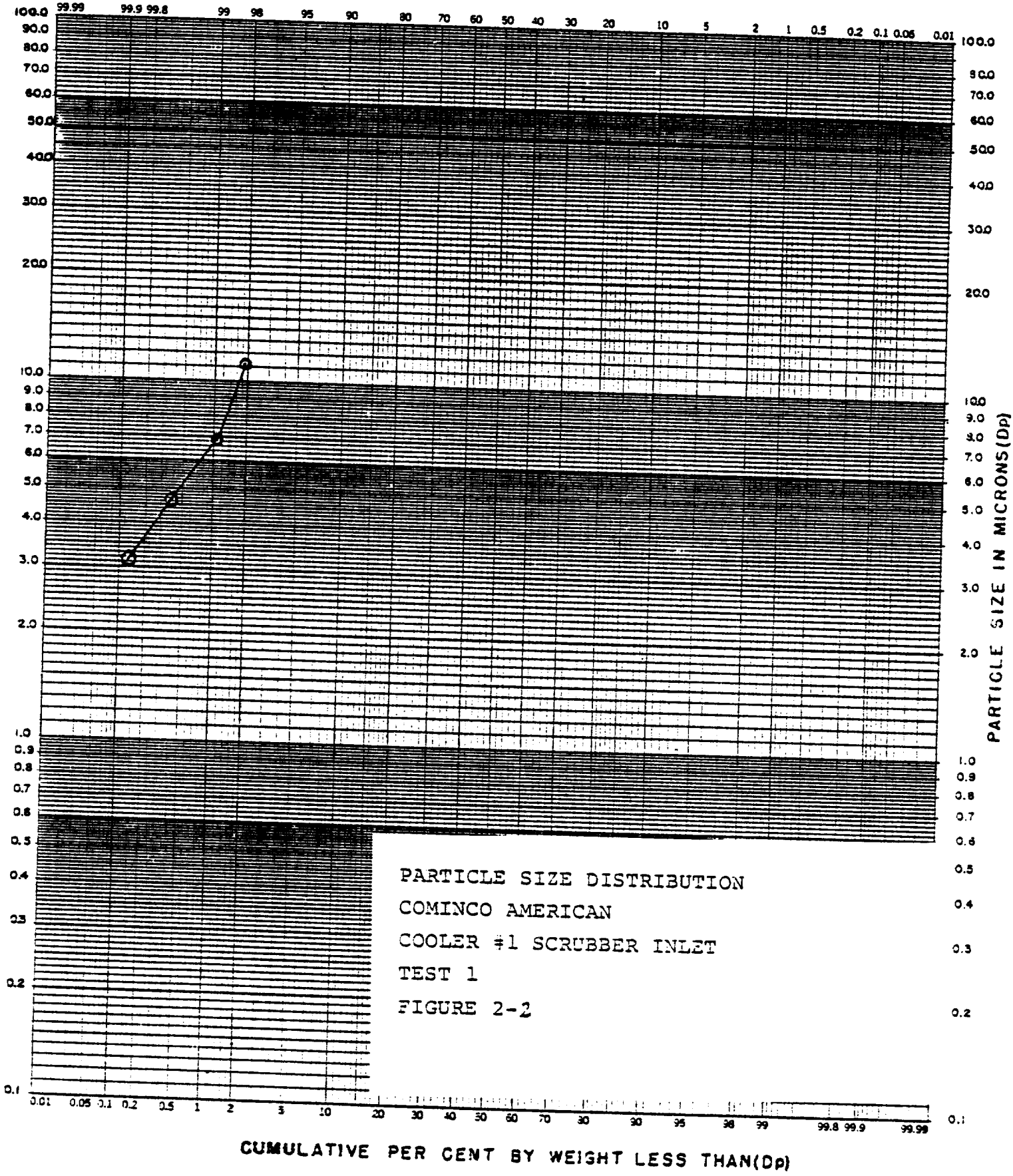
The analysis of inlet scrubber liquor showed high concentrations of ammonium nitrate and ammonia from test 1 to test 3. This can be expected to cause a decrease in scrubber efficiency from vapor pressure considerations. In fact, the test results confirmed

TABLE 2-10
SUMMARY OF PARTICLE SIZING TEST RESULTS
ON #1 COOLER SCRUBBER[a]

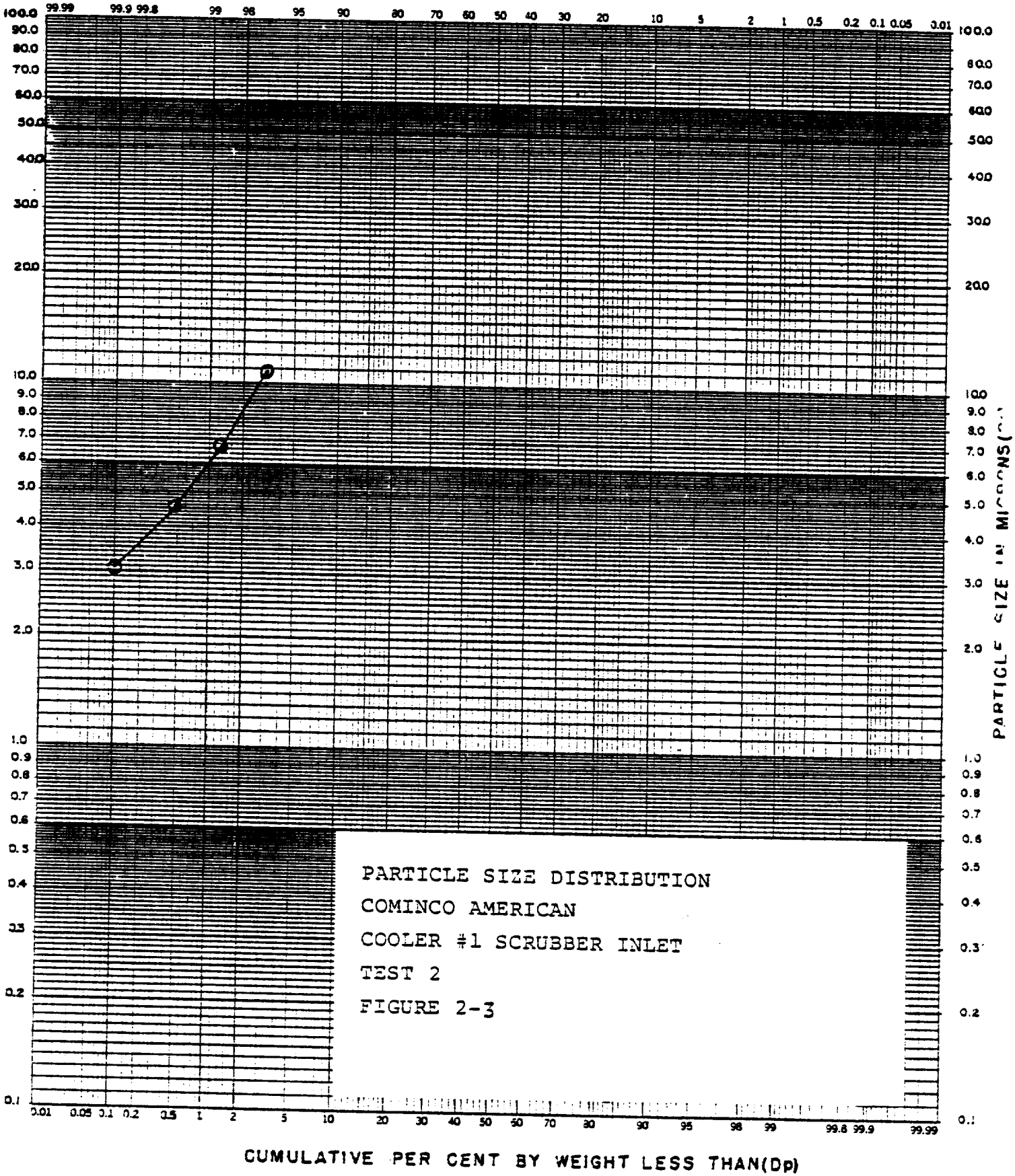
Test No.	Sampling Location	Test Date	Test Time	Particulate Concentration, Gr/DSCF (total)	Aerodynamic Size Range, μm	Mass in Size Range, %
1	Inlet	11/14/78	1511-1543	2.09892		
Stage 1					>11.04	98.16
2					11.04-6.89	0.71
3					6.89-4.66	0.74
4					4.66-3.17	0.25
5					3.17-2.03	0.13
6					2.03-1.01	0.00
7					1.01-0.62	0.00
8					0.62-0.39	0.00
Filter					< 0.39	0.00
2	Inlet	11/14/78	1612-1655	1.54792		
Stage 1					>10.76	97.00
2					10.76-6.71	1.68
3					6.71-4.54	0.84
4					4.54-3.09	0.38
5					3.09-1.98	0.10
6					1.98-0.98	0.00
7					0.98-0.60	0.00
8					0.60-0.38	0.00
Filter					< 0.38	0.00
3	Inlet	11/15/78	1205-1238	2.37225		
Stage 1					>10.76	97.66
2					10.76-6.71	1.20
3					6.71-4.54	0.73
4					4.54-3.09	0.31
5					3.09-1.98	0.10
6					1.98-0.98	0.00
7					0.98-0.60	0.00
8					0.60-0.37	0.00
Filter					< 0.37	0.00

[a] The complete results can be found in Appendix 6.3.

PARTICLE SIZE DISTRIBUTION



PARTICLE SIZE DISTRIBUTION



PARTICLE SIZE DISTRIBUTION

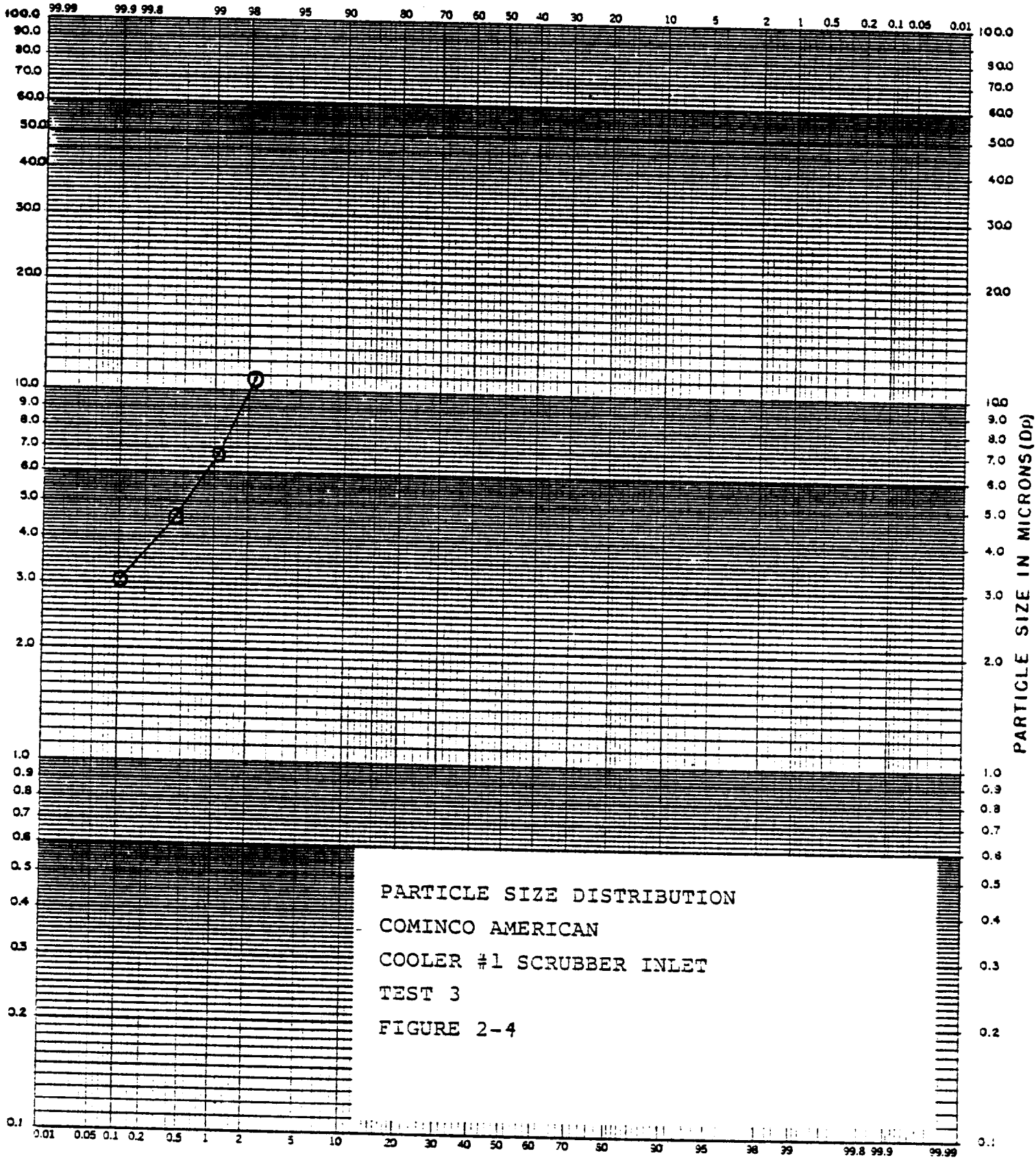


TABLE 2-11
SUMMARY OF SCRUBBER PRESSURE DROP MEASUREMENT
ON #1 COOLER INLET

Date	Test No.	Clock Time	P," H_2O
11/15/78	1	0918	13.2
		0933	13.2
		0948	13.2
		1003	13.2
		1031	13.2
		1046	13.2
		1101	13.2
		1116	13.2
11/15/78	2	1406	13.4
		1421	13.2
		1436	13.3
		1451	13.2
		1525	13.1
		1540	13.2
		1555	13.1
		1610	13.0
11/16/78	3	0852	13.2
		0907	13.0
		0922	13.0
		0937	13.0
		1010	12.9
		1025	13.0
		1040	13.0
		1055	13.0

TABLE 2-12
SCRUBBER LIQUID RESULTS

Test No.	1				2				3				Average			
Date	11/15/78				11/15/78				11/16/78							
Time	0950-1135		0950-1135		1445-1615		1445-1615		0845-1100		0845-1100					
Location	Inlet (SW-1)		Outlet (SW-2)		Inlet (SW-1)		Outlet (SW-2)		Inlet (SW-1)		Outlet (SW-2)		Inlet (SW-1)		Outlet (SW-2)	
Scrubber Solution Analysis	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab
pH	1.9	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.8	1.8	1.8	1.8
Temperature °F[a]	113	113	96	96	112	112	102	102	113	113	97	97	113	113	98	98
Ammonium Nitrate (gm moles/liter)	10.1	3.7	10.3	3.7	10.6	4.2	10.5	4.7	11.1	4.4	10.7	4.2	10.6	4.1	10.5	4.2
Ammonia (gm moles/liter)		12.63		11.48		12.92		21.53		22.96		23.68		16.17		18.90
Percent Solids (mg/l)		852958		854104		937066		935169		979758		970142		923261		919805

[a] Temperatures measured immediately after sample collected.

that the ammonia removal efficiency decreased in the scrubber as the ammonia concentration of the inlet scrubber liquor increased.

The scrubber water samples were analyzed for ammonium nitrate in the field. Difficulty was encountered due to crystallization of the samples in the extremely cold air. Field analysis was performed on an aliquot taken from the top of the sample. Laboratory analysis was performed after the samples were heated to redissolve the crystals.

G) Process Sample Results

Table 2-13 presents a summary of bulk density and sieve analysis. These tests were performed on product samples (procedures presented in Appendix 6.10).

Table 2-14 presents a summary of product sample analysis.

H) Relative Humidity and Ambient Air Temperature Results

Table 2-15 presents a chart of the relative humidity and ambient temperature. These measurements were recorded at the inlet test location approximately every 15 minutes during the testing periods.

I) Fyrite Analysis of Carrier Gases Results

Results of the Fyrite analysis of carrier gases in the inlet and outlet of the Cooler No. 1 scrubber are presented in Table 2-16. Identical results were obtained for the inlet and outlet. Analyses were performed in accordance with EPA Method 3, "Gas Analysis for Carbon Dioxide and Oxygen".

TABLE 2-13
SUMMARY OF BULK DENSITY AND SIEVE ANALYSIS

Test No.	1		2		3	
General Data						
Date	11/15/78		11/15/78		11/16/78	
Location	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Bulk Density ($lbs/ft.^3$)	54.3	53.4	52.3	55.1	51.5	54.0
Sieve Analysis (% Retained on Seive)						
Sieve #5	0.00	0.00	0.00	0.00	0.07	0.08
Sieve #6	2.96	1.66	2.66	1.63	0.88	0.62
Sieve #8	38.82	26.24	34.25	28.21	56.23	45.44
Sieve #10	39.76	43.86	41.06	42.90	37.69	43.98
Sieve #12	14.70	21.12	17.08	20.44	4.65	8.34
Sieve #14	3.49	6.46	4.40	5.83	0.42	1.16
Sieve #16	0.12	0.33	0.50	0.79	0.03	0.20
Sieve #18	0.02	0.16	0.02	0.09	0.00	0.06
Sieve #20	0.02	0.07	0.00	0.04	0.01	0.07
Pan	0.11	0.10	0.03	0.06	0.02	0.05

TABLE 2-14
SUMMARY OF PRODUCT ANALYSIS

Test No.	1	2	3	Average
Cooler Inlet Product				
Moisture (%)	0.111	0.142	0.127	0.127
pH	4.95	4.8	4.91	4.89
Total Ammonium Nitrate (gm-moles/liter)	0.52	0.54	0.54	0.53
Weight of Product* (grams)	5.00785	4.99747	5.01382	-
Cooler Outlet Product				
Moisture (%)	0.116	0.120	0.088	0.108
pH	4.94	4.92	4.97	4.94
Total Ammonia Nitrate (gm-moles/liter)	0.50	0.54	0.45	0.50
Weight of Product* (grams)	4.99748	5.00157	4.99691	0

*Note: The pH and total ammonium nitrate was determined by dissolving a known weight of product in 100 ml of distilled water. The weights used are presented in the table.

TABLE 2-15
RELATIVE HUMIDITY AND
AMBIENT AIR TEMPERATURE RESULTS

Date	Test No.	Time	Ambient Temp.	Relative Humidity	Barometric Pressure
11/15/78	1	0918	39	61	29.10
		0928	42	70	29.10
		0943	43	63	29.09
		0958	44	64	29.09
		1013	43	63	29.09
		1031	44	57	29.09
		1041	44	57	29.10
		1056	43	63	29.10
		1111	43	63	29.10
		1126	43	56	29.10
11/15/78	2	1406	46	59	29.13
		1416	49	49	29.14
		1431	46	59	29.14
		1446	47	53	29.13
		1501	46	52	29.13
		1525	48	48	29.13
		1535	46	52	29.13
		1550	46	52	29.13
		1605	44	57	29.13
		1626	44	57	29.13
11/16/78	3	0852	41	81	28.99
		0902	42	85	29.00
		0917	42	70	29.00
		0932	43	70	29.00
		0942	43	70	28.99
		1020	40	84	28.99
		1035	40	76	28.98
		1050	39	83	28.98

TABLE 2-16
SUMMARY OF RESULTS
FYRITE ANALYSIS OF CARRIER GASES

	Scrubber Inlet	Scrubber Outlet
Date	11/14/78	11/14/78
Carbon Dioxide %	0.0	0.0
Oxygen %	20.5	20.5

3.0 PROCESS DESCRIPTION AND OPERATION

A) Process Description

Process Equipment

The Cominco American plant in Beatrice, Nebraska produces ammonium nitrate granules for use as fertilizer. The facility was built for Cominco by C and I Girdler in 1966. Its design production rate is 436 Mg* (480 tons) per day. Unit operations at the Cominco plant include ammonium nitrate solution production, solution concentration, granule formation, screening, cooling, and coating. After solution production, ammonium nitrate is separated into two parallel production lines for concentration, granulation, screening, and cooling. Granules removed from the two coolers are mixed together again before being coated, stored, and shipped.

Granulation takes place in two C and I Girdler rotary drum granulators. (These are predecessors of C and I Girdler Spherodizer^{R} units). In the granulators, ammonium nitrate is cooled by a countercurrent air flow to form solid granules. These are conveyed from the granulators to two sets of enclosed Rotex screens, which remove oversized and undersized material. Coarse material is crushed and then recycled to the granulators along with fine material. Correctly sized granules fall through enclosed pipes to two rotary drum coolers, where they are further cooled by countercurrent air flow.

*Megagrams

Ammonium nitrate granules are lifted from the coolers by bucket elevators to a common, open belt conveyor. The production rate is determined by a weigh belt on the conveyor. The granules are fed down the conveyor into a rotary drum coater. They are then lifted by a covered belt conveyor to bulk warehouses from which they are shipped as final product.

Emission Control

Emission control equipment at the Cominco facility consists of a condenser for neutralizer overheads, wet scrubbers which control emissions from granulation and coating equipment, and baghouses which control emissions from coded solids coating, handling, and shipping. One wet scrubber is devoted entirely to controlling emissions from the "No. 1" cooler.

Contaminated steam produced in the ammonia--nitric acid neutralizer is used to preheat the ammonia feed and also to preheat feed water for a process steam boiler. The resulting condensate is used as scrubber liquor. Presently, about one half of the steam is condensed, while the remainder is simply vented to the atmosphere.

The scrubbers are Joy Turbulance medium pressure drop wet impingement scrubbers. They are referred to as "Doyle" units. Air entering each of these scrubbers enters through a cone-shaped downcomer, which causes it to impinge on a liquor pool. Also, the spray of scrubber liquor is applied to the entering air stream in each downcomer. After impinging on the liquor pool, the air stream passes over and under a set of baffles and exits the scrubber. Air flow through the

scrubber is induced by a fan on the scrubber outlet. Air exiting the scrubber fans is combined in a common header and flows to the stack. Scrubber liquor for each bank of scrubbers is recirculated through a "weak Liquor Tank" for each bank. The weak liquor concentration is 63 to 65 percent ammonium nitrate and is circulated to the scrubbers at a total of about 227 liters per minute (60 gpm).

B) Process Operation

Cooler Number 1 Production Rate

To determine the production rate of cooler number 1 during testing, certain parameters related to this rate were monitored and recorded. Weigh belt readings indicating the combined production rate of coolers 1 and 2 were recorded. Plant operating personnel stated, however, that the production rates of the two coolers were not equal during testing. Therefore, to roughly determine the production rate of cooler 1 relative to the combined total, the spray pressures to granulators 1 and 2 were also monitored and recorded. Average production rates for cooler number 1 during the various tests have been calculated using the weigh belt readings and spray pressure readings, and are presented in Table 3-1. (See Appendix 6.8 for the weigh belt and spray pressure readings and a description of the production rate calculation).

Cooler Number 1 Operation

Samples of ammonium nitrate granules entering cooler number 1 were taken to determine whether the cooler

TABLE 3-1
PRODUCTION RATE OF COOLER NUMBER 1 DURING TESTS

Test	Date	Time	Production Rate Mg/hr.*	Tons/Hr.
Scrubber Inlet No. 1	11/15	0913-1126	11.49	12.66
Scrubber Outlet No. 1	11/15	0906-1144	11.54	12.72
Scrubber Inlet No. 2	11/15	1401-1620	11.26	12.41
Scrubber Outlet No. 2	11/15	1400-1626	11.26	12.41
Scrubber Inlet No. 3	11/16	0847-1106	11.89	13.10
Scrubber Outlet No. 3	11/16	0845-1114	11.84	13.05

*Megagram per hour

was tested during steady-state, representative operation. In addition, parameters related to the operation of the cooler were monitored and recorded during testing. Inlet and outlet temperatures of the air and granule streams through the cooler were monitored, as was the ambient air temperature. The ammonium nitrate melt temperatures into granulator number 1 and at the granulator nozzle were monitored, since they are directly related to the moisture content of granules entering cooler number 1. Average values and ranges of these parameters for the three major testing periods are presented in Table 3-2. Since the granulator spray pressures and the total production rate were also monitored, ranges and averages are presented for these parameters as well. The ranges and averages of a given parameter for a given test period are expressed as percentages of the average value of the parameter for all three test periods. (Actual values of the parameters, along with averages and standard deviations for the three major test periods, are presented in Appendix 6.8).

Table 3-2 shows that the average values of the melt temperature into granulator 1 and at the spray nozzle were approximately the same for the three test periods. The table also shows that the variations of these parameters during the individual tests were very small. However, the cooler outlet air temperature and the cooler inlet and outlet solids temperatures varied considerably during individual test periods. As would be expected, the outside air temperature also showed a great deal of variation. It is not known what effect these variations have on the cooler's emissions.

TABLE 3-2 RELATIVE AVERAGES AND RANGES FOR PROCESS AND CONTROL EQUIPMENT OPERATING PARAMETERS

PARAMETER	11/15; 0845-1147		11/15; 1400-16:21		11/16; 08:37-11:18	
	Range*	Average*	Range*	Average*	Range*	Average*
Cooler inlet air temperature	--†	--†	--†	--†	--†	--†
Cooler outlet air temperature	101-106	105	111-115	113	84-91	87
Cooler inlet granule temperature	100-104	102	106-114	110	88-94	91
Cooler outlet granule temperature	88-105	98	105-123	108	88-105	96
Melt temperature into granulator	99-100	100	99-100	100	99-100	100
Melt temperature at granulator nozzle	100-101	100	100	100	100-101	100
Ambient temperature	95-104	99	104-110	107	95-98	96
Granulator Spray Pressure -- no. 1 line	94-101	100	97-101	101	97-103	99
Granulator spray pressure -- no. 2 line	94-101	98	100-101	101	100-101	101
Total product weight -- lines 1 and 2	94-106	100	94-102	98	98-114	102
Scrubber liquor temperature (Recorded in control room)	91-103	97	91-111	99	101-111	104

*Ranges and averages are expressed as percentages of the overall time-weighted average values for the three test periods (for these values, see Appendix 6,8)

†Cooler inlet air temperature readings were not accurate.

Plant personnel indicated that the product being made during the first test period (11/15; 0845-1147) was not of as good a quality as they would have preferred. They expected this situation to cause an increase in the particulate loading in the cooler exhaust stream.

Scrubber Operation

To determine whether the number 1 cooler scrubber was operating normally and at steady-state, samples of the scrubber liquor inlet and outlet streams were periodically taken. These were analyzed for ammonium nitrate concentration and pH. In addition, the scrubber liquor temperature was monitored and recorded during testing. The relative averages and ranges of this temperature during the three major test periods are presented in Table 3-2. The table indicates that the liquor temperature showed considerable variation from test to test (up to 7 percent) and during the individual tests (up to 20 percent for the second test period). (Actual values of this parameter are presented in Appendix 6.8). It is not known what affect these variations have on the scrubber efficiency.

4.0 TEST PORT LOCATIONS AND SAMPLING POINT LOCATIONS

The location of the test ports and sampling points at each test location was determined in accordance with guidelines outlined in EPA Method 1 (Sample and Velocity Traverses for Stationary Sources).

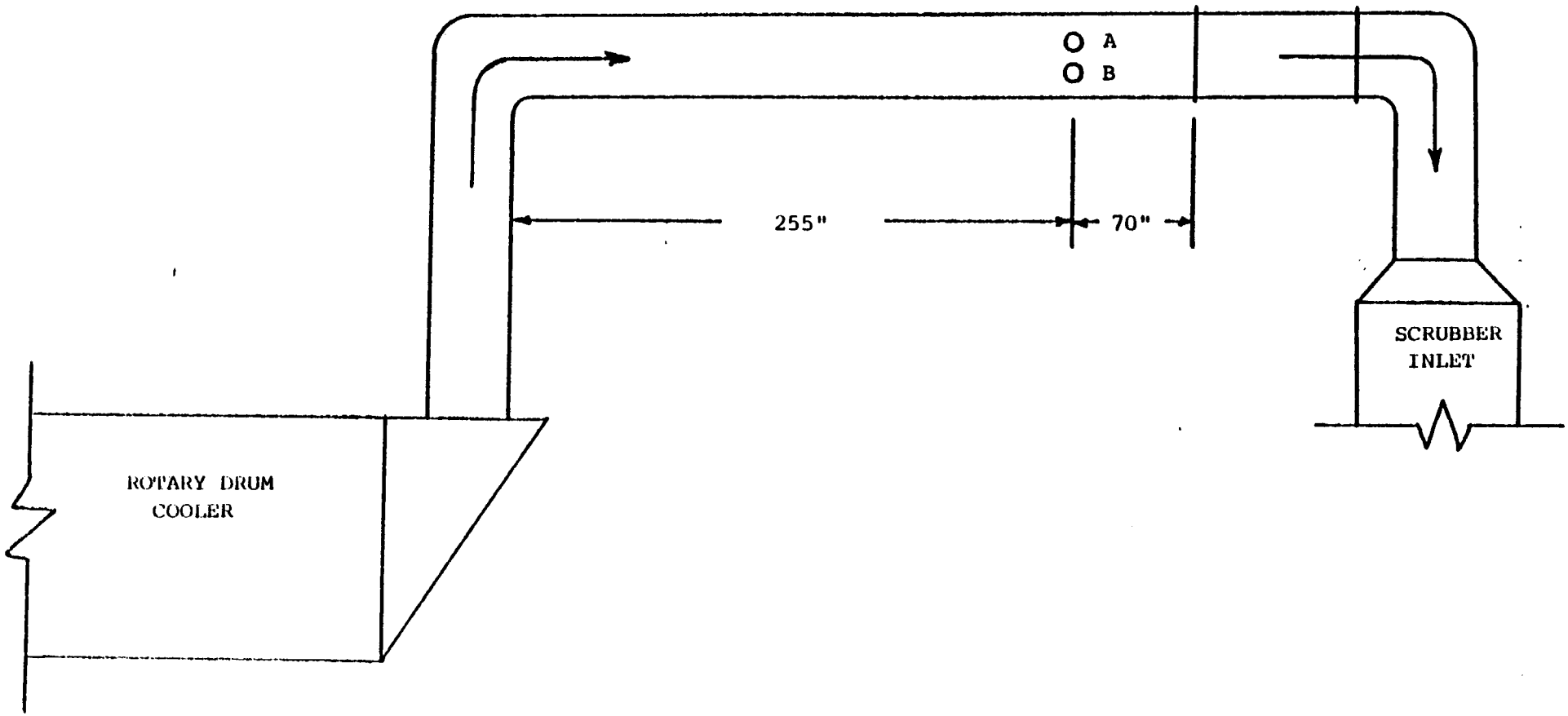
A. Inlet Location

The sampling ports on Cooler No. 1 scrubber inlet are located in the duct venting the exhaust gases from the rotary drum cooler to the Doyle scrubber (Figure 4-1). The duct is 24 inches by 42.25 inches at this location. The equivalent diameter is 30.61 inches. The ports are located 255 inches (8.33 duct diameter) downstream of a bend in the duct and 70 inches (2.29 duct diameters) upstream of a bend in the duct. To conduct the ammonium nitrate and ammonia tests at this location, EPA Method 1 requires that 12 traverse points be used. Six traverse points were sampled in each of the two ports (Figure 4-2). Each point was sampled twice for 5 minutes each, resulting in a total test time of 120 minutes.

The particle sizing tests were conducted at the inlet location (Figure 4-1). Point four in ports A and B was used to obtain an isokinetic sample for each test run (Figure 4-2). Each point was sampled for half the total test time per run.

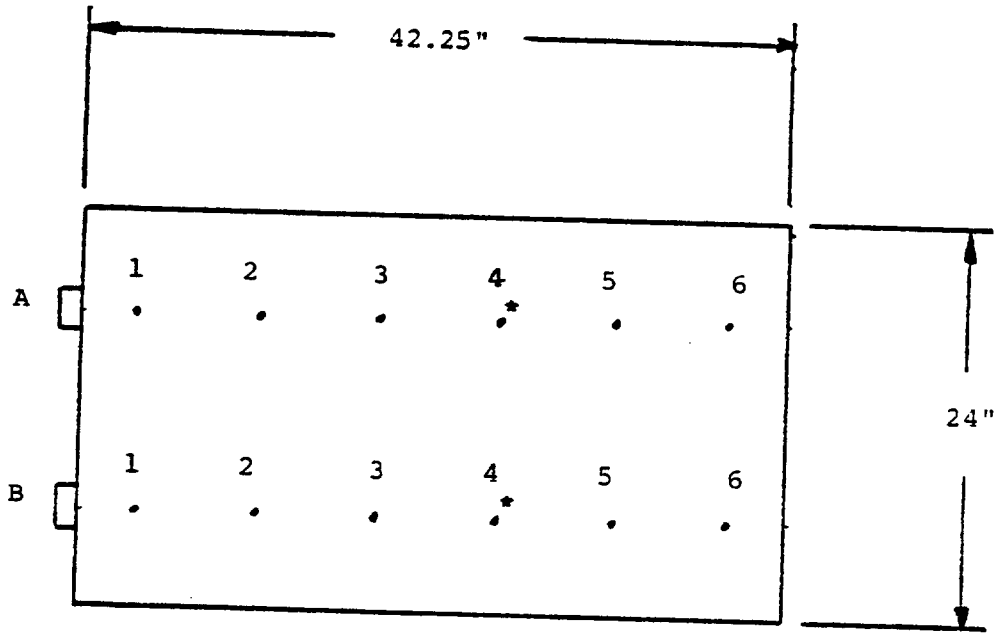
B. Outlet Location

The sampling ports on Cooler No. 1 scrubber outlet are located in the header duct venting the three



COOLER #1 SCRUBBER INLET SAMPLING PORT LOCATIONS

FIGURE 4-1



SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	3.52
2	10.56
3	17.60
*4	24.64
5	31.68
6	38.72

* A particle sizing sample was taken at point four in each port during every run.

COOLER #1 SCRUBBER INLET SAMPLING POINT LOCATIONS

FIGURE 4-2

Doyle scrubbers to the stack (Figure 4-3). The duct diameter at the sampling location is 28 inches. The ports are located 112 inches (4.00 duct diameters) downstream of the fan inlet and 32 inches (1.14 duct diameters) upstream of an expansion in duct diameter. At this location, EPA Method 1 requires that 36 traverse points be used. Eighteen traverse points were sampled in each of two ports (Figure 4-4). Each point was sampled for 4 minutes each, resulting in a total test time of 144 minutes.

C. Scrubber

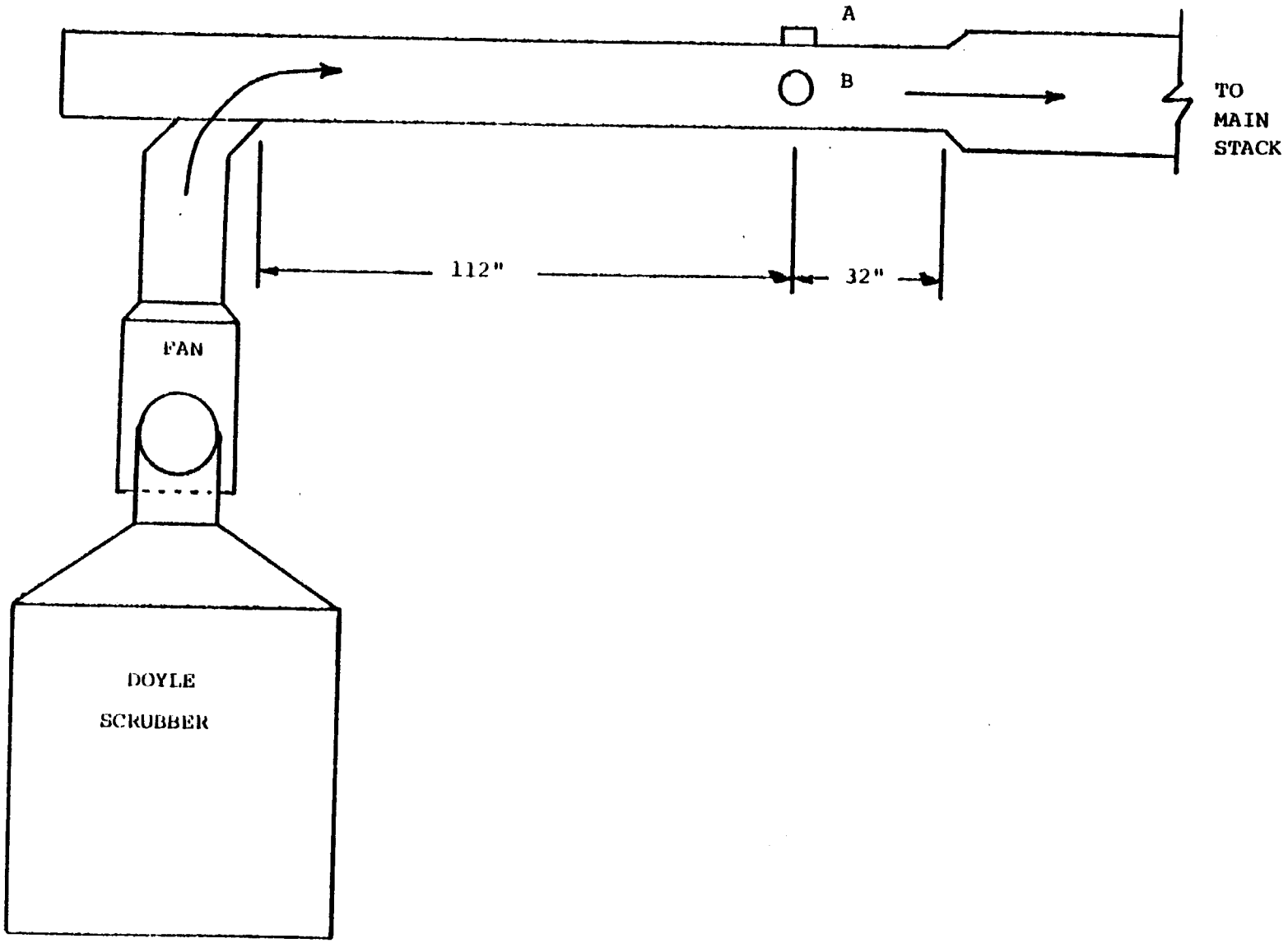
The scrubber liquor sample for SW1 was collected from a valve located on the first floor inside the cooler building. The sample from SW2 was taken from a valve located outside on a platform at the rear of the scrubber. The gas pressure drop was measured at the inlet to the Cooler No. 1 scrubber.

D. Relative Humidity and Ambient Air Temperature Measurements

The relative humidity and ambient air temperature were measured at the inlet to the Cooler No. 1 scrubber.

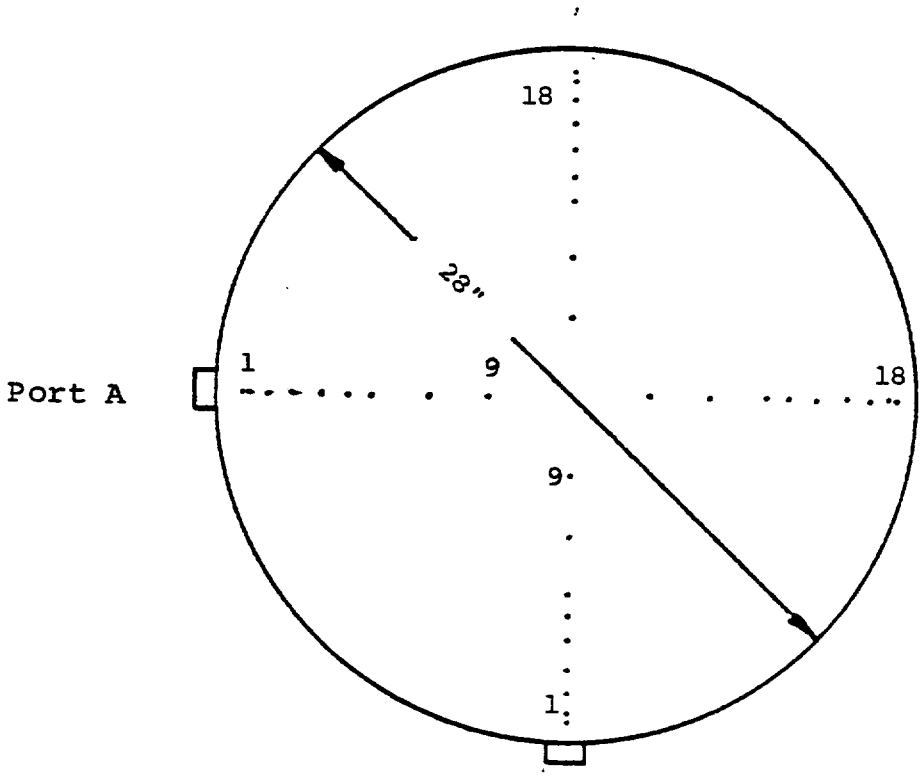
E. Process Samples Collection Locations

Throughout the testing program, various process samples were collected directly from their applicable process units/operations. Included were product samples which were collected at the inlet and outlet to the rotary drum cooler, from conveyor belts or free flowing vents, depending on the location.



COOLER #1 SCRUBBER OUTLET SAMPLING PORT LOCATIONS

FIGURE 4-3



SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	1.23
3	2.10
4	3.05
5	4.09
6	5.26
7	6.08
8	8.29
9	10.70
10	17.30
11	19.71
12	21.92
13	22.74
14	23.91
15	24.95
16	25.90
17	26.77
18	27.00

COOLER #1 SCRUBBER OUTLET SAMPLING POINT LOCATIONS

FIGURE 4-4

5.0 SAMPLING AND ANALYTICAL PROCEDURES

A) Introduction - Test Port Locations, Sampling Point Determination, Gas Velocity and Gas Composition.

York Research Corporation performed an emission test program at the Cominco American plant located in Beatrice, Nebraska. Sampling was performed from November 14 to November 16, 1978 on Cooler No. 1. The objective of the test program was to provide a portion of the emission data of controlled ammonium nitrate production facilities to support planned source emission standards in the ammonium nitrate industry.

The sampling locations included: Cooler No. 1 Scrubber Inlet and Cooler No. 1 Scrubber Outlet. Figure 1-1 shows the sampling locations in the process. Samples were collected for insoluble particulate, ammonium nitrate and ammonia at each test location. The particle size distribution was evaluated at the scrubber inlet test location. Scrubber water samples were collected at both inlet and discharge locations. Product samples were collected at inlet and outlet locations of the rotary drum cooler. Gas pressure drop across the scrubber, relative humidity and ambient air temperature measurements were recorded at the inlet test location approximately every 15 minutes during the testing periods.

The location of the test ports and sampling points at each test location were determined in accordance with guidelines in EPA Method 1 (40 CFR 60 Appendix A, Reference Method 1, Sample and Velocity Traverses for

Stationary Sources). (Refer to Section 4.0 Test Port Locations and Sampling Point Locations, in this report for more detailed information on sampling locations).

The gas velocity at each test location was determined in accordance with guidelines outlined in EPA Method 2 (40 CFR 60, Appendix A, Reference Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S pitot tube).

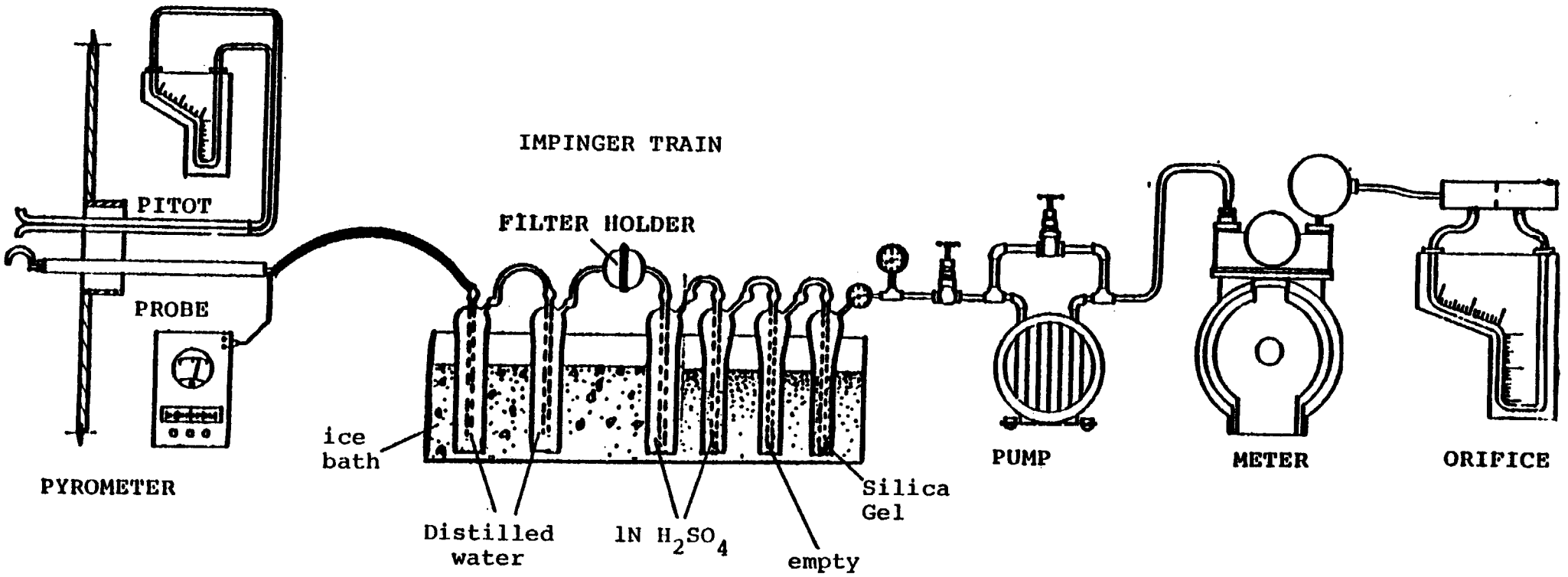
A precalibrated type "S" pitot tube and thermocouple were rigidly attached to each sampling probe. The velocity pressure was measured on an inclined monometer, and the temperature on a pyrometer. Readings were recorded at each traverse point.

The gas composition was determined in accordance with guidelines outlined in EPA Method 3 (40 CFR 60, Appendix A, Reference Method 3, Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight).

Since there is no combustion involved in this process, the gas composition at each test location was assumed to be air. A check was made with a Fyrite analyzer for carbon dioxide and oxygen content.

B)1. Ammonium Nitrate and Ammonia, Inlet and Outlet Sample Procedures

The ammonium nitrate and ammonia concentrations were determined by using a modification of "Determination of Particulate, Ammonia Nitrate and Ammonia Emissions from Ammonium Nitrate Plants", August 29, 1978 (See Appendix 6.10).



AMMONIUM NITRATE SAMPLING TRAIN

FIGURE 4-5

The sampling apparatus at each location consisted of a probe, a teflon line, six impingers, a filter, a vacuum pump, a dry gas meter and a flow meter (Figure 4-5). The probes were glass lined. The inlet location changed to a stainless steel lined probe after the first test due to a broken liner. The probes were heated ~~(200°F ± 25°)~~ 125°F at both the inlet and outlet test locations. Stainless steel button-hook nozzles were attached to each probe with stainless steel couplings. An "S" type pitot tube and thermocouple were attached to each probe for monitoring velocity pressure and temperature. Each probe was connected to the impinger train by means of a flexible teflon sample line.

The impinger train consisted of six impingers and a filter holder connected in series. The first two impingers were initially filled with 100 ml each of distilled water. Between the second and third impinger was a coarse fritted glass filter holder which contained a tared glass fiber filter. The filter holder was heated ~~(200°F ± 25°)~~ 50°F to prevent condensation. The third and fourth impingers were initially filled with 100 ml each of 1N H_2SO_4. The fifth impinger was dry and the sixth contained 300 grams of dry indicating type silica gel. The first, second, fourth, and fifth impingers were of Greenburg-Smith design, modified by replacing the tip with a 1/2 inch glass tube.

From the sixth impinger the effluent stream flowed through a check valve, flexible rubber vacuum tubing, a vacuum gauge, a needle valve, a leakless vacuum

pump and a dry gas meter. A calibrated orifice completed the train and was used to measure instantaneous flow rates. The dual manometer across the calibrated orifice was an inclined verticle type graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths from 1 to 10 inches.

During each test run the following readings were taken at each traverse point.

- Point designation
- Clock time
- Dry gas meter reading (cf)
- Velocity head (Δp in inches of water)
- Desired orifice pressure drop (ΔH in inches of water)
- Actual orifice pressure drop (ΔH in inches of water)
- Dry gas temperature at gas meter inlet (°F)
- Dry gas temperature at gas meter outlet (°F)
- Vacuum gauge reading (in. Hg)
- Dry gas temperature at the discharge of last impinger (°F)
- Stack temperature (°F)

In addition, the ambient wet bulb/dry bulb temperature and scrubber pressure drop measurements were recorded every 15 minutes.

The relationship of Δp rating with the ΔH reading is a function of the following variables:

- Orifice calibration factor
- Gas meter temperature
- Moisture content of flue gas

- Ratio of flue gas pressure to barometric pressure
- Stack temperature
- Sampling nozzle diameter

A nomograph was used to correlate all the above variables such that a direct relationship between Δp and ΔH was determined by the sampler and isokinetic conditions could be maintained.

B)2. Ammonium Nitrate and Ammonia, Sample Recovery Procedure

At the completion of the test the sample was recovered in the following manner:

The contents of the impingers containing the distilled water and a distilled water wash of the impingers, probe, nozzle and teflon sample line were combined. This sample was then filtered using a tared glass fiber filter and a vacuum filtration system. The contents of the acid impingers along with an acid wash were placed in a sample bottle. The glass fiber filter and silica gel were returned to their original containers. Summarizing the cleanup procedure:

- Container #1 - The filter used to filter the water sample
- Container #2 - The distilled water sample
- Container #3 - The train filter
- Container #4 - The 1N H_2SO_4 sample
- Container #5 - The silica gel

B)3. Ammonium Nitrate and Ammonia, Analytical Procedures

Ammonium Nitrate

The total volume of sample was measured. A 100 ml aliquot was treated with ionic strength and pH adjuster reagents. The nitrate molarity of the sample was then determined using a specific ion electrode and meter standardized prior to analysis with several dilutions of a stock ammonium nitrate standard.

The weight of ammonium nitrate in the sample was determined by the following equation:

$$W_n = 0.08 \ (V_t \ C_t - V_b \ C_b)$$

Where: W_n = Weight of ammonium nitrate collected, grams.

V_t = Total volume of sample, ml
C_t = Nitrate molarity of sample, gm moles/liter
V_b = Total volume of initial impinger solution plus rinse, ml
C_b = Nitrate molarity of blank water, gm-moles/liter
0.08=Grams NH_4NO_3 per milliequivalent (meq.), where $(V_t \ C_t - V_b \ C_b)$ = meq. NH_4NO_3

Since all blanks contained no nitrate, the equation reduced to the following:

$$W_n = 0.08 \ (V_t \ C_t)$$

The train filters were macerated in 150 ml of distilled water. The liquid sample was then analyzed for nitrate molarity using the above procedure. (Refer to Appendix 6.10 for detailed procedure).

Ammonia

Two analytical methods were employed for the determination of ammonia. Method 1 was used for samples with low levels of ammonia, (0.05 mg/l to 1.00 mg/l NH_3-N) while Method 2 was used for samples with high levels (1.00 mg/l to 1,400 mg/l NH_3-N) of ammonia.

- Method 1

  The total volume of sample was measured. A 20 ml aliquot of sample was made alkaline and treated with Nessler reagent and made up to 25 ml. The resulting characteristic color was measured colorimetrically at 405 nm versus a series of ammonia standards. The results were reported as total micrograms in the sample.

- Method 2

  The total volume of the sample was measured. A 50-100 ml aliquot was withdrawn and made alkaline simultaneously with a specific ion electrode in the sample. The concentration of ammonia was then measured potentiometrically using an ammonia specific ion electrode versus ammonia standards. The results were reported as total micrograms in the sample.

  The filter solution was analyzed for ammonia using Method 1. (Refer to Appendix 6.10 for detailed procedure.

C)1. Particle Size Distribution, Sample Procedure

The particle size distribution samples were collected using an Andersen Cascade Impactor. The impactor

consists of multiple stages which collect different particle sizes (Figure 4-6). Each stage consists of an orifice of specific diameter above a collection plate. The orifice sizes of each stage are different and are arranged in descending order, the largest being stage 1. The sampling system was set up as shown in Figure 4-7. During the sampling a cyclone preseparator was used to precut particles above 10 microns and avoid overloading the collection substrates. The stack conditions were determined and the sample was extracted isokinetically at a single flow rate.

As the sample flows through each orifice, it is deflected around a glass fiber substrate placed on the collection plate. Particles of a specific size become impacted on the substrate while the remaining particles, entrained in the gas stream, proceed to the next collection stage. The range of particle sizes retained on the substrate varies according to the velocity of the gas (as determined by the sampling rate and orifice diameter), the gas viscosity and the particle density. Since the orifices are arranged in descending diameters, the gas velocity increases and the particle size collected on each stage decreases.

At the completion of each test the contents of the preseparator were placed in a sample bottle. The preseparator was then rinsed three times with distilled water and this sample was added to the sample bottle. The glass fiber substrates were returned to their original containers and sealed.

ANDERSEN STACK SAMPLER

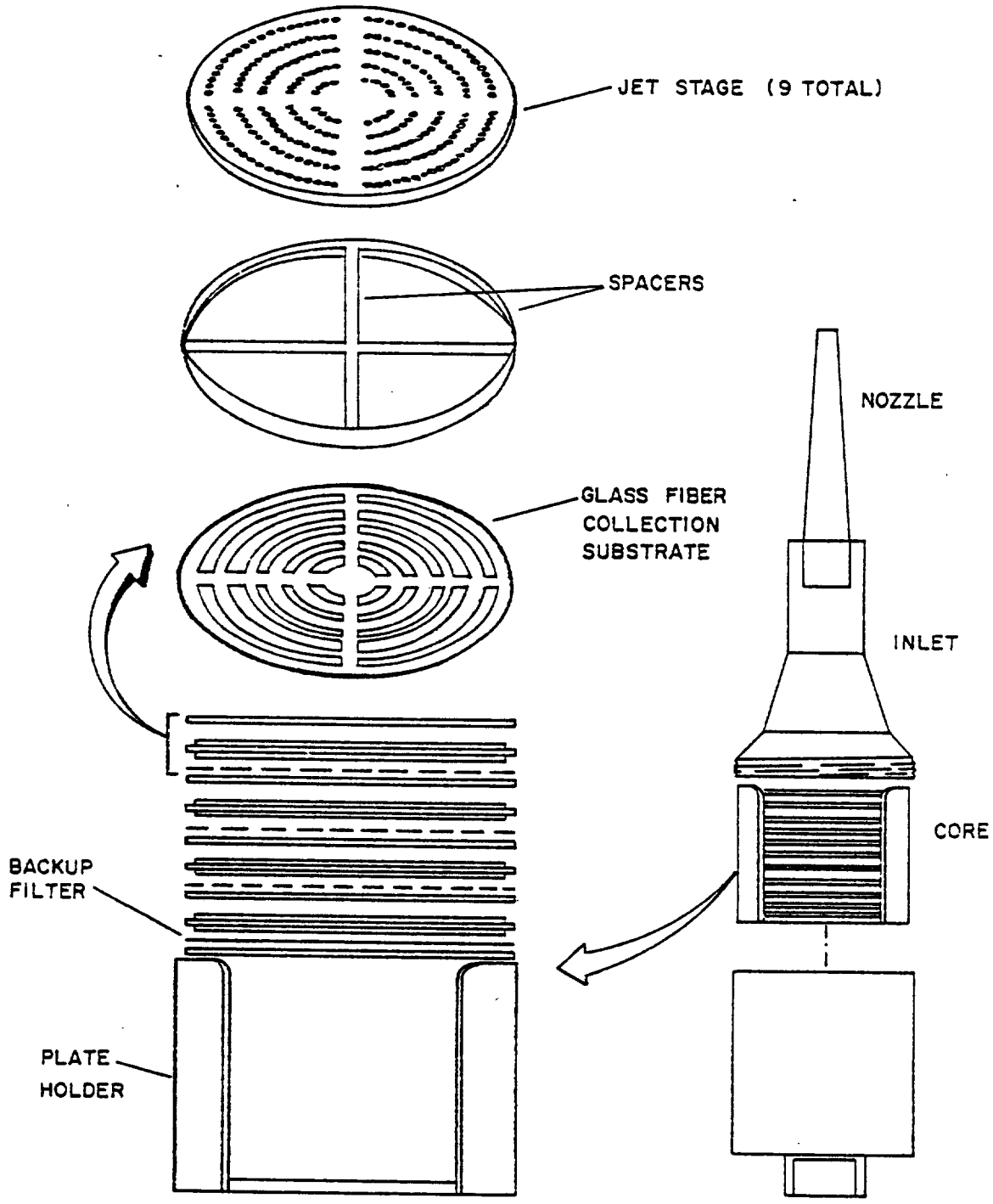


FIGURE 4-6

ANDERSEN SAMPLING TRAIN

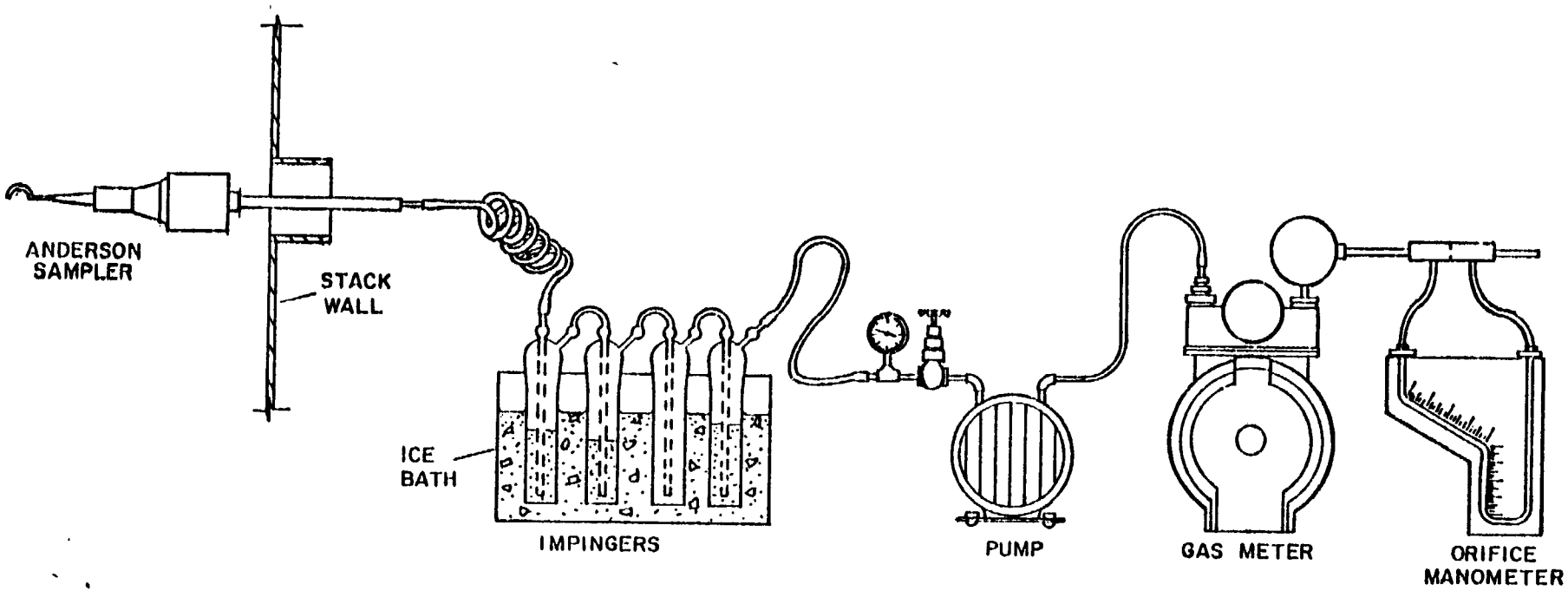


FIGURE 4-7

C)2. Particle Size Distribution, Analytical Procedure

The fiberglass substrate filters were dessicated and weighed to a constant weight. The net weight gain was recorded to the nearest 0.01 mg.

The distilled water rinse of the cyclone preseparator was transferred to a tared beaker. The beaker was heated to a temperature well below the boiling point until the water was evaporated. The beaker was then dessicated and weighed to a constant weight. The net weight gain was recorded to the nearest 0.01 mg.

D)1. Scrubber Water, Sample Collection Procedures

During testing on the Doyle scrubber, samples of the scrubber effluent were taken. Samples were taken of the scrubber inlet and scrubber discharge water. The sample tap at the outlet had to be steamed prior to each sample collection due to the "salting" of the liquid in the sample line. The samples were taken at approximately 30 minute intervals.

D)2. Scrubber Water, Analytical Methods

The temperature, pH and time of collection of each sample was recorded. At the conclusion of the test the samples from each location were composited and then filtered. Each sample was analyzed for percent solids, ammonium nitrate and ammonia.

Refer to section 5.0 B)2. for methods on ammonium nitrate and ammonia analysis.

Percent Solids

A representative aliquot (10 ml) of each sample was withdrawn using Class A pipets. The aliquots were transferred to tared beakers. The liquid was evaporated at 103°C. The contents of the beakers were cooled, dessicated and weighed to a constant weight to obtain percent solids.

E)1. Product Sample Collection Procedures

During the sampling, product samples were collected for bulk density and sieve analysis. These samples were taken at the inlet and outlet of the rotary drum cooler, either from conveyor belts or free flowing vents depending on the location.

Conveyor belt samples were taken by scooping a collection container (1 quart capacity) across the flow on the conveyor belt. To insure the collection of a representative sample, three scoops were made to fill the jar. Samples from the free flowing vents were taken by placing the collection container in the vent directly in the stream of product flow.

E)2. Bulk Density, Sieve Analysis and Percent Ammonium Nitrate Analytical Procedures

Bulk Density

The bulk density of the ammonium nitrate was determined using a graduated cylinder and platform balance.

The sample was passed through a riffle and a 300-350 ml portion was obtained. The tare weight of the graduated cylinder was determined. The sample was then passed into the graduated cylinder until it overflowed the cylinder. The sample was then leveled with the top of the cylinder. The cylinder and contents were then reweighed. The bulk density was then determined by the following:

Bulk Density (lbs./ft.^{3}) = (Weight of Sample) (0.2497)

Sieve Analysis

The mean particle size of the product was estimated by a sieve analysis. This analysis employed a sieve shaker, timer, balance, sample splitter and sieves (sieves 5,6,8,10,12,14,16,18,20 and a pan were used).

A sample of approximately 200 grams was obtained by reducing a grab sample in a sample splitter. The sample was then weighed to the nearest 0.2 gram. The sieves were then arranged in numerical order with the smallest sieve number on top and a pan on the bottom. The sample was poured into the top sieve while tapping the stack of sieves. The stack was vigorously shaken in a rotary horizontal motion for one minute. The sieves were then inserted in the shaker and shaken for five minutes. After shaking, the contents of each sieve and bottom pan were weighed.

The percent in each sieve was calculated as follows:

$$\% \text{ Retained} = \frac{(\text{Weight of material})\ (100)}{(\text{Total Weight})}$$

Percent Ammonium Nitrate

A representative portion of granules were extracted from each batch of product sample. This portion of sample was crushed and dissolved and then analyzed for ammonium nitrate according to the procedure quoted in Appendix 6.10, 1.

F)1. Scrubber Gas Pressure Drop Measurements

The gas pressure drop was determined at the Cooler No. 1 scrubber inlet every 15 minutes during the test period. The pressure drop was measured on an inclined manometer. Problems such as plugging of the gas lines to the manometer, and moisture in the lines were overcome by using a Thomas pump to clear the lines.

G)1. Relative Humidity and Ambient Air Temperature Measurements

The relative humidity was measured using two thermometers (one wet bulb, one dry bulb) at the inlet to Cooler No. 1 scrubber. The ambient air temperature was recorded from the dry bulb thermometer. Both measurements were taken every 15 minutes during the test period.