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Office of Air Quality Planning and Standards
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Air

EPA

Ammonium Nitrate

Emission Test Report
N-ReN Corporation
Pryor, Oklahoma

YO-95

Environmental Consultants

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EMISSION MEASUREMENT BRANCH
MAIL DROP 13
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

FINAL REPORT

EMISSION TEST PROGRAM: AMMONIUM NITRATE MANUFACTURING PLANT

Conducted at

N-ReN CORPORATION
CHEROKEE DIVISION
P.O. BOX 429
PRYOR, OKLAHOMA 74361

CONTRACT NUMBER 68-02-2819

TASK ASSIGNMENT 8

PROJECT NUMBER 78-NHF-5

YORK PROJECT NUMBER 1-9517-08

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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 United States Environmental Protection Agency (USEPA).

The scope of the work, issued under EPA Contract No. 68-02-2819, Work Assignment No. 8, was under the supervision of YRC Project Director, Mr. James W. Davison. Mr. Roger A. Kniskern, of YRC, served as Project Manager and was responsible for summarizing the test and analytical data contained in this report. Analyses of the samples were performed at the YRC laboratory in Stamford, Connecticut under the direction of Ms. Kay Wahl.

Mr. Mark L. Bornstein and Mr. Stephen K. Harvey of GCA were responsible for monitoring the process operations during the testing program. GCA personnel provided the Process Description and Operations Section and Appendix 6.9 of this report.

Personnel from N-ReN Corporation in Pryor, Oklahoma, whose assistance and guidance contributed greatly to the success of the test program, included Mr. J. C. Canon, Plant Manager, and Mr. John Garrison, Technical Service Manager.

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

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

Project No. 1-9517-08

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1.0 INTRODUCTION

Section 111 of the Clean Air Act of 1970 charges the Administrator of the United States Environmental Protection Agency (USEPA) 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) will reflect the degree of emission limitation achievable through application of the best demonstrated emission control technology. To assemble this background information, the USEPA utilizes emission data obtained from controlled sources involved in the particular industry under consideration.

Based on the above criteria, the USEPA's Office of Air Quality Planning and Standards (OAQPS) selected the N-ReN Ammonium Nitrate manufacturing plant in Pryor, Oklahoma as a site to conduct 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 the emission test program at the N-ReN Corporation. The test program was designed to provide a portion of the emission data base required for establishing the 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 pan granulation facilities. The tests performed at the plant were designed to characterize and quantify uncontrolled and controlled emissions from the cooling process of the solids, as well as to determine the collection efficiency of the control equipment for the evaporator, pan granulator and precooler emissions.

The N-ReN manufacturing plant in Pryor produces granulated ammonium nitrate for use as a fertilizer. This particular plant is the only one of its kind in the United States utilizing a pan granulation process.

Hot nitric acid and ammonia are sprayed into a neutralizer tank where they react exothermically, producing ammonium nitrate. The heat released in the reaction concentrates the ammonium nitrate and produces steam. The reaction proceeds as follows:

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3 + \text{heat}$$

The resulting 85% ammonium nitrate solution is concentrated to 99.5% in a falling film evaporator. The hot ammonium nitrate solution (or melt) is sprayed into the pan granulator, where the ammonium nitrate is cooled and granules of specific particle size are formed. The granular product is transferred to a rotary drum precooler. From the precooler, the product is conveyed to a cooler and then to a coater, where it is coated with a clay mixture. At this point, the finished product is delivered to the warehouse for storage.

At several locations throughout the process the product is screened, with the oversized and undersized material being reprocessed. Figure 1 presents the process flow diagram for ammonium nitrate production at the N-ReN plant. The product, air, and scrubber liquor streams, as well as the sampling point locations, are indicated on the diagram.

Emissions from the evaporator and pan granulator units are controlled by a venturi scrubber. Emissions from the precooler and chain mill area are vented to a Buffalo Forge scrubber before being released to the atmosphere. Wet cyclones are used to control emissions from the product cooler. Details of the process and the emission control equipment utilized at N-ReN Corporation are provided in Section 3 of this report.

Emission sampling was conducted from November 3 to November 10, 1978 at the following process locations:

- Evaporator Scrubber Inlet
- Combined Evaporator-Pan Granulator Scrubber Inlet

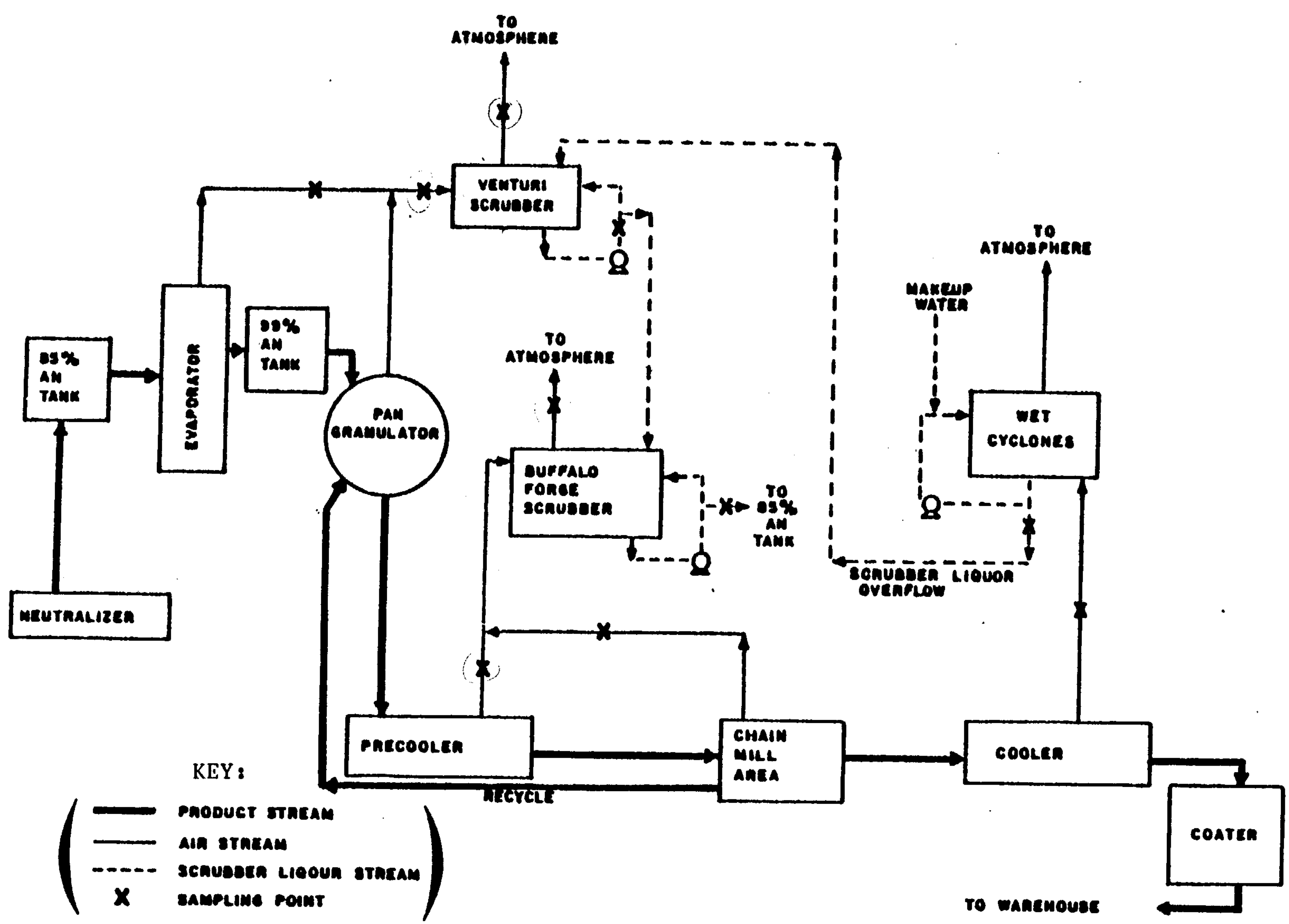

Figure 1

Process Flow Diagram
N-ReN Corporation, Pryor, Oklahoma

- Combined Evaporator-Pan Granulator Scrubber Outlet
- Precooler Scrubber Inlet
- Chain Mill Scrubber Inlet
- Combined Precooler-Chain Mill Scrubber Outlet
- Cooler Scrubber Inlet

Concurrent tests performed at the inlet and outlet locations provided velocity, moisture, gas composition, ammonium nitrate and ammonia emissions data. Samples were collected and analyzed for insoluble particulate, ammonium nitrate, and ammonia in accordance with the prescribed EPA methods.

The cooler and precooler scrubber inlet locations were tested for determination of particle size distribution. These tests were performed using the prescribed procedures, as instructed by the manufacturer, which are applicable to cascade impactors.

Pressure drop measurements across the venturi and Buffalo Forge scrubbers were recorded every 15 minutes during the testing periods. The static pressure was measured in lieu of pressure drop at the cooler inlet to the wet cyclones emission control system. Wet-bulb/dry-bulb and ambient air temperatures measurements were also recorded every 10-15 minutes during the test runs conducted on the evaporator-pan granulator, precooler and cooler. Visible emissions observations were conducted on the venturi and Buffalo Forge scrubber stacks during the testing program.

Samples of inlet and outlet scrubber solutions were collected every 30 minutes during the ammonium nitrate and ammonia testing. The pH and temperature were recorded immediately after collection. These samples were analyzed for nitrate concentration, ammonia concentration and percent solids in YRC laboratory in Stamford, Connecticut.

Process materials were collected at various times during the emission tests. These samples included:

- Pan Granulator Product
- 85% Ammonium Nitrate (AN) Solution
- Precooler Product
- Cooler Inlet and Outlet Product
- AN Melt and Clay

YRC personnel were responsible for collecting and measuring the above parameters, while GCA personnel were responsible for monitoring and recording the necessary process parameters (e.g., production rate). Tables 1 through 8 present "daily summary logs" for all sampling performed at N-ReN Corporation from November 3 to November 10, 1978. The production rate is included in these tables and is discussed in detail in Section 3 and Appendix 6.9.

The following sections of this report include:

- summary and discussion of test results
- process description and operation
- location of sampling points
- sampling and analytical procedures.

In addition, Appendix 6.14 contains the summary and results of cleanup evaluations performed on the sampling apparatus and reagents used for sample recovery during the test program.

Detailed descriptions of sampling methods and procedures, field and laboratory data, and calculations are presented in various appendices.

TABLE 1

DAILY SUMMARY LOG FOR COOLER SAMPLING CONDUCTED
ON NOVEMBER 3, 1978 AT N-ReN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (Ton/Hour)	Ammonium Nitrate Particulate[a] Cooler Inlet	Static Pressure (in. H_2O)	Ambient Temperature (^oF)	Relative Humidity (%)
1026	14.4 ↓	Started Run 1 ↓			
1046			-1.4		
1056			-1.4		
1111			-1.6		
1126		Switched Ports Continued ↓	-1.3		
1200					
1205			-1.5		
1220			-1.9		
1235			-1.8		
1250			-1.6		
1300	14.4	Completed Run 1	-1.3		
1450	14.7 ↓	Started Run 2 ↓			
1455			-1.8		
1505				87	34
1515			-1.7	87	34
1525			-1.6	86	33
1535			-1.9	86	33
1545				84	32
1550		Switched Ports Continued ↓	-1.6		
1557					
1600			-1.8	84	34
1610			-1.9	84	34
1620			-1.9	84	34
1630			-1.8	84	38
1640			-1.3	83	37
1650			-1.7		
1655				82	36
1657	14.7	Completed Run 2			

[a] Particulate samples also analyzed for ammonia.

TABLE 2

DAILY SUMMARY LOG FOR COOLER SAMPLING CONDUCTED

ON NOVEMBER 4, 1978 AT N-ReN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Ammonium Nitrate Particulate[a] Cooler Inlet	Particle Size Inlet	Static Pressure (in.H_2O)	Ambient Temperature (^oF)	Relative Humidity (%)	Process Material Samples[b]			
							Cooler		Other	
							Inlet	Outlet	Melt	Clay
0845	14.1	Started Run 3		-2.0	63	69				
0900	↓	↓		-2.0	67	58				
0915	↓	↓		-1.9	70	46				
0930	↓	↓		-1.6	72	49				
0945	↓	Switched Ports								
0958	↓	Continued								
1000	↓	↓		-1.8	75	50				
1015	↓	↓		-1.8	76	41				
1030	↓	↓		-1.8	78	39				
1045	↓	↓		-1.6	78	39				
1058	14.1	Completed Run 3								
1310			Started Run 1							
1410			Completed Run 1							
1430	14.7	Started Run 4		-2.0	84	41				
1445	↓	↓		-1.7	84	41				
1500	↓	↓		-1.8	84	41				
1515	↓	↓		-1.5	84	41				
1530	↓	Switched Ports								
1536	↓	Continued								
1540	↓	↓		-1.7	84	41				
1555	↓	↓		-1.7	84	31				
1610	↓	↓		-1.8	83	32				
1625	↓	↓		-1.5	82	39				
1630	↓	↓					Grab	Grab	Grab	Grab
1636	14.7	Completed Run 4								

(↓ marks stand for the arrows printed on the page that join the start and end entries in these columns; they are not printed characters.)

[a] Particulate samples also analyzed for ammonia.

[b] Process samples retained by N-ReN.

TABLE 3
DAILY SUMMARY LOG FOR COOLER SAMPLING CONDUCTED
ON NOVEMBER 5, 1978 AT N-ReN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Particle Size Cooler Inlet
0850 1050	Not Measured	Started Run 2 Completed Run 2
1130 1330	Not Measured	Started Run 3 Completed Run 3

TABLE 4
DAILY SUMMARY LOG FOR COOLER SAMPLING CONDUCTED
ON NOVEMBER 6, 1978 AT N-ReN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Particle Size Cooler Inlet
0911 0951	Not Measured	Started Run 1 Completed Run 1
1035 1050	Not Measured	Started Run 2 Completed Run 2
1135 1150	Not Measured	Started Run 3 Completed Run 3

TABLE 5

DAILY SUMMARY LOG FOR EVAPORATOR, PAN GRANULATOR, AND PRECOOLER SAMPLING CONDUCTED
ON NOVEMBER 7, 1978 AT N-REN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Ammonium Nitrate Particulate[a]: Evaporator Inlet[c]	Ammonium Nitrate Particulate[a]: Pan Granulator Inlet	Ammonium Nitrate Particulate[a]: Combined[b] Outlet	Scrubber Solutions: Inlet pH	Scrubber Solutions: Inlet Temp(^{o}F)	Scrubber Solutions: Outlet pH	Scrubber Solutions: Outlet Temp(^{o}F)	Pressure Drop (in.H_2O)	Ambient Temp (^{o}F)	Relative Humidity (%)	Visible Emissions: Combined[b] Stack	Visible Emissions: Precooler Outlet Stack
0947													Started
1047													Stopped
1050	14.7			Started									
1110				Run 1								Started	
1116		Started										Test 1	
1122		Run 1		Stopped									
1125		Stopped							27.1				
1310												Stopped	
1313			Started										
1322		Con't	Run 1	Con't									
1325									27.3				
1330													
1334										71	31		
1340		Stopped							27.4				
1343		Con't								73	24		
1353										82	20		
1355									27.4				
1358				Switched									
1400				Ports	8.7	90	7.5	124		80	24		
1401			Switched										
1407		Switched	Ports										
1410		Ports		Con't					27.4				
1425				Stopped					26.9				
1552				Con't									
1555									26.7				
1600												Con't	
1601			Con't									Test 1	
1603			Sampling							80	22		
1607		Con't											
1610		Sampling							26.8				
1613										78	27		
1623										78	25		
1637				Completed									
1645				Run 1						81	25		
1650			Completed										
1655	14.7	Completed	Run 1										
1700		Run 1										Completed Test 1	

[a] Particulate samples also analyzed for ammonia.

[b] Includes controlled emissions from evaporator and pan granulator.

[c] Gas composition sample collected at 1500 and analyzed for CO_2, O_2 by Orsat method.

Note - Collected sample from 85% AN tank at 1245 (retained by N-ReN)

TABLE 6

DAILY SUMMARY LOG FOR EVAPORATOR AND PAN GRANULATOR SAMPLING CONDUCTED ON NOVEMBER 8, 1978 AT N-REN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Ammonium Nitrate Particulate[a]			Scrubber Solutions				Pressure Drop (In.H_2O)	Ambient Temp (°F)	Relative Humidity (%)	Visible Emissions	Process Material Samples	
		Evaporator Inlet	Pan Granulator Inlet[c]	Combined[b] Outlet	Inlet		Outlet					Evap. & Pan Gran. Combined Stack	85% Solution	Pan Granulator Product
					pH	Temp(°F)	pH	Temp(°F)						
0908	14.7			Started Run 2										
0910			Started Run 2						26.9					
0912		Started Run 2												
0913										71	41			
0915					8.85	61	7.35	123				Started Test 2		
0920									27.0					
0923										73	39			
0930										72	35			
0935									27.1	72	35			
0945									27.0	74	33			
0950					8.85	64	7.42	123						
0955										74	36			
0958			Switched Ports Con't											
1000		Switched Ports Con't							26.7				Grab	Grab[d]
1005														
1006														
1008				Switched Ports Con't										
1013										76	32			
1015									27.0					
1024										76	32			
1030					8.78	63	7.37	124	27.2					
1036										76	28			
1045									27.0					
1053			Completed Run 2							76	28			
1054		Completed Run 2												
1100					8.82	64	7.35	124	28.4					
1113				Completed Run 2										
1115	14.7											Completed Test 2		
1300					8.67	72	6.75	126						
1310	15.2		Started Run 3											
1323				Started Run 3					26.8	87	17			
1327		Started Run 3												
1340									26.5	87	17			
1345												Started Test 3		
1355									26.5	87	17			
1406			Switched Ports											
1410									26.7					
1415		Switched Ports Con't			8.61	73	6.85	130		86	23			
1416			Con't											
1421									26.8					
1423				Switched Ports Con't										
1431										85	25			
1437										86	21			
1445					8.55	76	6.90	123		84	22			
1504			Completed Run 3						27.0	84	22			
1509		Completed Run 3							26.8					
1515					8.60	79	6.95	131						
1524	15.2			Completed Run 3										
1530												Completed Test 3	Grab	
1605														

[a] Particulate samples also analyzed for ammonia.

[b] Includes controlled emissions from evaporator and pan granulator.

[c] Gas composition sample collected and analyzed for CO_2, O_2 by Orsat.

[d] Product sample represents composite for Runs 1, 2, and 3.

TABLE 7
DAILY SUMMARY LOG FOR PRECOOLER AND CHAIN MILL
SAMPLING ON NOVEMBER 9, 1978 at N-ReN CORPORATION IN PRYOR, OKLAHOMA

Clock Time	Production Rate (tons/hour)	Ammonium Nitrate Particulate[a]			Scrubber Solutions				Pressure Drop (in.H_2O)	Ambient Temp. (^oF)	Relative Humidity (%)	Visible Emissions	Process Materials Samples[c]	
		Precooler Inlet	Chain Mill Inlet	Combined[b] Outlet	Inlet		Outlet					Precooler-Chain Mill Combined Outlet	85% Solution	Precooler Product
					pH	Temp(^oF)	pH	Temp(^oF)						
1130												Started Test		
1349	14.9		Started Run 1											
1350		Started Run 1 Experienced number of probe nozzle pluggings		Started Run 1										
1355									3.3	70	30			
1400					7.05	130	5.71	99		70	30			
1413									3.5	71	28			
1421			Switched Ports Con't							74	24			
1425										75	20			
1436									3.2	75	23			
1447									3.0	72	28			
1453			Switched Ports Con't											
1455					6.80	138	5.58	101		73	27			
1457														
1502				Switched Ports Con't										
1504									3.0	73	27			
1516									2.9	73	24		Grab	
1520		Stopped Run 1 (only completed 1 axis)							3.0					
1524				Stopped for Inlet Con't										
1529			Switched Ports											
1530					6.98	136	5.65	99						
1542														
1600														Collected Composite Sample
1602			Con't						2.9					
1610									3.4					
1625					6.95	136	5.65	99	3.4					
1630												Completed Test		
1634	14.9		Completed Run 1	Completed Run 1					3.9					

[a] Particulate samples also analyzed for ammonia.
[b] Includes controlled emissions from precooler and chain mill.
[c] Process samples retained by N-ReN.

TABLE 8

DAILY SUMMARY LOG FOR PRECOOLER AND CHAIN MILL
SAMPLING ON NOVEMBER 10, 1978 at N-ReN Corporation in Pryor, Oklahoma

Clock Time	Production Rate (tons/hour)	Ammonium Nitrate Particulate[a]: Precooler Inlet	Ammonium Nitrate Particulate[a]: Chain Mill Inlet	Ammonium Nitrate Particulate[a]: Combined Outlet[b]	Scrubber Solutions: Inlet pH	Scrubber Solutions: Inlet Temp (°F)	Scrubber Solutions: Outlet pH	Scrubber Solutions: Outlet Temp (°F)	Pressure Drop (in. H_2O)	Ambient Temp. (°F)	Relative Humidity (%)	Process Material Sample[c]: 85% Solution	Process Material Sample[c]: Precooler Product
0827	14.7			Started Run 2									
0837			Started Run 2										
0840		Started Run 2							7.7	63	60		
0845					6.75	128	5.63	102					
0857									6.8	64	56		
0915					7.27	129	5.90	99	6.9	65	57		
0921									6.9	65	57		
0933									6.8	66	54		Collected Composite Sample
0939				Switched Ports									
0941			Switched Ports	Con't					6.8	67	58		
0943													
0945			Con't	Stopped									
0946		Stopped Process Delay										Grab	
0947			Stopped										
1003				Con't									
1005		Con't	Con't										
1009		Switched Ports											
1015		Con't							6.7	68	54		
1021									6.7	68	54		
1030					7.55	128	5.95	116	6.7	68	54		
1037									6.9	69	54		
1100					7.62	126	6.10	116	7.1	69	54		
1105			Completed Run 2										
1111				Completed Run 2									
1127	14.7	Completed Run 2											
1338	14.6	Started Run 3	Started Run 3										
1340				Started Run 3									
1345					6.83	138	5.75	103					
1348													
1352									7.0	74	50		
1408													
1415					6.51	138	5.55	106	6.5	74	50		
1420													
1432									6.5	75	54		
1450		Switched Ports							6.6	75	58		
1452			Switched Ports	Switched Ports					7.0	75	58		
1455					6.30	140	5.40	104					
1456		Con't											
1458				Con't								Grab	
1506			Con't										
1514													
1530					6.30	138	5.25	109	6.9	78	46		Collected Composite Sample
1538													
1546									7.0	76	51		
1558									6.6	74	50		
1600		Completed Run 3							7.0	74	50		
1610	14.6		Completed Run 3	Completed Run 3					7.0	74	50		

[a]Particulate samples also analyzed for ammonia.

[b]Includes controlled emissions from precooler and chain mill.

[c]P s sa ret. by [illegible]

2.0 SUMMARY AND DISCUSSION OF TEST RESULTS

2.1 Introduction

The results of the emission test program conducted at the N-ReN Corporation in Pryor, Oklahoma are presented in Tables 9 through 38 and Figures 2 through 5. These results are discussed briefly in nine separate categories. Detailed discussions are presented in Section 5.0, "Sampling and Analytical Procedures", and in various related appendices.

Samples were collected concurrently at the evaporator inlet, the combined evaporator-pan granulator inlet, and the combined evaporator-pan granulator outlet. These sampling locations are incorporated with the venturi scrubber. Concurrent sampling was also conducted at the precooler inlet, the chain mill inlet, and the combined precooler-chain mill outlet. These sampling locations are associated with the Buffalo Forge scrubber. The inlet to the scrubber which vents the cooler operation was also sampled. Major problems encountered in the sampling program and deviations from normal sampling procedures are discussed in Section 5.0, "Sampling and Analytical Procedures", and in Appendix 6.13.

2.2 Ammonium Nitrate Results

The ammonium nitrate emission data represent the recovery of the untreated water sample, and the train filter for each test run. Most of the ammonium nitrate catch was found in the untreated water sample and only minor amounts were found on some of the filters.

The ammonium nitrate particulate is expressed as both measured nitrate and measured ammonia in the following tables. The ammonium nitrate concentration was calculated from the amount of ammonia recovered during each test. A sample calculation for the determination of ammonium nitrate from ammonia is provided in Appendix 6.13. The rationale for incorporating a stoichiometrically valid expression for ammonium nitrate particulate lies in its usefulness as an alternative for evaluating emissions.

A. Evaporator-Pan Granulator

Table 9 summarizes the collection efficiencies of the venturi scrubber as calculated from insoluble particulate, ammonium nitrate particulate and total particulate, in English units. Table 9-A presents this data in Metric Units. The factors used to convert data from English to Metric units appear in Appendix 6.2.

Cyclonic flow patterns were suspected at the combined evaporator-pan granulator inlet location, resulting in measured volumetric flow rates ten to fiften percent lower than actual volumetric flow rates. Since emissions calculations are based on volumetric flow rates, these are also believed to be low by ten to fifteen percent. Consequently, the efficiency calculations would be expected to be less than the actual efficiency. This would mean that a calculated average collection efficiency of 97.9% would actually be about 98.5%.

It should also be noted that the percent moisture by volume data presented in Tables 9 and 9-A have been adjusted in accordance with saturation moisture for the average stack temperature. A detailed explanation of this adjustment is forthcoming.

Summaries of uncontrolled emissions from the evaporator and combined evaporator-pan granulator streams appear in Tables 10 and 11, respectively. Problems were encountered during the first run at the evaporator inlet, resulting in insoluble and total particulate concentrations which were not representative of the actual operating conditions. A vacuum, following a testing delay, caused the 1.0N H_2SO_4 solution in the

TABLE 9
PARTICULATE AND AMMONIUM NITRATE CONCENTRATION AND EMISSION DATA SUMMARY OF GASES ENTERING AND EXITING THE SCRUBBER OF THE EVAPORATOR AND PAN GRANULATOR (VENTURI SCRUBBER) (ENGLISH UNITS)

Location	Run 1		Run 2		Run 3		Average	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	11/7/78		11/8/78		11/8/78			
Volume of Gas Sampled (DSCF)[a]	44.24	77.63	59.83	75.94	54.80	78.74	52.96	77.44
Percent Moisture by Volume	23.2	19.5	27.9	19.5	26.8	19.0	26.0	19.3
Average Stack Temperature (^{o}F)	186	140	192	140	194	138	191	139
Stack Volumetric Flow Rate (DSCFM)[b]	7936[c]	9089	7355[c]	8773	7619[c]	9214	7637[c]	9025
Percent Isokinetic	78	101	114	103	101	101	98	102
Production Rate (Tons/Hour)	14.7		14.7		15.2		14.9	
Insoluble Particulates—Filter Catch and Collection Water Filtrate								
mg	115.77	5.86	28.66	3.51	38.58	16.21	61.00	8.53
gr/DSCF	0.0403	0.0012	0.0074	0.0007	0.0108	0.0032	0.0195	0.0017
lb/hr	2.74[d]	0.09	0.46[d]	0.05	0.71[d]	0.25	1.30[d]	0.13
lb/ton	0.186	0.006	0.031	0.004	0.047	0.017	0.088	0.009
Collection Efficiency, Percent	96.7		89.1		64.8		83.5	
Ammonium Nitrate Particulate--								
mg	3104.40	50.08	1621.12	43.12	1200.16	20.90	1975.23	38.03
gr/DSCF	1.0807	0.0100	0.4173	0.0088	0.3373	0.0041	0.6118	0.0076
lb/hr	73.51[d]	0.78	26.31[d]	0.66	22.02[d]	0.32	40.61[d]	0.59
lb/ton	5.001	0.053	1.790	0.045	1.449	0.021	2.747	0.040
Collection Efficiency, Percent	98.9		97.5		98.5		98.3	
Total Particulate—Insoluble & Ammonium Nitrate								
mg	3220.17	55.94	1649.78	46.63	1238.74	37.11	2036.23	46.56
gr/DSCF	1.1210	0.0111	0.4247	0.0095	0.3481	0.0073	0.6313	0.0093
lb/hr	76.25[d]	0.87	26.77[d]	0.71	22.73[d]	0.57	41.92[d]	0.72
lb/ton	5.187	0.059	1.821	0.048	1.496	0.038	2.835	0.048
Collection Efficiency, Percent	98.9		97.3		97.5		97.9	

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 Cyclonic flow patterns suspected; volumetric flows believed to be approximately 10-15 percent low.

d Pound per hour results are based on volumetric flows and are therefore suspected to be 10-15 percent low.

TABLE 9 A

PARTICULATE AND AMMONIUM NITRATE CONCENTRATION AND EMISSION DATA SUMMARY — GASES ENTERING AND EXITING THE SCRUBBER OF THE EVAPORATOR AND PAN GRANULATOR (VENTURI SCRUBBER) (METRIC UNITS)

Location	Run 1 Inlet	Run 1 Outlet	Run 2 Inlet	Run 2 Outlet	Run 3 Inlet	Run 3 Outlet	Average Inlet	Average Outlet
Date	11/7/78		11/8/78		11/8/78			
Volume of Gas Sampled (DNm^3)[a]	1.25	2.20	1.69	2.15	1.55	2.23	1.50	2.19
Percent Moisture by Volume	23.2	19.5	27.9	19.5	26.8	19.0	26.0	19.3
Average Stack Temperature (°C)	85.3	60.2	88.6	59.8	89.8	59.0	87.9	59.7
Stack Volumetric Flow Rate (DNm^3/min.)[b]	225[c]	257	208[c]	248	216[c]	261	216[c]	255
Percent Isokinetic	78	101	114	103	101	101	98	102
Production Rate (Mg/hr)	13.3		13.3		13.8		13.5	
Insoluble Particulates-- Filter Catch and Collection Water Filtrate								
mg	115.77	5.86	28.66	3.51	38.58	16.21	61.00	8.53
g/DNm^3	0.0922	0.0027	0.0169	0.0016	0.0247	0.0073	0.0446	0.0039
Kg/hr	1.24[d]	0.04	0.21[d]	0.02	0.32[d]	0.11	0.60[d]	0.06
Kg/Mg	0.093	0.003	0.016	0.002	0.024	0.009	0.044	0.005
Collection Efficiency, Percent	96.7		89.1		64.8		83.5	
Ammonium Nitrate Particulate--								
mg	3104.40	50.08	1621.12	43.12	1200.16	20.90	1975.23	38.03
g/DNm^3	2.4726	0.0229	0.9548	0.0201	0.7717	0.0094	1.3997	0.0174
Kg/hr.	33.34[d]	0.35	11.93[d]	0.30	9.99[d]	0.15	18.42[d]	0.27
Kg/Mg	2.501	0.027	0.895	0.023	0.725	0.011	1.374	0.020
Collection Efficiency, Percent	98.9		97.5		98.5		98.3	
Total Particulate-- Insoluble & Ammonium Nitrate								
mg	3220.17	55.94	1649.78	46.63	1238.74	37.11	2036.23	46.56
g/Nm^3	2.5648	0.0254	0.9717	0.0217	0.7965	0.0167	1.4444	0.0213
Kg/hr.	34.59[d]	0.39	12.14[d]	0.32	10.31[d]	0.26	19.01[d]	0.33
Kg/Mg	2.594	0.030	0.911	0.024	0.748	0.019	1.418	0.024
Collection Efficiency, Percent	98.9		97.3		97.5		97.9	

a Dry Normalized Cubic Meters at 20°C and 760 mm. Hg.

b Dry Normalized Cubic Meters Per Minute, 20°C and 760 mm. Hg.

c Cyclonic flow patterns suspected; Volumetric flows believed to be approximately 10-15 percent low.

d Kilogram per hour results are based on volumetric flows and are therefore suspected to be 10-15 percent low.

TABLE 10

SUMMARY OF UNCONTROLLED EMISSIONS FROM THE EVAPORATOR

Date	Run 1 11/7/78		Run 2 11/7/78		Run 3 11/8/78		Average	
Volume of Gas Sampled (DSCF)[a]	26.41		29.34		21.31		25.69	
Percent Moisture by Volume	55.2		57.9		59.8		57.6	
Average Stack Temperature (°F)	198		205		213		205	
Stack Volumetric Flow Rate (DSCFM)[b]	1403		1321		1048		1257	
Percent Isokinetic	104		122		112		113	
Production Rate (Tons/Hour)	14.7		14.7		15.2		14.9	
Insoluble Particulate-- Filter Catch and Collection Water Filtrate								
mg	354.45		2.70		3.09		(No average presented)	
gr/DSCF	Filter contaminated with 1N H_2SO_4 from back impinger		0.0014		0.0022			
lb/hr			0.02		0.02			
lb/ton			0.0014		0.0013			
Ammonium Nitrate Particulate-- Nitrate and Ammonium Nitrate measured as Ammonia	Measured as		Measured as		Measured as		Measured as	
	Nitrate	Ammonia	Nitrate	Ammonia	Nitrate	Ammonia	Nitrate	Ammonia
mg	150.72	1569	157.92	1805	135.20	1369	147.95	1581
gr/DSCF	0.0879	0.9168	0.0829	0.9494	0.0977	0.9914	0.0895	0.9525
lb/hr	1.06	11.03	0.94	10.75	0.88	8.91	0.96	10.23
lb/ton	0.072	0.750	0.064	0.731	0.058	0.586	0.065	0.689
Total Particulate-- Insoluble & Ammonium Nitrate								
mg	Filter contaminated with 1N H_2SO_4 from impingers		160.62	1807.70	138.29	1372.09	(No average presented)	
gr/DSCF			0.0843	0.9502	0.0999	0.9936		
lb/hr			0.96	10.77	0.90	8.93		
lb/ton			0.065	0.732	0.059	0.587		
Percent particulate catch	-	-	1.7	<1	2.2	<1	-	-

[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.

TABLE 11

SUMMARY OF UNCONTROLLED EMISSIONS FOR THE COMBINED EVAPORATOR AND PAN GRANULATOR STREAM

	Run 1		Run 2		Run 3		Average	
Date	11/7/78		11/8/78		11/8/78			
Volume of Gas Sampled (DSCF)[a]	44.24		59.83		54.80		52.96	
Percent Moisture by Volume	23.2		27.9		26.8		26.0	
Average Stack Temperature (°F)	186		192		194		191	
Stack Volumetric Flow Rate (DSCFM)[b]	7936[c]		7355[c]		7619[c]		7637[c]	
Percent Isokinetic	78		114		101		98	
Production Rate (Tons/Hour)	14.7		14.7		15.2		14.9	
Insoluble Particulates-- Filter Catch and Collection Water Filtrate								
mg	115.77		28.66		38.58		61.00	
gr/DSCF	0.0403		0.0074		0.0108		0.0195	
lb/hr[d]	2.74		0.46		0.71		1.30	
lb/ton	0.186		0.031		0.047		0.088	
Ammonium Nitrate Particulate-- Nitrate and Ammonium Nitrate measured as Ammonia	Measured as		Measured as		Measured as		Measured as	
	Nitrate	Ammonia	Nitrate	Ammonia	Nitrate	Ammonia	Nitrate	Ammonia
mg	3104.40	4156	1621.12	2548	1200.16	2228	1975.23	2977
gr/DSCF	1.0807	1.4497	0.4173	0.6572	0.3373	0.6274	0.6118	0.9114
lb/hr[d]	73.51	98.64	26.31	41.44	22.02	40.99	40.61	60.36
lb/ton	5.001	6.710	1.790	2.819	1.449	2.697	2.747	4.075
Total Particulate-- Insoluble & Ammonium Nitrate								
mg	3220.17	4271.8	1649.78	2576.7	1238.74	2266.6	2036.23	3038.4
gr/DSCF	1.1210	1.490	0.4247	0.6646	0.3481	0.6382	0.6313	0.9309
lb/hr[d]	76.25	101.38	26.77	41.90	22.73	41.70	41.92	61.66
lb/ton	5.187	6.896	1.821	2.850	1.496	2.744	2.835	4.163
Percent particulate catch	3.6	2.7	1.7	1.1	3.1	1.7	2.8	1.8

[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] Cyclonic flow suspected; Volumetric flows believed to be approximately 10-15 percent low.

[d] Pound per hour results are based on volumetric flows and are therefore suspected to be 10-15 percent low.

impingers to back up into the filter holder and subsequently wet the filter. This is the probable cause of this filter being considerably heavier than the other filters (see Appendix 6.10). During this run, it was also noted that crystallization occurred in the impingers at the combined evaporator-pan granulator inlet and outlet locations. These crystals dissolved when the impingers were warmed to room temperature. Additional reagent was added to the inlet impinger trains during the second and third runs to prevent crystallization.

While sampling at the evaporator inlet, the operator had problems maintaining a constant orifice pressure differential, resulting in high isokinetic sampling ratios for the second and third runs (see Table 10).

While sampling at the combined evaporator-pan granulator inlet, the velocity pitot tubes became clogged several times, requiring the use of velocity pressure data obtained from the initial velocity traverse for determination of orifice pressure drops. The fluctuating moisture content of the flue gas, in addition to the other problems encountered, caused the isokinetic sampling ratio to vary during the sampling run (see Table 11).

Table 12 summarizes the uncontrolled emissions from the pan granulator inlet. The results were determined from the differences between data obtained from sampling at the combined evaporator-pan granulator inlet and the evaporator inlet. Therefore, these results reflect the sampling conditions and experimental anomalies at both of these locations.

Controlled emissions from the combined evaporator-pan granulator inlet are presented in Table 13. The moisture measurements exceeded the saturation point at the stack temperature for each run. The percent moisture by volume values

TABLE 12

SUMMARY OF UNCONTROLLED EMISSIONS FROM THE PAN GRANULATOR [a]

Date	Run 1 11/7/78		Run 2 11/8/78		Run 3 11/8/78		Average	
Stack Volumetric Flow Rate (DSCFM) [b]	6533 [c]		6034 [c]		6571 [c]		6379	
Production Rate (Tons/Hour)	14.7		14.7		15.2		14.9	
Insoluble Particulate-- Filter Catch and Collection Water Filtrate								
gr/DSCF	Evaporator filter contaminated by 1N H_2SO_4 from impingers		0.0085		0.0122		(no average presented)	
lb/hr			0.44		0.69			
lb/ton			0.030		0.045			
Ammonium Nitrate Particulate-- Nitrate and Ammonium Nitrate measured as Ammonia	Measured as Nitrate	Ammonia	Measured as Nitrate	Ammonia	Measured as Nitrate	Ammonia	Measured as Nitrate	Ammonia
gr/DSCF	1.2934	1.5641	0.4904	0.5932	0.3752	0.5694	0.7197	0.9089
lb/hr	72.45	87.61	25.37	30.69	21.14	32.08	39.65	50.13
lb/ton	4.929	5.960	1.726	2.088	1.391	2.111	2.682	3.386
Total Particulate-- Insoluble & Ammonium Nitrate								
gr/DSCF	Evaporator filter contaminated by 1N H_2SO_4 from impingers		0.4989	0.6017	0.3874	0.5816	(no average presented)	
lb/hr			25.80	31.13	21.83	32.77		
lb/ton			1.756	2.118	1.436	2.156		
Percent particulate catch			1.7	1.4	3.1	2.1		

[a] Data determined by difference of evaporator and combined evaporator-pan granulator data

[b] Dry Standard Cubic Feet Per Minute at 68°F., 29.92 in. Hg.

[c] Cyclonic flow suspected at the combined inlet.

TABLE 13
SUMMARY OF CONTROLLED EMISSIONS FROM EVAPORATOR AND
PAN GRANULATOR SCRUBBER OUTLET

DATE	Run 1		Run 2		Run 3		Average	
	11-7-78		11-8-78		11-8-78			
Volume of Gas Sampled (DSCF)[a]	77.63		75.94		78.74		77.44	
Percent Moisture by Volume	24.0 (19.5)[c]		24.1(19.5)[c]		23.2(19.0)[c]		23.8(19.3)[c]	
Average Stack Temperature (°F)	140		140		138		139	
Stack Volumetric Flow Rate (DSCFM)[b]	8700(9089)[c]		8365(8773)[c]		8824(9214)[c]		8630(9025)[c]	
Pressure Drop Across Scrubber (in. H_2O)	27.1		27.1		26.7		27.0	
Percent Isokinetic	106(101)[c]		108(103)[c]		106(101)[c]		107(102)[c]	
Percent Opacity Average	7		10		10		9	
Production Rate (tons/hour)	14.7		14.7		15.2		14.9	
Insoluble Particulate--[d] Filter Catch and Collection Water Filtrate								
mg	5.86		3.51		16.21		8.53	
gr/DSCF	0.0012		0.0007		0.0032		0.0017	
lb/hr	0.09		0.05		0.25		0.13	
lb/ton	0.006		0.004		0.017		0.009	
Ammonium Nitrate Particulate--[d] Nitrate and Ammonium Nitrate measured as Ammonia	MEASURED		MEASURED		MEASURED		MEASURED	
	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Ammonia
mg	50.08	5347	43.12	3735	20.90	2780	38.03	3954
gr/DSCF	0.0100	1.0629	0.0088	0.7591	0.0041	0.5449	0.0076	0.7890
lb/hr	0.78	82.83	0.66	57.10	0.32	43.05	0.59	60.99
lb/ton	0.053	5.635	0.045	3.884	0.021	2.832	0.040	4.117
Total Particulate[d]--Insoluble and Ammonium Nitrate								
mg	55.94	5352.86	46.63	3738.51	37.11	2796.21	46.56	3962.53
gr/DSCF	0.0111	1.0641	0.0095	0.7597	0.0073	0.5480	0.0093	0.7906
lb/hr	0.87	82.92	0.71	57.15	0.57	43.29	0.72	61.12
lb/ton	0.059	5.641	0.048	3.887	0.038	2.848	0.048	4.125
Percent particulate catch	10.5	<1.0	7.5	<1.0	43.7	<1.0	20.6	<1.0

[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] Data in parenthesis adjusted for excessive moisture. Measured moisture exceeds state of saturation at measured temperature.

[d] Emission factors calculated using adjusted volumetric flows.

have been adjusted for this excessive moisture. A psychrometric chart was employed for these adjustments and is presented in Appendix 6.13. The stack volumetric flow rates and isokinetic ratios have also been adjusted to conform with the percent moisture by volume at saturation.

Data for the average percent opacity readings and the pressure differentials across the scrubber are also presented in Table 13. It should be noted that the pressure differential decreased slightly as the production rate increased during the third run.

B. Precooler - Chain Mill

Table 14 presents a comprehensive emission data summary for gases entering and exiting the Buffalo Forge scrubber. The inlet data represent the sum of the individual volumetric flow rates for corresponding test runs conducted at the precooler and chain mill inlets. The collection efficiencies of the Buffalo Forge scrubber are noticeably higher than those of the venturi scrubber, with an average total particulate removal of 99.4%. This would be expected due to an increase in the retention time of the flue gas, enabling more time for gas-liquid contact and subsequent mass transfer.

Summaries of uncontrolled emissions from the precooler and chain mill are presented in Tables 15 and 16, respectively. The results of the first run at the precooler inlet are based on a 24 point traverse (out of 48 total traverse points) conducted on the horizontal sampling port. Appendix 6.13 provides a detailed explanation of this test run.

Table 17 summarizes the controlled emissions from the Buffalo Forge scrubber outlet. Average percent opacity readings and pressure differential measurements across the scrubber are also included.

TABLE 14
PARTICULATE AND AMMONIUM NITRATE CONCENTRATION
AND EMISSION DATA SUMMARY –
GASES ENTERING AND EXITING THE SCRUBBER OF THE
PRECOOLER AND CHAIN MILL (BUFFALO FORGE SCRUBBER)
(ENGLISH UNITS)

Location	Run 1		Run 2		Run 3		Average	
	Inlet[c]	Outlet	Inlet[c]	Outlet	Inlet[c]	Outlet	Inlet	Outlet
Date	11/9/78		11/10/78		11/10/78			
Volume of Gas Sampled (DSCF)[a]	-	89.15	-	89.54	-	93.19	-	90.63
Percent Moisture by Volume	-	3.4	-	4.0	-	4.9	-	4.1
Average Stack Temperature (^{o}F)	-	112	-	112	-	113	-	112
Stack Volumetric Flow Rate (DSCFM)[b]	23264	25866	26106	25843	30069	27062	26480	26257
Percent Isokinetic	-	102	-	102	-	102	-	102
Production Rate (Tons/Hour)	14.9		14.7		14.6		14.7	
Insoluble Particulate -- Filter Catch and Collection Water Filtrate								
gr/DSCF	-	0.0006	-	0.0019	-	0.0006	-	0.0010
lb/hr	16.15	0.13	21.19	0.41	27.94	0.13	21.76	0.23
lb/ton	1.084	0.009	1.441	0.028	1.914	0.009	1.480	0.015
Collection Efficiency, Percent	99.2		98.1		99.5		98.9	
Ammonium Nitrate Particulate								
gr/DSCF	2.0474	0.0108	2.5086	0.0201	2.5254	0.0145	2.3605	0.0151
lb/hr	408.39	2.39	561.50	4.46	651.07	3.37	540.32	3.41
lb/ton	27.409	0.160	38.197	0.303	44.594	0.231	36.733	0.231
Collection Efficiency (Percent)	99.4		99.2		99.5		99.4	
Total Particulate -- Insoluble & Ammonium Nitrate								
gr/DSCF	2.1284	0.0114	2.6032	0.0220	2.6337	0.0151	2.4551	0.0161
lb/hr	424.54	2.52	582.69	4.87	679.01	3.50	562.08	3.64
lb/ton	28.493	0.169	39.639	0.331	46.508	0.240	38.213	0.246
Collection Efficiency (Percent)	99.4		99.2		99.5		99.4	

[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] Inlet data calculated by adding standard volumetric flow rates of corresponding test runs of the precooler and chain mill inlets.

TABLE 14-A

PARTICULATE AND AMMONIUM NITRATE CONCENTRATION AND EMISSION DATA SUMMARY — GASES ENTERING AND EXITING THE SCRUBBER OF THE PRECOOLER AND CHAIN MILL (BUFFALO FORGE SCRUBBER) (METRIC UNITS)

Location	Run 1		Run 2		Run 3		Average	
	Inlet[c]	Outlet	Inlet[c]	Outlet	Inlet[c]	Outlet	Inlet	Outlet
Date	11-9-78		11-10-78		11-10-78			
Volume of Gas Sampled (DNm^3)[a]	-	2.53	-	2.54	-	2.64	-	2.57
Percent Moisture by Volume	-	3.4	-	4.0	-	4.9	-	4.1
Average Stack Temperature (°C)	-	44.3	-	44.2	-	45.2	-	44.5
Stack Volumetric Flow Rate (DNm^3/min.)[b]	659	733	739	732	852	766	750	744
Percent Isokinetic	-	102	-	102	-	102	-	102
Production Rate (Mg/hr.)	13.5		13.3		13.2		13.3	
Insoluble Particulates -- Filter Catch and Collection Water Filtrate								
g/DNm^3	-	0.0014	-	0.0043	-	0.0014	-	0.0023
Kg/hr.	7.326	0.059	9.612	0.186	12.674	0.059	9.870	0.104
Kg/Mg.	0.542	0.005	0.721	0.014	0.957	0.005	0.740	0.008
Collection Efficiency (Percent)	99.2		98.1		99.5		98.9	
Ammonium Nitrate Particulate								
g/DNm^3	4.6845	0.0247	5.7397	0.0460	5.7781	0.0332	5.4008	0.0345
Kg/hr.	185.246	1.084	254.696	2.023	295.325	1.529	245.089	1.547
Kg/Mg.	3.705	0.080	19.099	0.152	22.297	0.116	18.367	0.116
Collection Efficiency (Percent)	99.4		99.2		99.5		99.4	
Total Particulate -- Insoluble and Ammonium Nitrate								
g/DNm^3	4.8698	0.0261	5.9561	0.0503	6.0259	0.0345	5.6173	0.0368
Kg/hr.	192.571	1.143	264.308	2.209	307.999	1.588	254.959	1.651
Kg/Mg.	14.247	0.085	19.820	0.166	23.254	0.120	19.107	0.123
Collection Efficiency (Percent)	99.4		99.2		99.5		99.4	

[a] Dry Normalized Cubic Meters at 20°C. and 760 mm. Hg.

[b] Dry Normalized Cubic Meters Per Minute, at 20°C. and 760 mm. Hg.

[c] Inlet data calculated by adding standard volumetric flow rates of corresponding test runs of the precooler and chain mill inlets.

TABLE 15
SUMMARY OF UNCONTROLLED EMISSIONS FROM THE PRECOOLER

DATE	Run 1[c]		Run 2		Run 3		Average	
	11-9-78		11-10-78		11-10-78			
Volume of Gas Sampled (DSCF)[a]	40.97		82.09		92.69		71.92	
Percent Moisture by Volume[d]	2.0		2.0		2.0		2.0	
Average Stack Temperature (°F)	200		181		182		188	
Stack Volumetric Flow Rate (DSCFM)[b]	21593[e]		24707		28666		24989	
Percent Isokinetic	100		101		98		100	
Production Rate--(tons/hour)	14.9		14.7		14.6		14.7	
Insoluble Particulate--Filter Catch and Collection Water Filtrate								
mg	222.23		522.14		669.56		471.31	
gr/DSCF	0.0835		0.0980		0.1112		0.0976	
lb/hr	15.46		20.74		27.33		21.18	
lb/ton	1.038		1.411		1.872		1.440	
Ammonium Nitrate Particulate--Nitrate and Ammonium Nitrate measured as Ammonia	MEASURED		MEASURED		MEASURED		MEASURED	
	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Amonnia
mg	5669.40	5570	13902.80	13082	15622.00	11019	11731.40	9890
gr/DSCF	2.1355	2.0979	2.6136	2.4593	2.6009	1.8346	2.4500	2.1306
lb/hr	395.36	388.39	553.65	520.97	639.26	450.92	529.42	453.43
lb/ton	26.534	26.067	37.663	35.440	43.785	30.885	35.994	30.797
Total Particulate--Insoluble and Ammonium Nitrate								
mg	5892	5792	14425	13604	16292	11689	12203	10362
gr/DSCF	2.2192	2.1817	2.7117	2.5574	2.7121	1.9458	2.5477	2.2283
lb/hr	410.9	403.9	574.4	541.8	666.6	478.3	550.6	474.6
lb/ton	27.57	27.11	39.08	36.85	45.66	32.76	37.44	32.24
Percent particulate catch	3.8	3.8	3.6	3.8	4.1	5.7	3.8	4.4

[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] Only 1 axis traversed during run.

[d] Average ambient air moisture used for test data.

[e] Volumetric flow data suspected to be low due to only 1 traverse being performed during run.

TABLE 16
SUMMARY OF UNCONTROLLED EMISSIONS FROM THE CHAIN MILL

	RUN 1		RUN 2		RUN 3		AVERAGE	
Date	11-9-78		11-10/78		11-10-78			
Volume of Gas Sampled (DSCF)[a]	97.62		82.55		85.37		88.51	
Percent Moisture by Volume	0.8		1.6		4.4		2.2	
Average Stack Temperature (°F)	83		81		93		85	
Stack Volumetric Flow Rate (DSCFM)[b]	1671		1399		1403		1491	
Percent Isokinetic	101		101		105		102	
Production Rate (Tons/Hour)	14.9		14.7		14.6		14.7	
Insoluble Particulate-- Filter Catch and Collection Water Filtrate								
mg	306.62		202.50		281.49		263.54	
gr/DSCF	0.0484		0.0378		0.0508		0.0456	
lb/hr	0.69		0.45		0.61		0.59	
lb/ton	0.046		0.031		0.042		0.040	
Ammonium Nitrate Particulate Nitrate and Ammonium Nitrate measured as Ammonia	MEASURED		MEASURED		MEASURED		MEASURED	
	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Ammonia	as Nitrate	as Ammonia
mg	6200.00	5980	4096.40	4562	6156.80	6263	5484.40	5602
gr/DSCF	0.9801	0.9452	0.7658	0.8528	1.1130	1.1321	0.9530	0.9767
lb/hr	14.04	13.54	9.19	10.23	13.39	13.62	12.21	12.46
lb/ton	0.942	0.909	0.625	0.696	0.917	0.933	0.828	0.846
Total Particulate-- Insoluble and Ammonia Nitrate								
mg	6507	6287	4299	4765	6438	6544	5748	5865
gr/DSCF	1.0285	0.9936	0.8036	08906	1.1638	1.1829	0.9986	1.0224
lb/hr	14.73	14.23	9.64	10.68	14.00	14.23	12.79	13.05
lb/ton	0.988	0.955	0.656	0.727	0.959	0.975	0.868	0.886
Percent particulate catch	4.7	4.9	4.7	4.3	4.4	4.3	4.6	4.5

[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.

TABLE 17

SUMMARY OF CONTROLLED EMISSIONS FROM THE PRECOOLER AND CHAIN MILL SCRUBBER OUTLET

	Run 1		Run 2		Run 3		Average	
Date	11-9-78		11-10-78		11-10-78			
Volume of Gas Sampled (DSCF)[a]	89.15		89.54		93.19		90.63	
Percent Moisture by Volume	3.4		4.0		4.9		4.1	
Average Stack Temperature (°F)	112		112		113		112	
Stack Volumetric Flow Rate (DSCFM)[b]	25866		25843		27062		26257	
Pressure Drop Across Scrubber (in. H_2O)	3.2		6.9		6.8		5.6	
Percent Isokinetic	102		102		102		102	
Percent Opacity Average	9.8		--		--		--	
Production Rate (Tons/hour)	14.9		14.7		14.6		14.7	
Insoluble Particulate - Filter Catch and Collection Water Filtrate								
mg	3.51		10.78		3.46		5.92	
gr/DSCF	0.0006		0.0019		0.0006		0.0010	
lb/hour	0.13		0.41		0.13		0.23	
lb/ton	0.009		0.028		0.009		0.015	
Ammonium Nitrate 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	62.40	164.85	117.12	1309.88	87.79	1758.92	89.10	1077.88
gr/DSCF	0.0108	0.0285	0.0202	0.2258	0.0145	0.2913	0.0152	0.1819
lb/hour	2.40	6.33	4.47	50.02	3.37	67.58	3.41	41.31
lb/ton	0.161	0.425	0.304	3.403	0.231	4.629	0.232	2.819
Total Particulate - Insoluble and Ammonium Nitrate								
mg	65.91	168.36	127.90	1320.66	91.25	1762.38	95.02	1083.80
gr/DSCF	0.0114	0.0291	0.0221	0.2277	0.0151	0.2919	0.0162	0.1829
lb/hour	2.53	6.46	4.88	50.43	3.50	67.71	3.64	41.53
lb/ton	0.170	0.434	0.332	3.431	0.240	4.638	0.247	2.834
Percent Particulate Catch	5.3	2.1	8.4	<1	3.8	<1	5.8	1.0

[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. Cooler

The emission test results for the cooler scrubber inlet appear in Tables 18 and 19. Four tests were conducted at this location. The first test was repeated due to an unacceptable final leak check on the sampling apparatus and several process disturbances. The static pressure at the inlet to the scrubber was measured rather than scrubber pressure drop because there was no pressure tap.

2.3 Ammonia Results

Tables 20 through 27 present the results of total ammonia, ammonium nitrate (as calculated from moles of ammonia), and excess ammonia (ammonia not combined with ammonium nitrate) for each test location. The excess ammonia was determined from the difference between ammonium nitrate (as calculated from moles of ammonia) and measured nitrate particulate. A sample calculation for excess ammonia is provided in Appendix 6.13.

The ammonia emission data represent the catch of the treated water sample, the 1.0 N H_2SO_4 sample and the train filter. At each test location, the highest concentration of ammonia was found in the treated water sample. The average percentage of ammonia in the treated water samples at each location is as follows:

- Evaporator Inlet 72.3%
- Combined Evaporator-Pan Granulator Inlet 72.9%
- Combined Evaporator-Pan Granulator Outlet 33.5%
- Precooler Inlet 99.8%
- Chain Mill Inlet 99.5%
- Combined Precooler-Chain Mill Outlet 66.8%
- Cooler Inlet 97.9%

The ammonia collection efficiency of the Buffalo Forge Scrubber is presented in Table 26. The efficiency was calculated by adding the total ammonia recovered from corresponding test

TABLE 18

SUMMARY OF EMISSION TEST RESULTS FOR THE COOLER SCRUBBER INLET (English and Metric Units)

	Units		Run 1		Run 2		Run 3		Run 4		Average	
Date	English	Metric	English	Metric	English	Metric	English	Metric	English	Metric	English	Metric
			11-3-78		11-3-78		11-4-78		11-4-78			
Volume of Gas Sampled	DSCF[a]	DNm^3 [b]	106.36	301	105.19	2.98	109.83	3.11	111.01	3.14	108.10	3.06
Percent Moisture by Volume			1.4		1.3		1.3		1.2		1.3	
Average Stack Temp.	^oF	^oC	167	74.8	173	78.1	168	75.3	174	78.8	171	76.8
Stack Volumetric Flow Rate	DSCFM[c]	DNm^3/min [d]	12536	355	12396	351	12249	347	12348	350	12382	351
Percent Isokinetic			96		96		101		101		99	
Production Rate	Tons/hr	Mg/hr	14.4	13.1	14.7	13.3	14.1	12.8	14.7	13.3	14.5	13.2
Insoluble Particulate-Filter Catch and Collection Water Filtrate	mg		25.24		14.04		24.75		18.97		20.76	
	gr/DSCF	g/DNm^3	0.0037	0.0085	0.0021	0.0048	0.0035	0.0080	0.0026	0.0059	0.0030	0.0069
	lb/hr	kg/hr	0.39	0.177	0.22	0.010	0.36	0.163	0.28	0.127	0.31	0.141
	lb/ton	kg/Mg	0.027	0.013	0.015	0.008	0.026	0.013	0.019	0.010	0.022	0.011
Ammonium Nitrate Particulate	mg		480.85		295.91		600.52		348.71		431.50	
	gr/DSCF	g/DNm^3	0.0698	0.1597	0.0434	0.0991	0.0844	0.1931	0.0485	0.1109	0.0615	0.1407
	lb/hr	kg/hr	7.50	3.402	4.61	2.091	8.86	4.018	5.13	2.327	6.53	2.962
	lb/ton	kg/Mg	0.521	0.260	0.313	0.157	0.628	0.314	0.349	0.174	0.453	0.226
Total Particulate-Insoluble and Ammonium Nitrate	mg		506.09		309.95		625.27		367.68		452.25	
	gr/DSCF	g/DNm^3	0.0735	0.1682	0.0455	0.1041	0.0879	0.2011	0.0511	0.1169	0.0645	0.1476
	lb/hr	kg/hr	7.89	3.579	4.83	2.191	9.22	4.182	5.41	2.454	6.84	3.103
	lb/ton	kg/Mg	0.548	0.274	0.328	0.164	0.654	0.327	0.368	0.184	0.475	0.237

[a] Dry Standard Cubic Feet at 68^oF, 29.92 in. Hg.

[b] Dry Normalized Cubic Meters at 20^oC, 760 mm Hg.

[c] Dry Standard Cubic Feet at 68^oF, 29.92 in. Hg. per minute

[d] Dry Normalized Cubic Meters at 20^oC, 760 mm Hg. per minute

TABLE 19
SUMMARY OF EMISSIONS TEST RESULTS FOR THE COOLER
SCRUBBER INLET

	Run 1		Run 2		Run 3		Run 4		Average	
Date	11-3-78		11-3-78		11-4-78		11-4-78			
Volume of Gas Sampled (DSCF)[a]	106.36		105.19		109.83		111.01		108.10	
Percent Moisture by Volume	1.4		1.3		1.3		1.2		1.3	
Average Stack Temperature (°F)	167		173		168		174		171	
Stack Volumetric Flow Rate (DSCFM)[b]	12536		12396		12249		12348		12382	
Percent Isokinetic	96		96		101		101		99	
Average Static Pressure (in.H_2O)	-1.5		-1.6		-1.8		-1.7		-1.7	
Production Rate (tons/hour)	14.4		14.7		14.1		14.7		14.5	
<u>Insoluble Particulate</u>--Filter Catch and Collection Water Filtrate										
mg	25.24		14.04		24.75		18.97		20.75	
gr/DSCF	0.0037		0.0021		0.0035		0.0026		0.0030	
lb/hr	0.39		0.22		0.36		0.28		0.31	
lb/ton	0.027		0.015		0.026		0.019		0.022	
<u>Ammonium Nitrate Particulate</u>--Nitrate and Ammonium Nitrate measured as Ammonia	MEASURED		MEASURED		MEASURED		MEASURED		MEASURED	
	as Nitrate	as Ammonia[c]	as Nitrate	as Ammonia[c]	as Nitrate	as Ammonia[c]	As Nitrate	as Ammonia[c]	as Nitrate	as Ammonia[c]
mg	561.60	480.85	315.60	295.91	638.40	600.52	360.00	348.71	468.90	431.50
gr/DSCF	0.0815	0.0698	0.0463	0.0434	0.0897	0.0844	0.0500	0.0485	0.0669	0.0615
lb/hr	8.74	7.50	4.91	4.61	9.40	8.86	5.29	5.13	7.09	6.53
lb/ton	0.607	0.521	0.334	0.313	0.666	0.628	0.360	0.349	0.492	0.453
<u>Total Particulate</u>--Insoluble and Ammonium Nitrate										
mg	586.84	506.09	329.64	309.95	663.15	625.27	378.97	367.68	489.65	452.25
gr/DSCF	0.0852	0.0735	0.0484	0.0455	0.0932	0.0879	0.0526	0.0511	0.0699	0.0645
lb/hr	9.13	7.89	5.13	4.83	9.76	9.22	5.57	5.41	7.40	6.84
lb/ton	0.634	0.548	0.349	0.328	0.692	0.654	0.379	0.368	0.514	0.475
Percent particulate catch	4.3	5.0	4.2	4.5	3.7	4.0	5.0	5.2	4.3	4.7

[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] Used for Concentration and Emission Factors.

TABLE 20

SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED EMISSIONS AT THE EVAPORATOR-CALCULATED FROM COLLECTED AMMONIA

	Run 1	Run 2	Run 3	Average
Date	11/7/78	11/8/78	11/8/78	
Volume of Gas Sampled (DSCF)[a]	26.41	29.34	21.31	25.69
Stack Volumetric Flow Rate (DSCFM)[b]	1403	1321	1048	1257
Production Rate (Tons/hour)	14.7	14.7	15.2	14.9
Total Ammonia				
mg	333.42	383.53	290.93	335.96
gr/DSCF	0.1948	0.2017	0.2107	0.2024
lb/hr	2.34	2.28	1.89	2.17
lb/ton	0.159	0.155	0.124	0.146
Ammonium Nitrate Calculated From Moles of Ammonia				
mg	1569	1805	1369	1581
gr/DSCF	0.9168	0.9494	0.9914	0.9525
lb/hr	11.03	10.75	8.91	10.23
lb/ton	0.750	0.731	0.586	0.689
Excess Ammonia (ammonia not combined with ammonium nitrate)				
mg	301.4	350.0	262.2	304.5
gr/DSCF	0.1761	0.1841	0.1899	0.1834
lb/hr	2.12	2.09	1.71	1.97
lb/ton	0.144	0.142	0.112	0.133

[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.

TABLE 21
SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED EMISSIONS
AT THE COMBINED EVAPORATOR-PAN GRANULATOR INLET - CALCULATED FROM COLLECTED AMMONIA

	Run 1	Run 2	Run 3	Average
Date	11-7-78	11-8-78	11-8-78	
Volume of Gas Sampled (DSCF)[a]	44.24	59.83	54.80	52.96
Stack Volumetric Flow Rate (DSCFM)[b]	7936[c]	7355[c]	7619[c]	7637
Production Rate (Tons/Hour)	14.7	14.7	15.2	14.9
Total Ammonia				
mg	883.15	541.35	473.40	632.63
gr /DSCF	0.3081	0.1396	0.1333	0.1937
lb /hr	20.96	8.81	8.71	12.83
lb /ton	1.426	0.599	0.573	0.866
Ammonium Nitrate Calculated From Moles of Ammonia				
mg	4156	2548	2228	2977
gr /DSCF	1.4497	0.6572	0.6274	0.9114
lb /hr	98.64	41.44	40.99	60.36
lb /ton	6.710	2.819	2.697	4.075
Excess Ammonia (Ammonia Not Combined With Ammonium Nitrate				
mg	223.5	197.0	218.4	213.0
gr /DSCF	0.0780	0.0508	0.0615	0.0634
lb /hr	5.30	3.20	4.02	4.17
lb /ton	0.361	0.218	0.264	0.281

[a]Dry Standard Cubic Feet at 68°F, 22.92 in. Hg.
[b]Dry Standard Cubic Feet Per Minute at 68°F, 29.92 in. Hg.
[c]Cyclonic Flow Suspected.

TABLE 22

SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED EMISSIONS AT THE PAN GRANULATOR INLET TO THE SCRUBBER-CALCULATED FROM COLLECTED AMMONIA[a]

Date	Run 1 11-7-78	Run 2 11-8-78	Run 3 11-8-78	Average
Stack Volumetric Flow Rate (DSCFM)[b]	6533[c]	6034[c]	6571[c]	6379
Production Rate (Tons/Hour)	14.7	14.7	15.2	14.9
Total Ammonium				
gr/DSCF	0.3324	0.1262	0.1211	0.1932
lb/hr	18.62	6.53	6.82	10.66
lb/ton	1.267	0.444	0.449	0.720
Ammonium Nitrate Calculated From Moles of Ammonia				
gr/DSCF	1.5641	0.5932	0.5694	0.9089
lb/hr	87.61	30.69	32.08	50.13
lb/ton	5.960	2.088	2.111	3.386
Excess Ammonia (ammonia not combined with ammonium nitrate)				
gr/DSCF	0.0568	0.0215	0.0410	0.0398
lb/hr	3.18	1.11	2.31	2.20
lb/ton	0.216	0.076	0.152	0.148

[a] Data determined by difference of evaporator and combined evaporator-pan granulator data.

[b] Dry Standard Cubic Feet Per Minute at 68°F, 29.92 in. Hg.

[c] Cyclonic flow suspected at the combined inlet.

TABLE 23
SUMMARY OF AMMONIA AND AMMONIUM NITRATE CONTROLLED EMISSIONS AT THE EVAPORATOR AND PAN GRANULATOR SCRUBBER OUTLET-CALCULATED FROM COLLECTED AMMONIA

	Run 1	Run 2	Run 3	Average
DATE	11-7-78	11-8-78	11-8-78	
Volume of Gas Sampled (DSCF)[a]	77.63	75.94	78.74	77.44
Stack Volumetric Flow Rate (DSCFM)[b]	9089[c]	8773[c]	9214[c]	9025
Production Rate (Tons/Hour)	14.7	14.7	15.2	14.9
Total Ammonia				
mg	1136.16	793.78	590.81	840.25
gr/DSCF	0.2259	0.1613	0.1158	0.1677
lb/hr	17.60	12.13	9.15	12.96
lb/ton	1.197	0.825	0.602	0.875
Ammonium Nitrate Calculated from Moles of Ammonia				
mg	5347	3735	2780	3954
gr/DSCF	1.0629	0.7591	0.5449	0.7890
lb/hr	82.83	57.10	43.05	60.99
lb/ton	5.635	3.884	2.832	4.117
Excess Ammonia (ammonia not combined with ammonium nitrate)				
mg	1126.0	784.8	586.3	832.4
gr/DSCF	0.2238	0.1595	0.1149	0.1661
lb/hr	17.44	12.00	9.08	12.84
lb/ton	1.186	0.816	0.597	0.866

[a] Dry Standard Cubic Feed at 68°F., 29.92 in. Hg.

[b] Dry Standard Cubic Feed Per Minute at 68°F., 29.92 in. Hg.

[c] Volumetric flows adjusted for excessive moisture. All subsequent calculations adjusted accordingly.

TABLE 24
SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED
EMISSIONS-CALCULATED FROM COLLECTED AMMONIA AT THE PRECOOLER

	Run 1[c]	Run 2	Run 3	Average
DATE	11-9-78	11-10-78	11-10-78	
Volume of Gas Sampled (DSCF)[a]	40.97	82.09	92.69	71.92
Stack Volumetric Flow Rate (DSCFM)[b]	21593[d]	24707	28666	24989
Production Rate (Tons/Hour)	14.9	14.7	14.6	14.7
Total Ammonia				
mg	1188.53	2779.97	2341.63	2101.71
gr/DSCF	0.4458	0.5226	0.3899	0.4528
lb/hr	82.53	110.71	95.82	96.35
lb/ton	5.539	7.531	6.563	6.544
Ammonium Nitrate Calculated from Moles of Ammonia				
mg	5570	13082	11019	9890
gr/DSCF	2.0979	2.4593	1.8346	2.1306
lb/hr	388.39	520.97	450.92	453.43
lb/ton	26.067	35.440	30.885	30.797
Excess Ammonia (ammonia not combined with ammonium nitrate)				
mg	0[e]	0[e]	0[e]	0[e]
gr/DSCF	-	-	-	-
lb/hr	-	-	-	-
lb/ton	-	-	-	-

[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] Only 1 axis traversed during run.

[d] Volumetric flow data suspected to be low due to 1 axis-traverse being conducted during run.

[e] Negative values calculated.

TABLE 25

SUMMARY OF AMMONIA AND AMMONIUM NITRATE UNCONTROLLED EMISSIONS-CALCULATED FROM COLLECTED AMMONIA AT THE CHAIN MILL

	Run 1	Run 2	Run 3	Average
Date	11/9/78	11/10/78	11/10/78	
Volume of Gas Sampled (DSCF)[a]	97.62	82.55	85.37	88.51
Stack Volumetric Flow Rate (DSCFM)[b]	1671	1399	1403	1491
Production Rate (Tons/Hour)	14.9	14.7	14.6	14.7
Total Ammonia				
mg	1270.61	969.43	1330.86	1190.30
gr/DSCF	0.2009	0.1812	0.2406	0.2076
lb/hr	2.88	2.17	2.89	2.65
lb/ton	0.193	0.148	0.198	0.180
Ammonium Nitrate Calculated From Moles of Ammonia				
mg	5980	4562	6263	5602
gr/DSCF	0.9452	0.8528	1.1321	0.9767
lb/hr	13.54	10.23	13.62	12.46
lb/ton	0.909	0.696	0.933	0.846
Excess Ammonia (Ammonia not combined with ammonium nitrate)				
mg	0[c]	98.6	22.7	40.4
gr/DSCF	-	0.0184	0.0041	0.0075
lb/hr	-	0.22	0.05	0.09
lb/ton	-	0.015	0.003	0.006

[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]Negative Value Calculated.

TABLE 26

SUMMARY OF AMMONIA AND AMMONIUM NITRATE CONTROLLED EMISSIONS AT THE PRECOOLER AND CHAIN MILL SCRUBBER OUTLET —CALCULATED FROM COLLECTED AMMONIA

	Run 1	Run 2	Run 3	Average
Date	11-9-78	11-10-78	11-10-78	
Volume of Gas Sampled (DSCF)[a]	89.15	89.54	93.19	90.63
Stack Volumetric Flow Rate (DSCFM)[b]	25866	25843	27062	26257
Production Rate (Tons/hour)	14.9	14.7	14.6	14.7
Total Ammonia				
mg	35.03	278.35	373.77	229.05
gr/DSCF	0.0061	0.0480	0.0619	0.0387
lb/hour	1.34	10.63	14.36	8.78
lb/ton	0.090	0.723	0.984	0.599
Ammonium Nitrate Calculated From Moles of Ammonia				
mg	164.85	1309.88	1758.92	1077.88
gr/DSCF	0.0285	0.2258	0.2913	0.1819
lb/hour	6.33	50.02	67.58	41.31
lb/ton	0.425	3.403	4.629	2.819
Excess Ammonia (Ammonia not combined with ammonium nitrate)				
mg	21.8	253.5	355.1	210.1
gr/DSCF	0.0038	0.0437	0.0588	0.0354
lb/hour	0.84	9.68	13.64	8.05
lb/ton	0.056	0.659	0.935	0.550
Ammonia Collection Efficiency (percent)	98.4	90.6	85.5	91.5

[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.

TABLE 27

SUMMARY OF AMMONIA AND AMMONIUM NITRATE EMISSIONS AT COOLER SCRUBBER INLET —CALCULATED FROM COLLECTED AMMONIA

	Run 1	Run 2	Run 3	Run 4	Average
Date	11/3/78	11/3/78	11/4/78	11/4/78	
Volume of Gas Sampled-(DSCF)[a]	106.36	105.19	109.83	111.01	108.10
Percent Moisture by Volume	1.4	1.3	1.3	1.2	1.3
Average Stack Temperature--(°F)	167	173	168	174	171
Stack Volumetric Flow Rate--(DSCFM)[b]	12536	12396	12249	12348	12382
Percent Isokinetic	96	96	101	101	99
Production Rate--(tons/hour)	14.4	14.7	14.1	14.7	14.5
Total Ammonia					
mg	102.18	62.88	127.61	74.10	91.69
gr/DSCF	0.0148	0.0092	0.0179	0.0103	0.0131
lb/hr	1.59	0.98	1.88	1.09	1.39
lb/ton	0.111	0.067	0.134	0.074	0.097
Ammonia Nitrate Calculated From Moles of Ammonia					
mg	480.85	295.91	600.52	348.71	431.50
gr/DSCF	0.0698	0.0434	0.0844	0.0485	0.0615
lb/hr	7.50	4.61	8.86	5.13	6.54
lb/ton	0.521	0.313	0.628	0.349	0.453
Excess Ammonia-(ammonia not combined with ammonium nitrate)					
mg	0[c]	0[c]	0[c]	0[c]	0[c]
gr/DSCF	-	-	-	-	-
lb/hr	-	-	-	-	-
lb/ton	-	-	-	-	-

[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] Negative values calculated.

runs conducted on the precooler and chain mill inlets and comparing this value with the total ammonia obtained at the outlet.

2.4 Visible Emissions Observation Results

Visible emissions observations were conducted on the venturi scrubber and Buffalo Forge scrubber outlet stacks. Summaries of these observations are presented in Tables 28 and 29 and Figures 2 and 3. The emissions measurements were recorded of the plume between the stack and the detached steam plume on the evaporator and pan granulator stack. The length of the steam plume was estimated and recorded during each observation period. The observations were made for the duration of the particulate testing at the outlet locations. The average percent opacity measurement seldom exceeded 10% for either stack.

2.5 Particle Size Distribution Results

Tables 30 and 31 and Figures 4 and 5 display the results of the particle size distribution tests conducted on the precooler and cooler scrubber inlets. A cyclone pre-separator was used for each test, with the exception of the first test conducted at the cooler inlet. Test 3 at the cooler inlet shows only two points because negative weights had been calculated for six of the nine substrates (see Figure 4).

2.6 Gas Composition Results

The results of the gas composition analyses are shown in Table 32. Orsat Analyses were performed on the flue gases at the evaporator and combined evaporator-pan granulator inlets. Since there was no combustion involved in the process, all of the other sampling locations were assumed to be venting air, whose standard composition is 0% CO_2, 20.9% O_2, and 79.1% N_2.

TABLE 28

SUMMARY OF VISIBLE EMISSIONS OBSERVATIONS
VENTURI SCRUBBER STACK

TEST NO.	1	2	3	4
GENERAL DATA				
Date	11/7	11/7	11/8	11/8
Time	1110-1310	1600-1700	0915-1115	1345-1530
Steam Dispersion Distance (Ft)	80	68	100	47
SIX MINUTE INTERVAL AVERAGE OPACITY (%)				
1	5	10	8	10
2	5	9.5	11	10
3	7	11	9	10
4	7.5	11	10	10
5	5	8	10	10
6	5	10	10	10
7	5	11.5	9	10
8	6	10.4	10	10
9	5	11.5	10	10
10	6	10	10	9
11	5	-	10	8
12	7	-	10	10
13	5	-	10	10
14	5	-	10	9
15	5	-	10	10
16	5	-	10	10
17	5	-	10	10
18	5	-	12	10*
19	5	-	10	-
20	6	-	10	-

* 3 Minute Interval

TABLE 29

SUMMARY OF VISIBLE EMISSIONS OBSERVATIONS
BUFFALO FORGE SCRUBBER STACK

TEST NO.	1	2	3
GENERAL DATA			
Date	11/10	11/10	11/10
Time	0947-1047	1130-1430	1430-1630
SIX MINUTE INTERVAL AVERAGE OPACITY (%)			
1	10	11	10
2	9	11	10
3	10	10	11
4	11	10	11
5	10	10	10
6	10	10	10
7	10	10	10
8	10	11	10
9	10	10	10
10	9	10	10
11	-	11	9
12	-	10	11
13	-	10	10
14	-	11	8
15	-	10	9
16	-	10	7.5
17	-	11	8.5
18	-	10	7
19	-	10	6.5
20	-	10	7
21	-	10	-
22	-	10	-
23	-	10	-
24	-	10	-
25	-	10	-
26	-	10	-
27	-	10	-
38	-	10	-
29	-	10	-
30	-	10	-

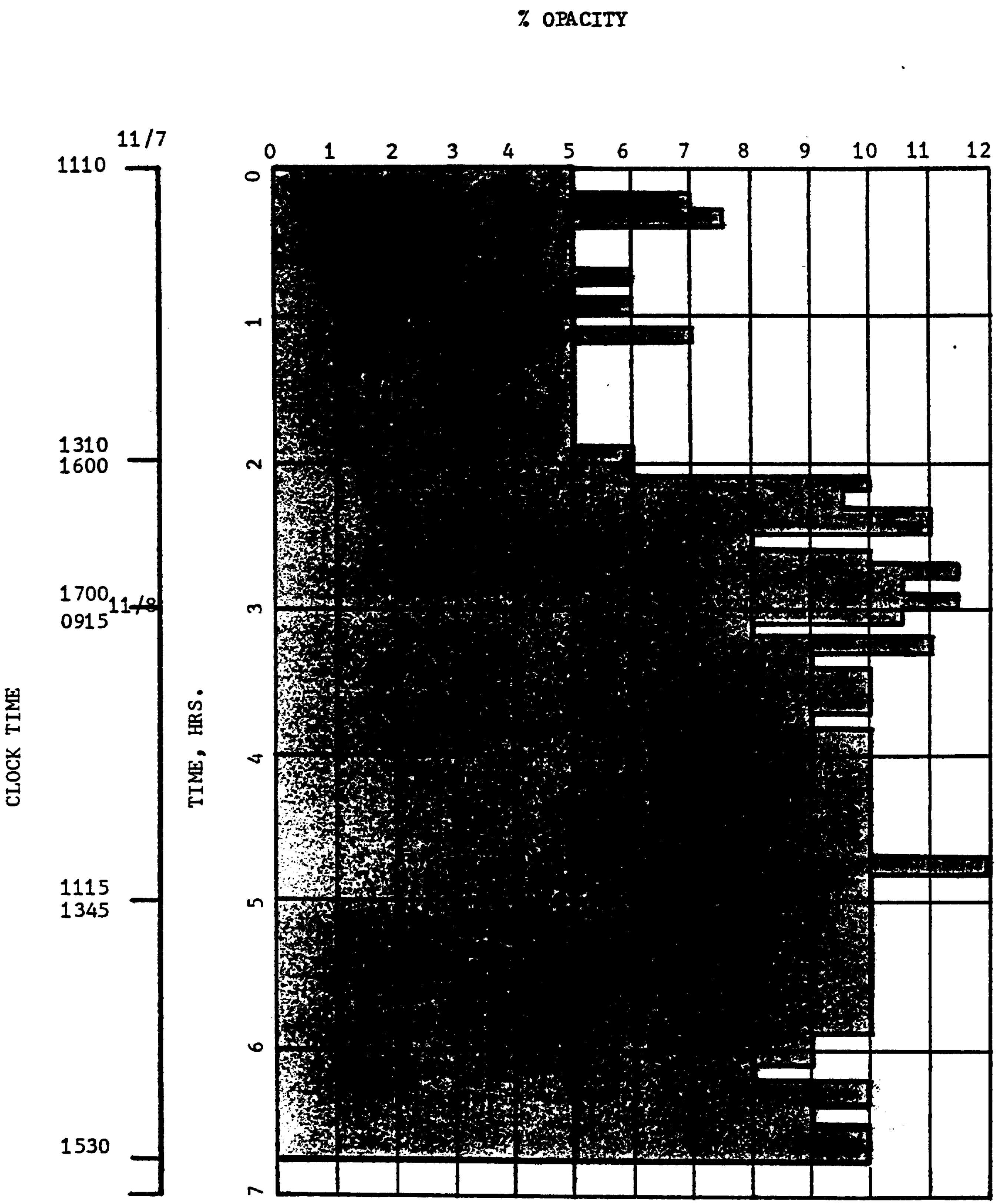

Figure 2

Venturi Scrubber Stack
Visible Emission Observations Plot

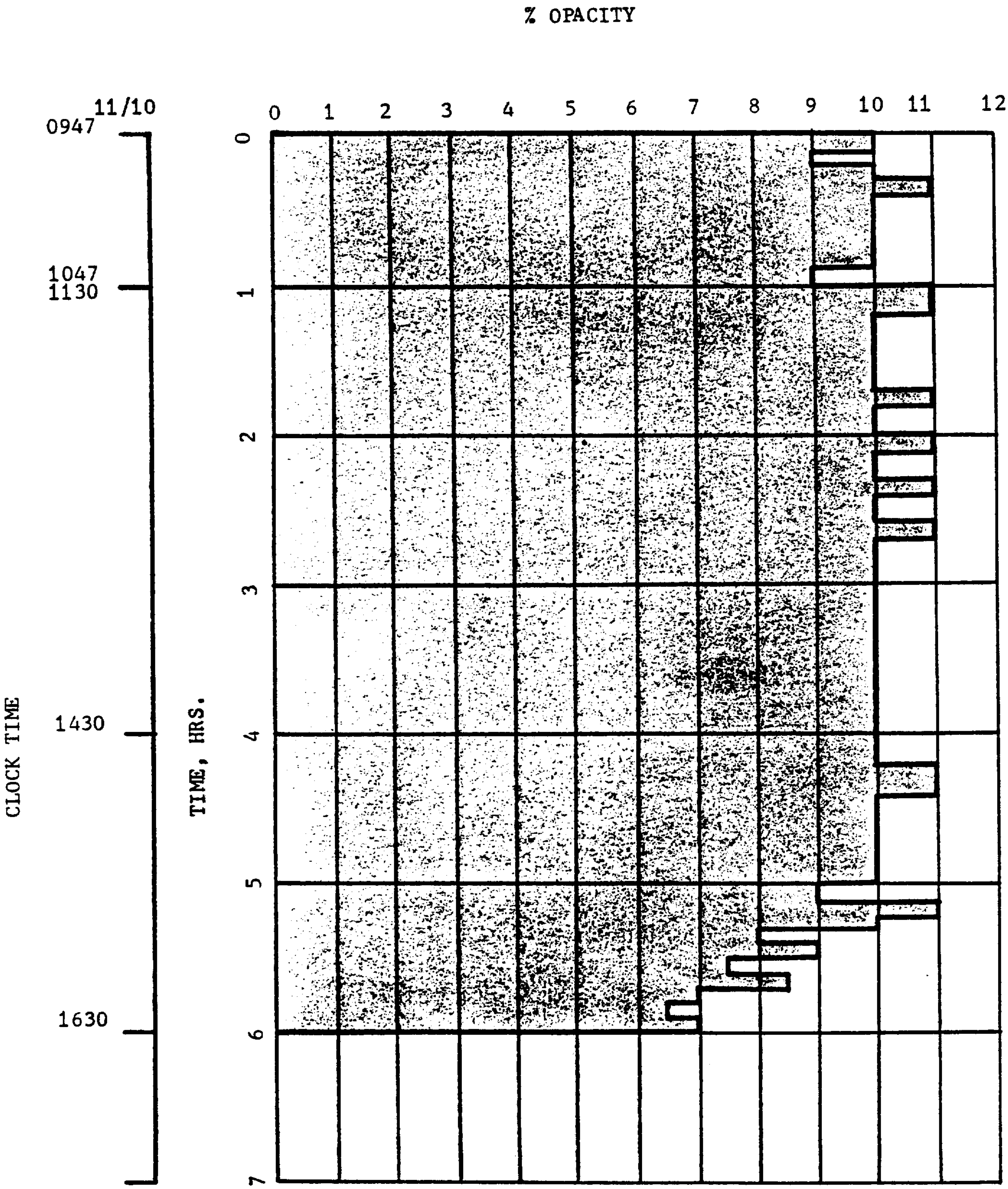

Figure 3

Buffalo Forge Scrubber Stack
Visible Emission Observations Plot

TABLE 30

SUMMARY OF PARTICLE SIZE DISTRIBUTION TESTS CONDUCTED ON THE COOLER SCRUBBER INLET AT N-ReN CORPORATION PRYOR, OKLAHOMA

Test Number	Test Date	Test Time	Particulate Concentration (gr/DSCF)	Particle Size Range (microns)	Mass in Size Range (%)
1	11/4/78	1310 - 1410	0.10320	>9.94	76.96
				9.94 - 6.19	15.71
				6.19 - 4.19	4.87
				4.19 - 2.84	1.17
				2.84 - 1.81	0.27
				1.81 - 0.89	0.30
				0.89 - 0.54	0.44
				0.54 - 0.32	0.14
				<0.32	0.13
2	11/5/78	0850 - 1050	0.03725	>9.96	96.75
				9.96 - 6.20	1.14
				6.20 - 4.19	0.63
				4.19 - 2.85	0.24
				2.85 - 1.82	0.12
				1.82 - 0.90	0.70
				0.90 - 0.54	0.27
				0.54 - 0.33	0.00
				<0.33	0.16
3	11/5/78	1130 - 1330	0.03354	>10.40	98.58
				10.40 - 6.48	0.00
				6.48 - 4.38	0.00
				4.38 - 2.98	0.00
				2.98 - 1.90	0.00
				1.90 - 0.94	0.70
				0.94 - 0.57	0.72
				0.57 - 0.35	0.00
				<0.35	0.00

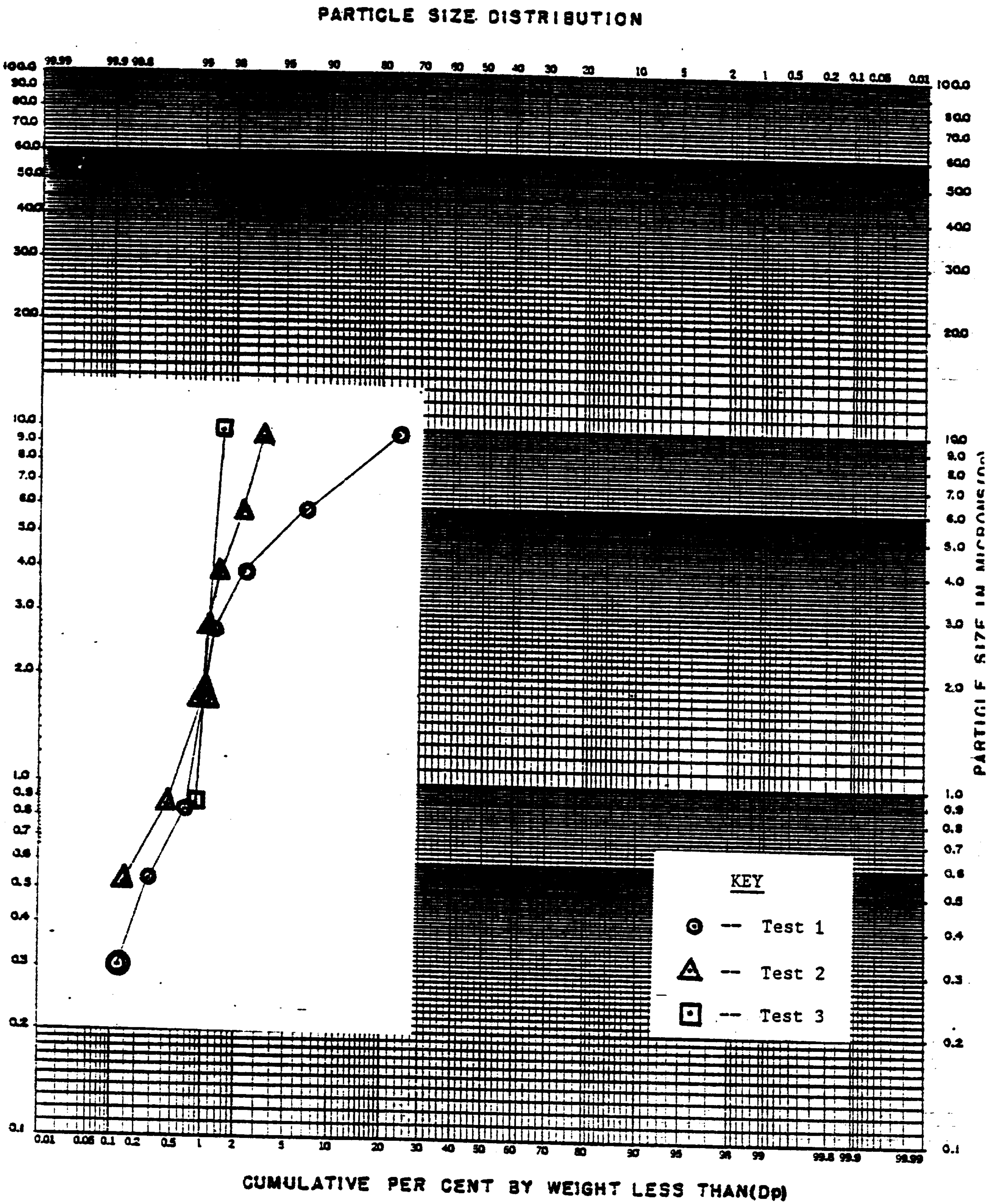

Figure 4
Composite Particle Size Distribution-Cooler Inlet

TABLE 31

SUMMARY OF PARTICLE SIZE DISTRIBUTION TESTS CONDUCTED
ON THE PRECOOLER SCRUBBER INLET AT N-ReN CORPORATION
PRYOR, OKLAHOMA

Test Number	Test Date	Test Time	Particulate Concentration (gr/DSCF)	Particle Size Range (microns)	Mass In Size Range (%)
1	11/6/78	0911 - 0951	1.53400	>9.32	99.34
				9.32 - 5.80	0.12
				5.80 - 3.92	0.07
				3.92 - 2.66	0.01
				2.66 - 1.69	0.01
				1.69 - 0.83	0.05
				0.83 - 0.49	0.18
				0.49 - 0.27	0.17
				<0.27	0.05
2	11/6/78	1035 - 1050	2.86298	>9.32	99.47
				9.32 - 5.80	0.31
				5.80 - 3.92	0.07
				3.92 - 2.66	0.00
				2.66 - 1.69	0.00
				1.69 - 0.83	0.04
				0.83 - 0.49	0.10
				0.49 - 0.26	0.00
				<0.26	0.00
3	11/6/78	1135 - 1150	2.94889	9.32	99.47
				9.32 - 5.80	0.31
				5.80 - 3.92	0.07
				3.92 - 2.66	0.00
				2.66 - 1.69	0.01
				1.69 - 0.83	0.04
				0.83 - 0.49	0.08
				0.49 - 0.27	0.02
				<0.27	0.00

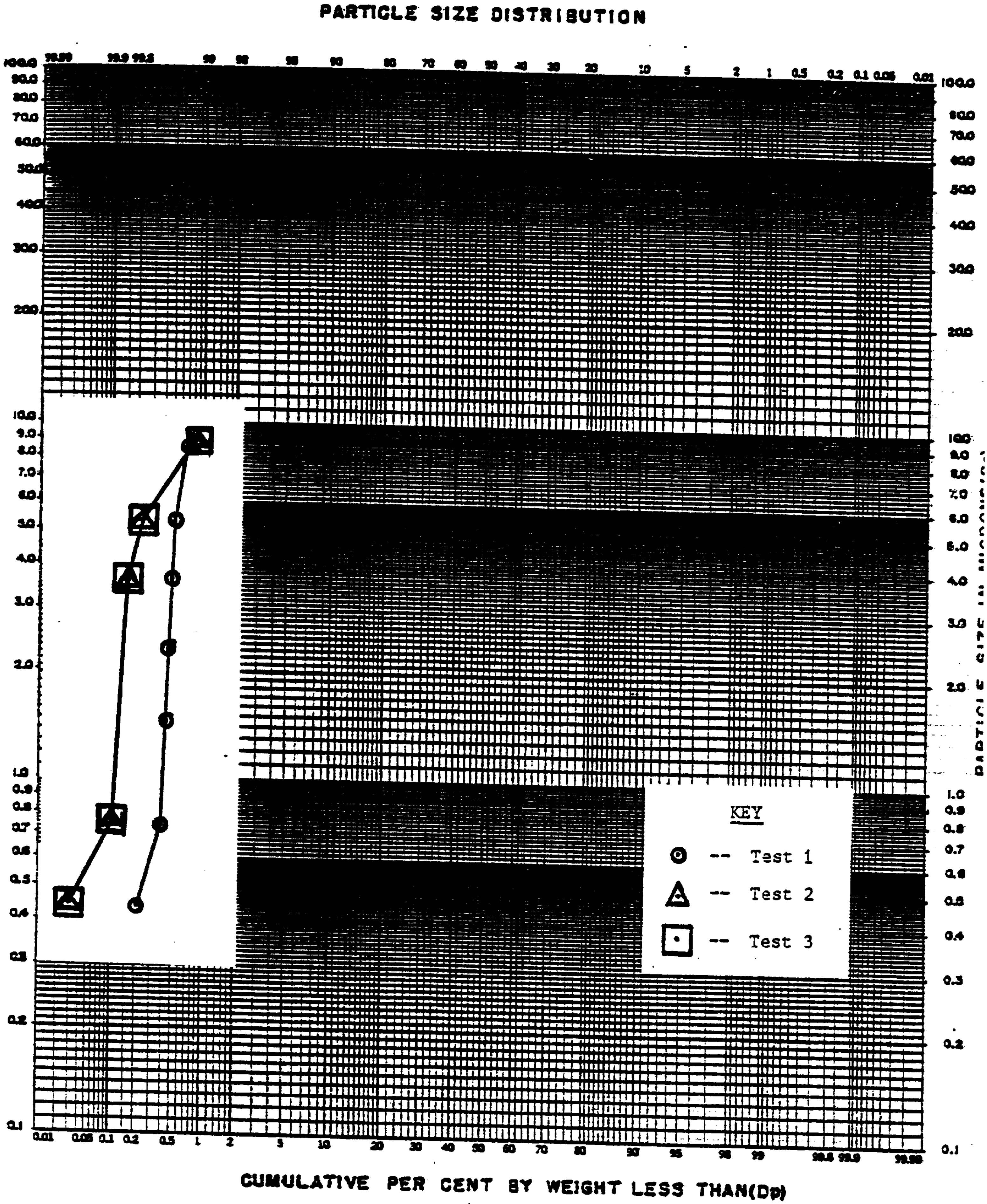

Figure 5
Composite Particle Size Distribution-Precooler Inlet

TABLE 32

SUMMARY OF GAS COMPOSITION DATA

Location	Date	Gas Composition (Average-Dry Percent Basis) % CO_2	% O_2	% N_2 **
Cooler Inlet	11/3 - 11/4	0	20.9	79.1
Evaporator Inlet	11/7 - 11/8	0*	18.4*	81.6
Evaporator-Pan Granulator Inlet	11/7 - 11/8	0*	20.9*	79.1
Evaporator-Pan Granulator Outlet	11/7 - 11/8	0	20.9	79.1
Precooler Inlet	11/9 - 11/10	0	20.9	79.1
Chain Mill Inlet	11/9 - 11/10	0	20.9	79.1
Precooler-Chain Mill Outlet	11/9 - 11/10	0	20.9	79.1

* These values are results from Orsat Analyses. These analyses were not performed at the other locations. The standard gas composition of air is 0% CO_2, 20.9% O_2, 0% CO and 79.1% N_2.

** By difference

2.7 Scrubber Solution Results

Scrubber solution analyses for the venturi scrubber and the Buffalo Forge scrubber are summarized in Tables 33 and 34, respectively. The temperature and pH measurements were made in the field immediately after collection of the samples. The treated and untreated samples were analyzed for ammonium nitrate and ammonia at YRC laboratory in Stamford, Connecticut. (See Appendix 6.11).

The higher removal efficiency of the Buffalo Forge scrubber for ammonium nitrate and ammonia is evident in Table 35 by the greater average net gain of these chemicals in both the treated and untreated samples. It should be noted that the inlet sampling location of the Buffalo Forge scrubber is also the outlet sampling location of the venturi scrubber. Consequently, the data for location "SW 2" in Tables 33 and 34 are similar.

2.8 Pressure Drop Measurement Results

Pressure drop measurements are presented for the venturi scrubber and the Buffalo Forge scrubber in Tables 36 and 37, respectively. The average Δp for the three tests at the venturi scrubber was calculated as 27.0 inches of H_2O. All readings are within 5.2% of this average.

At the Buffalo Forge scrubber, the average Δp for tests 1 through 3 was calculated as 5.6 inches of H_2O. However, the Δp's measured for the first test are significantly less (by a factor >2) than those of tests 2 or 3. This may be explained by either a fluctuation in the scrubber solution level or the concentration and temperature of the scrubber solution.

2.9 Temperature and Relative Humidity

Table 38 provides a summary of temperature (wet bulb and dry bulb) and relative humidity data recorded at the test site.

TABLE 33

SUMMARY OF SCRUBBER SOLUTION ANALYSIS - VENTURI SCRUBBER

Test #	1		2		3		AVERAGE	
Location[a]	SW 1	SW 2	SW 1	SW 2	SW 1	SW 2	SW 1	SW 2
Date	11/7	11/7	11/8	11/8	11/8	11/8	-	-
Time	1400	1400	0915-1130	0915-1130	1330-1515	1330-1515	-	-
Temperature (°F)[b]	90.0	124.0	63.0	123.5	75.0	127.5	76	125
pH[b]	8.7	7.5	8.83	7.37	8.61	6.88	8.71	7.25
Treated Sample								
Ammonium Nitrate(g/1)[c]	72.0	136.0	60.8	128.0	68.8	115.2	67.2	126.4
Ammonia (g/1)[d]	17.5	23.0	15.4	20.0	15.7	19.4	16.2	20.8
% Solids (mg/1)	7.149	9.871	6.907	11.699	7.488	9.884	7.181	10.485
Untreated Sample								
Ammonium Nitrate(g/1)[c]	56.0	92.8	72.0	122.4	64.0	128.0	64.0	114.4
Ammonia (g/1)[d]	15.4	19.4	15.1	20.0	14.2	19.4	14.9	19.6
% Solids (mg/1)	5.053	10.068	5.648	11.067	6.177	10.836	5.626	10.657

[a] SW 1 = Inlet; SW 2 = Outlet

[b] Temperature and pH recorded in field immediately after collection.

[c] Results were reported as moles NO_3/1 (see Appendix 6.11)

[d] Results were reported as µg NH_3 (see Appendix 6.11)

TABLE 34

SUMMARY OF SCRUBBER SOLUTION ANALYSIS - BUFFALO FORGE SCRUBBER

Test #	1		2		3		Average	
Location	SW 2	SW 3	SW 2	SW 3	SW 2	SW 3	SW 2	SW 3
Date	11/9	11/9	11/10	11/10	11/10	11/10	-	-
Time	1400-1625	1400-1625	0845-1100	0845-1100	1345-1530	1345-1530	-	-
Temperature (°F)[b]	135.0	99.5	128.0	108.0	138.5	105.5	133.8	104.3
pH[b]	6.95	5.65	7.30	5.90	6.49	5.49	6.91	5.68
Treated Sample								
Ammonium Nitrate (g/l)[c]	96.0	624.0	100.0	624.0	72.0	624.0	89.3	624.0
Ammonia (g/l)[d]	15.7	125.8	19.4	124.8	15.7	121.0	16.9	124.2
% Solids (mg/l)	8.319	62.334	9.938	65.233	8.187	64.643	8.815	64.070
Untreated Sample								
Ammonium Nitrate (g/l)[c]	89.6	672.0	96.0	704.0	84.0	672.0	89.9	682.7
Ammonia (g/l)[d]	17.5	127.4	18.8	125.8	15.7	122.1	17.3	125.1
% Solids (mg/l)	7.743	62.005	10.139	65.410	8.303	65.455	8.728	64.290

[a] SW 2 = Inlet; SW 3 = Outlet
[b] Temperature and pH recorded in field immediately after collection.
[c] Results were reported as moles NO_3/l (see Appendix 6.11)
[d] Results were reported as μg NH_3 (see Appendix 6.11)

TABLE 35

COMPARISON OF VENTURI AND BUFFALO FORGE SCRUBBER LIQUORS
AVERAGE NET GAINS FOR AMMONIUM NITRATE AND AMMONIA

Sample	Average Net Gain of Sample -Δ (g/l)	
	Venturi Scrubber	Buffalo Forge Scrubber
Treated		
Ammonium Nitrate	59.2	534.7
Ammonia	4.6	107.3
% Solids	3.384	5.031
Untreated		
Ammonium Nitrate	50.4	592.8
Ammonia	14.1	107.8
% Solids	55.255	55.562

TABLE 36

SUMMARY OF SCRUBBER PRESSURE DROP MEASUREMENTS

VENTURI SCRUBBER

DATE	TEST NO.	CLOCK TIME	Δp, in. H_2O
11/7/78	1	1115	-
		1125	27.1
		1325	27.3
		1340	27.4
		1355	27.4
		1410	27.4
		1425	26.9
		1555	26.5
		1610	26.8
		1625	26.9
		1635	26.9
	Average		27.1
11/8/78	2	0910	26.9
		0920	27.0
		0935	27.1
		0945	27.0
		1000	26.7
		1015	27.0
		1023	-
		1030	27.2
		1045	27.0
		1100	28.4
	Average		27.1
11/8/79	3	1325	26.8
		1340	26.5
		1355	26.5
		1410	26.7
		1425	26.8
		1440	-
		1500	27.0
		1510	26.8
	Average		26.7

AVERAGE Δp = 27.0 in. H_2O

TABLE 37

SUMMARY OF SCRUBBER PRESSURE DROP MEASUREMENTS

BUFFALO FORGE SCRUBBER

DATE	TEST NO.	CLOCK TIME	Δp, in. H_2O
11/9/78	1	1353	3.3
		1413	3.5
		1437	3.2
		1449	3.0
		1505	3.0
		1517	2.9
		1521	3.0
		1602	2.9
		1610	3.4
		1622	3.4
		1634	3.9
	Average		3.2
11/10/78	2	0841	7.7
		0857	6.8
		0913	6.9
		0921	6.9
		0933	6.8
		0941	6.8
		1013	6.7
		1021	6.7
		1029	6.7
		1037	6.9
		1105	7.1
	Average		6.9
11/10/78	3	1452	7.0
		1508	6.5
		1520	6.5
		1532	6.6
		1552	7.0
		1614	6.9
		1638	7.0
	Average		6.8

AVERAGE Δp = 5.6 in. H_2O

TABLE 38

TEMPERATURE AND RELATIVE HUMIDITY DATA
N-ReN CORPORATION
PRYOR, OKLAHOMA

Date	Time	Test Number	Test Location	Temperature, °F		Relative Humidity, %
				Wet Bulb	Dry Bulb	
11/3/78	1505	2[1]	Cooler	67	87	35
	1515			67	87	35
	1525			66	86	34
	1545			64	84	33
	1602			67	84	41
	1612			65	84	35
	1622			65	84	35
	1642			65	83	37
	1657			64	82	37
11/4/78	0850	3	Cooler	57	63	70
	0905			58	67	58
	0920			58	70	48
	0935			60	72	50
	1002			61	75	44
	1017			61	76	42
	1032			62	78	40
	1047			62	78	40
	1435	4	Cooler	65	84	35
	1450			65	84	35
	1505			65	84	35
	1541			65	84	35
	1556			65	84	35
	1611			64	84	33
	1626			63	83	32
	1641			63	82	34

[1] First test conducted at cooler inlet was invalid due to a leak in the sampling train.

TABLE 38 (cont.)

TEMPERATURE AND RELATIVE HUMIDITY DATA
N-ReN CORPORATION
PRYOR, OKLAHOMA

Date	Time	Test Number	Test Location	Temperature, °F Wet Bulb	Temperature, °F Dry Bulb	Relative Humidity,%
11/7/78	1334	1	Evaporator-Pan Granulator	54	71	31
	1343			53	73	23
	1352			58	82	21
	1401			58	80	24
	1607			57	80	21
	1618			58	78	28
	1628			57	78	25
	1643			59	81	25
11/8/78	0913	2	Evaporator-Pan Granulator	57	71	41
	0931			56	72	35
	0949			57	74	34
	0958			58	74	37
	1014			58	76	32
	1023			58	76	32
	1035			57	76	29
	1050			57	76	29
	1327	3		60	87	18
	1336			60	87	18
	1400			60	82	26
	1418			62	86	24
	1433			62	85	26
	1439			61	86	22
	1454			60	84	22
	1503			60	84	22
11/9/78	1410	1	Precooler	53	70	30
	1422			53	71	28
	1437			53	75	19
	1449			54	72	29
	1504			54	73	26

TABLE 38 (cont.)

TEMPERATURE AND RELATIVE HUMIDITY DATA
N-ReN CORPORATION
PRYOR, OKLAHOMA

Date	Time	Test Number	Test Location	Temperature, °F		Relative Humidity, %
				Wet Bulb	Dry Bulb	
	1513			53	73	23
11/10/78	0843	2	Precooler	55	63	60
	0858			55	64	56
	0913			55	64	56
	0925			56	65	57
	0943			57	66	58
	0955			58	67	58
	1007			58	67	58
	1025			58	68	55
	1043			59	69	55
	1101			59	70	52
	1338	3	Precooler	62	74	51
	1356			62	73	54
	1414			64	75	55
	1432			65	75	59
	1450			63	78	43
	1505			64	76	52
	1517			62	74	51
	1535			62	74	51
	1553			62	74	51
	1609			62	74	51

N.B.: Temperature measurements were made by a member of the test crew at the designated test site and recorded on the data sheets (Appendix 6.4)

The relative humidity values were extrapolated from relative humidity tables (See Appendix 6.12).

2.10 Process Samples Results

Composite samples of the various process materials were collected from the process samples used for the bulk density and sieve analyses. Bulk density and sieve analyses are discussed in detail in Section 5.10. The samples were given to Mr. John Garrison of N-ReN Corporation, to be stored for future analyses. No data are presented on the process samples because of N-ReN Corporation's request for confidential treatment of this material.

3.0 PROCESS DESCRIPTION AND OPERATION

3.1 Process Description

The N-ReN Corporation in Pryor, Oklahoma produces fertilizer grade ammonium nitrate using a pan granulation process. Installation of the pan granulator increased the capacity of the plant from 300 TPD (tons per day), the limit of the previous prill tower, to 400 TPD. Process equipment employed at the plant include the following:

- two-stage neutralization unit
- pan granulator
- screens
- rotary drum precooler
- cooler
- rotary drum coater

Figure 6 presents a flow diagram of the process. The neutralization step is carried out in two vessels in series. Overheads from both vessels are used to preheat the HNO_3 feed. The overheads from the first-stage neutralizer pass through an HV Brinks unit before being used for preheating. Overheads from the second neutralizer enter a Sly Scrubber after serving as a preheat source.

The AN product stream exiting the neutralizers enters a tank which also receives scrubber liquor recycle (85% AN tank). It then flows to a Whitlock, air-swept, falling film evaporator and is concentrated. Overheads from the evaporator enter the same adjustable-throat venturi scrubber that controls the pan granulator exhaust.

Concentrated AN solution leaves the evaporator and enters a process tank, where an additive is introduced into the melt. This additive surrounds the individual crystals formed during the granulation process and allows crystal expansion and contraction through various phase changes

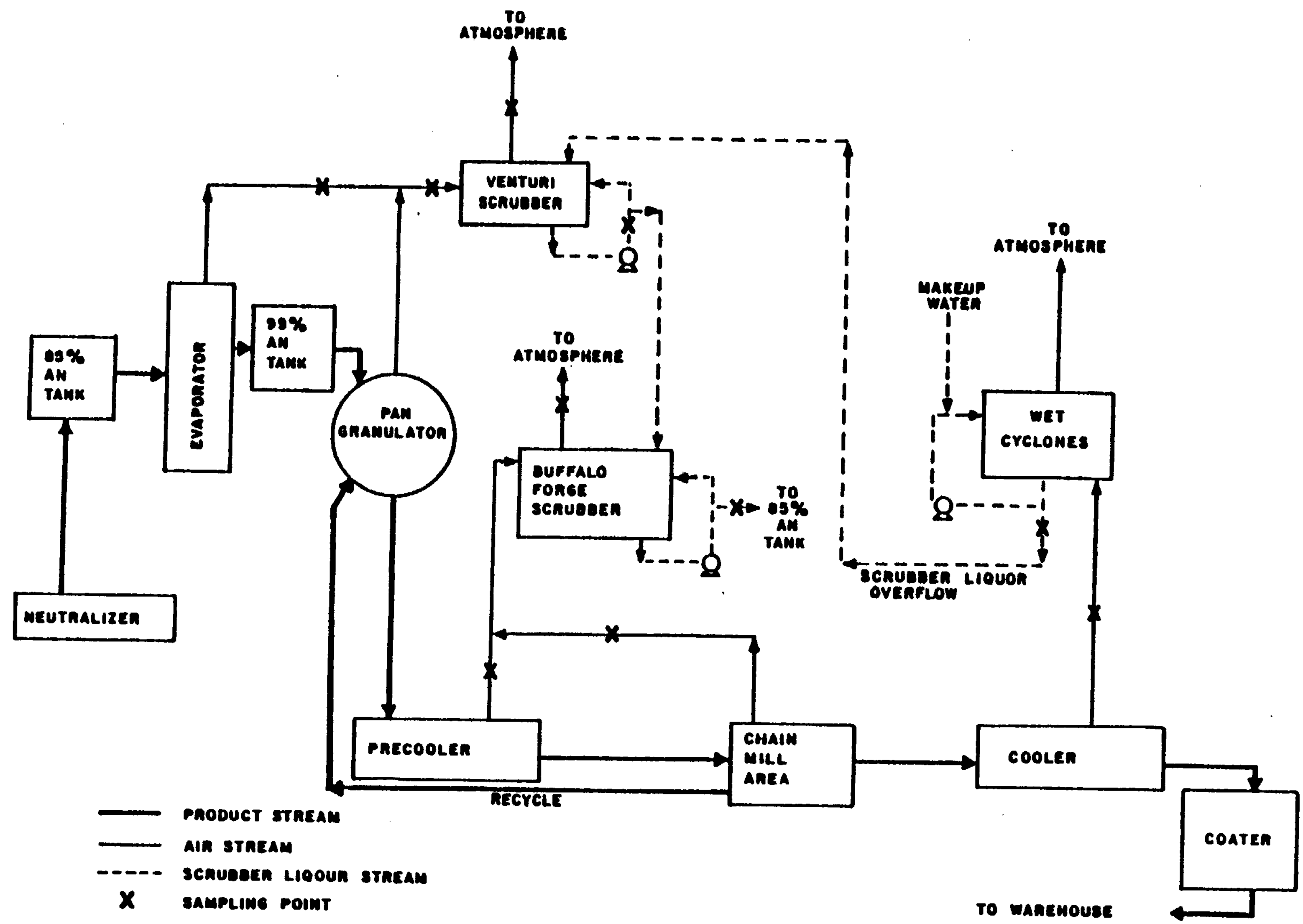

Figure 6

Process Flow Diagram
N-ReN Corporation, Pryor, Oklahoma

while preventing granule disintegration.

Formation of solid AN takes place in a pan granulator. The molten AN is sprayed onto a bed of seed material. Of particular importance to the operation of the pan granulator is the temperature of operation and rate of molten AN cooling.

All of the product which leaves the pan granulator is delivered to a rotary drum precooler. Inlet air to the precooler is cooled and exhausted through a Buffalo Forge scrubber.

Product exiting the precooler is sent through an enclosed lump breaker and delivered by a bucket elevator to the Rotex recycle screen. A dust pick-up on the recycle bucket elevator exhausts dust from the lump breaker and elevator through the Buffalo Forge scrubber. Undersized granules are recycled to the pan granulator. Those granules not passing through the crusher screen are returned to the crusher. The product size can be varied by simply changing the screen sizes. The initial Rotex recycle screen, the crusher screen, the crusher, and the transfer points are all exhausted to the Buffalo Forge scrubber.

Properly sized product leaving the Rotex recycle screen is conveyed by a belt and a vibrating conveyor to the rotary drum product cooler. Inlet air to the product cooler is cooled by chilling coils and then heated by steam coils. Air exiting the product cooler is exhausted through wet cyclones.

Product leaving the cooler is lifted by a bucket elevator to the Sweco product screen. Undersized and oversized material from this screen is recycled to the process tank upstream of the evaporators. Product AN granules leave the Sweco product screen and enter the coater screw.

A coating clay and Petro-AG flows by gravity to the enclosed coater screw. The mixture of AN granules with coating enters an enclosed rotary drum coater. The granules are lifted by an enclosed bucket elevator to a belt conveyor for transfer to the bulk storage warehouse. A dust exhaust pick-up on the bucket elevator maintains a negative pressure across the coater screw, rotary drum coater, and bucket elevator. This air pick-up is exhausted through a baghouse.

The AN granules are stored in piles in an enclosed heated warehouse. The final product is transferred by bulk trucks or railcars. Product granules are removed from the bulk storage piles by front-end loaders and dropped into a hopper which feeds the bulk loading equipment. The hopper has a dust pick-up that exhausts through a baghouse. There is no dust control where the granules are dropped into the trucks or railcars.

3.2 Emission Control Equipment

Emission control equipment at this facility consists of an HV Brinks unit on the first-stage neutralizer, a Sly Scrubber on the second-stage neutralizer, a variable-throat venturi scrubber on the evaporator and pan granulator, a Buffalo Forge scrubber on the precooler/crusher area and two wet cyclones on the cooler.

The HV Brinks unit on the first-stage neutralizer is an integral part of the vessel. Mist removed by Teflon elements is retuned directly to the neutralizer.

The off-gas stream from the second-stage neutralizer is passed through a Sly Scrubber before it is vented to the atmosphere.

The vent stack has a mist eliminator immediately at its exit point.

Both the evaporator and the pan granulator exhausts are controlled by the adjustable-throat venturi scrubber. After passing through the venturi, the air stream passes through a cyclonic droplet separator. An induced draft fan exhausts the air through the collection system.

The Buffalo Forge scrubber controls emissions from the pre-cooler/crusher area. There is a mesh pad mist eliminator at the scrubber outlet. An induced draft fan pulls the air through the collection system and exhausts it through a metal stack.

The exhaust air from the cooler passes through two wet cyclones in parallel, an induced draft fan, and out a metal stack.

Makeup water is supplied to the scrubber liquor for the wet cyclones. This liquor is used in the venturi scrubber. The scrubber liquor leaving the venturi enters the Buffalo Forge scrubber. A density meter controls the outlet scrubber liquor from this unit. The liquor is then returned to the process tank which is upstream of the evaporator.

3.3 Process and Control Equipment Monitoring

A. Cooler Tests

Production rates during the four cooler tests (designated as tests 1, 2, 3, and 4) were calculated to be 14.4, 14.7, 14.1 and 14.7 tons per hour, respectively. Process summary data are presented in Table 39. Recycle rates directly affect the amount of material flowing through the cooler. However, N-ReN has stated that this information is confidential. By comparing the relative differences in recycle

TABLE 39

RELATIVE AVERAGES AND RANGES FOR PROCESS EQUIPMENT OPERATING PARAMETERS

Cooler Test - Summary Data

No.	Column heading	Run No. 1, 11/3/78				Run No. 2, 11/3/78				Run No. 3, 11/4/78				Run No. 4, 11/4/78			
		Average	Standard D	High	Low	Average	Standard D	High	Low	Average	Standard D	High	Low	Average	Standard D	High	Low
4	Instantaneous weigh-belt weight	1,153	13.3	1,170	1,120	1,161	7.4	1,170	1,150	1,151	5.5	1,160	1,140	1,157	11.1	1,170	1,140
5	Gallons per minute of AN solution to 85 percent tank	52	2.7	57	48	50.8	1.0	52	50	50.8	1.0	52	50	48	0	48	48
6	Level of 99 percent tank	78	0	78	78	78	0	78	78	75	0	75	75	75	0	75	75
7	Level of 85 percent tank	80	0	80	80	80	0	80	80	80	0	80	80	80	0	80	80
8	Relative turbidity of melt	Not operating				Not operating				Δ 0.35	-	Δ 0.7	Δ 0	Δ+0.77	-	Δ+0.6	Δ 0
9	Product temperature into cooler, °F	3 readings taken during test Δ 0, -2, -2				3 readings taken during test Δ-2, 0, -1				1 reading Δ+8				2 readings Δ+4, +5			
10	Product temperature out of cooler, °F	128.6	3.2	130	120	132.9	1.9	135	131	124.4	3.3	130	120	132.8	3.0	137	130
11	Recycle rate of granulator AN	Δ+6.4	-	Δ+20	Δ 0	Δ+9.0	-	Δ+20	Δ 0	Δ+77	-	Δ+90	Δ+60	Δ+52	-	Δ+80	Δ+40

rates from one test to another, it is believed that there was no significant difference during the four tests.

The temperature of the product leaving the cooler appears to be dependent upon the temperature of the ambient air. As the ambient air temperature increased, the product temperature exiting the cooler also increased. The average difference in product temperatures for tests 2, 3 and 4 were within 8.5^{o}F, or 6.4 percent. This small difference in temperature is expected to have a negligible impact on emission rates.

The temperatures of the product entering the cooler for these same tests were within 10^{o}F. The temperature of the product entering the cooler also appears to be dependent upon ambient air temperature. These small differences in temperature should be considered a normal operating range.

B. Evaporator-Pan Granulator Tests

Production rates during the three evaporator-pan granulator tests (designated as tests 5, 6 and 7) were calculated to be 14.7, 14.7 and 15.2 tons per hour, respectively. Process summary data are presented in Table 40. The average temperature of the recycle stream to the granulator was lower in test 6 than in either of tests 5 or 7. The difference between tests 5 and 6 was 3.5^{o}F, and the difference between tests 6 and 7 was 6.1^{o}F. The average temperatures of the product leaving the granulator for the three tests were within 3^{o}F of each other. All other parameters monitored during these three tests indicate that the process equipment, production rate and control equipment were functioning in a reasonably stable manner.

C. Precooler-Chain Mill Tests

The production rates during the three precooler-chain mill tests (designated as tests 8, 9 and 10) were determined to

TABLE 40

RELATIVE AVERAGES AND RANGES FOR PROCESS AND CONTROL EQUIPMENT OPERATING PARAMETERS

Pan Granulator/Evaporator Test - Summary Data

No.	Column heading	Run No. 5, 11/7/78				Run No. 6, 11/8/78				Run No. 7, 11/8/78			
		Average	Standard D	High	Low	Average	Standard D	High	Low	Average	Standard D	High	Low
4	Instantaneous weighbelt weight	1,157	7.5	1,175	1,150	1,161	8.5	1,175	1,145	1,171	6.2	1,180	1,160
5	Gallons per minute of AN solution to 85 percent tank	50.9	2.3	54	46.5	50	0	50	50	50.9	0.6	52	50
6	Level of 99 percent tank	75	0.4	75	74	74	0.4	75	74	75	0	75	75
7	Level of 85 percent tank	80	0	80	80	80	0	80	80	80	0	80	80
8	Relative turbidity of melt	Δ+0.6	-	Δ+0.90	Δ+0.15	Δ-0.3	-	Δ-0.25	Δ-0.40	Δ+0.03	-	Δ+0.35	Δ-0.30
9	Melt temperature leaving evaporator, °F	Δ+0.8	-	Δ+2	Δ-3	Δ+1	-	Δ+1	Δ+1	Δ+1.25	-	Δ+2	Δ+1
10	Melt temperature to granulator, °F	Δ 0	-	Δ+2	Δ-3	Δ-1.3	-	Δ 0	Δ-3	Δ-0.5	-	Δ+1	Δ-3
11	Temperature of recycle to granulator, °F	Δ+4.4	-	Δ+10	Δ 0	Δ+0.9	-	Δ+4	Δ-3	Δ+7	-	Δ+9	Δ+5
12	Temperature product leaving granulator, °F	Δ+9.7	-	Δ+13	Δ+5	Δ+7	-	Δ+10	Δ+3	Δ+10	-	Δ+11	Δ+9
13	Venturi fan amperage	91.5	1.2	94	90	91	0.4	92	91	90	0.4	90	89
15	Pressure of melt to spray nozzles	Δ 0	-	Δ+0.2	Δ 0	Δ 0	-	Δ 0	Δ-0.1	Δ+0.2	-	Δ+0.4	Δ 0
16	Recycle rate of granulator AN	Δ+51	-	Δ+70	Δ+40	Δ+107	-	Δ+120	Δ+90	Δ+105	-	Δ+120	Δ+90
17	Revolutions per minute of granulator	2 readings during test				No data taken during test				No data taken during test			
18	Angle of granulator	-	-	-	-	-	-	-	-	-	-	-	-
19	Concentration scrubber liquor into venturi percent	2 readings during test 5, 5				2 readings during test 5, 5				2 readings during test 5, 5			
20	Concentration scrubber liquor exiting venturi percent	2 readings during test 7, 10.6				2 readings during test 7, 7				2 readings during test 7, 7			
21	Percent H_2O in product leaving granulator					. . . . . *Note 1							
22	Temperature scrubber liquor leaving venturi, °F	141	2.0	145	139	144	0.8	145	143	144	0.5	144	143
23	Temperature scrubber liquor into venturi, °F	1 reading during test 82				1 reading during test 62				2 readings during test 72, 74			
26	Temperature air exiting granulator, °F	162	4.0	169	156	160	2.4	162	156	165	1.8	168	163

* See Note 1 - Confidential Addendum. Contact Eric Noble, EPA - 919-541-5213

be 14.9, 14.7 and 14.6 tons per hour, respectively. Process summary data are presented in Table 41.

The temperature of the product entering the precooler in the first test averaged 3.8°F higher than the second test and 6.3°F higher than the third test. The recycle rate during the first test was slightly lower than that during the second or third precooler tests. This may explain why the temperature of the product leaving the granulator was higher during this test.

3.4 Process and Control Equipment Operation

Process operating parameters were monitored during the particulate sampling runs to insure that measurements representative of the normal plant operation were obtained. Production rate parameters were also monitored for determination of production rates during emission sampling. Scrubber operating parameters were monitored while tests on the control equipment for the pan granulator and the precooler were being conducted.

The results of the monitoring of the process and control equipment parameters are summarized in Tables 39 through 41. The symbol "Δ" denotes the deviation of the recorded value from the standard value. The standard value is defined as the first reading recorded for that particular parameter during a designated testing period. This method was employed to insure that those parameters deemed confidential by N-ReN Corporation would remain confidential. At the same time, this would allow GCA personnel to determine if any of these parameters directly affected the operation of the process. Averages of values recorded during the emissions testing, as well as maximum deviation from the overall average, are also presented in these tables.

TABLE 41
RELATIVE AVERAGES AND RANGES FOR PROCESS AND CONTROL EQUIPMENT OPERATING PARAMETERS

Precooler Test - Summary Data

No.	Column heading	Run No. 8, 11/9/78				Run No. 9, 11/10/78				Run No. 10, 11/10/78			
		Average	Standard D	High	Low	Average	Standard D	High	Low	Average	Standard D	High	Low
4	Instantaneous weighbelt weight	1,165	16.4	1,180	1,135	1,161	11.9	1,180	1,140	1,158	12.7	1,175	1,140
5	Gallons per minute of AN solution to 85 percent tank	37.1	6.9	46	30	51.3	3.0	55	47	45.1	5.5	54	40
6	Level of 99 percent tank	78	0.4	79	78	78	0	78	78	78.5	1.1	80	76
7	Level of 85 percent tank	76	0	76	76	78	0	78	78	78	0	78	78
8	Relative turbidity of melt	Δ+0.08	-	Δ+0.4	Δ-1.1	Δ-0.2	-	Δ+0.5	Δ-1.0	Δ+0.7	-	Δ+1.8	Δ-0.8
9	Product temperature into precooler, °F	Δ+13.9	-	Δ+15	Δ 0	Δ+10.1	-	Δ+11	Δ+9	Δ+7.6	-	Δ+14	Δ 0
10	Product temperature out of cooler, °F	1 reading during test Δ 0				1 reading during test Δ-10				No readings taken during test			
11	Recycle rate of granulator AN	Δ+63.3	-	Δ+80	Δ+40	Δ+73	-	Δ+110	Δ+50	Δ+78	-	Δ+100	Δ+50
14	Concentration scrubber liquor entering Buffalo Forge percent	2 readings during test 6, 10				1 reading during test 10.2				2 readings during test 11, 11			
15	Concentration scrubber liquor exiting Buffalo Forge percent	2 readings during test 56, 64				1 reading during test 55.5				2 readings during test 55, 54			
16	Buffalo Forge scrubber level	53	2.8	54.5	46.5	25.7	2.3	30.0	23.0	37.9	6.7	49.5	31.5
17	Buffalo Forge fan amperage	118	0.6	119	117	119	0	119	119	121	0.5	121	120
18	Air temperature into precooler, °F	Δ-11	-	Δ 0	Δ-15	Δ-1.6	-	Δ 0	Δ-4	Δ+0.7	-	Δ+5	Δ-3
19	Temperature scrubber liquor into Buffalo Forge, °F	149.5	3.4	153	143	144.7	3.7	150	140	150.3	4.3	154	143
20	Temperature scrubber liquor out of Buffalo Forge, °F	97	0.8	98	96	98.2	0.7	99	97	100.2	1.1	102	99
21	Buffalo Forge scrubber liquor nozzle pressure	75	0	75	75	80	1.1	81	78	79.4	1.3	81	78

The production rates during the cooler and evaporator-pan granulator tests can be calculated using the readings recorded from the integrator on the weighbelt to the warehouse. This integrator was calibrated by plant personnel during the week of testing. Each unit reading on the integrator corresponds to 0.02157 tons of product. The procedure used to calculate hourly production rates is presented below.

A = integrator weighbelt reading at end of test

B = integrator weighbelt reading at beginning of test

$$\left(\frac{A - B}{\text{Time between readings of A and B in minutes}}\right) \times \left(\frac{0.02157\ \text{tons}}{\text{unit integrator reading}}\right) = \frac{\text{tons production}}{\text{minute}}$$

$$\left(\frac{\text{tons production}}{\text{minute}}\right) \times \left(\frac{60\ \text{minutes}}{\text{hour}}\right) = \frac{\text{tons production}}{\text{hour}}$$

An equation correlating the average instantaneous weighbelt reading and the integrator reading on the weighbelt during the cooler and evaporator-pan granulator tests was developed for the precooler test. This was done because the integrator on the weighbelt to the warehouse was not functioning during the precooler tests.

A least squares analysis performed on seven sets of data points resulted in the following equation, with a correlation coefficient of 0.942:

$$\text{Production rate} \left(\frac{\text{tons}}{\text{hour}}\right) = 0.048 \times \left(\text{Average instantaneous weighbelt reading during test} - 41.1\right)$$

Therefore, for each of the precooler tests, the production rate can be calculated by applying the above equation to the average instantaneous weighbelt reading.

4.0 LOCATION OF SAMPLING POINTS

4.1 Introduction

Testing was conducted on the cooler, evaporator, pan granulator, precooler, and chain mill operations at the N-ReN Corporation in Pryor, Oklahoma. The locations of the ammonium nitrate-ammonia (AN-A) test ports and sampling points at each test site were determined in accordance with guidelines outlined in EPA Method 1 (Sample and Velocity Traverses for Stationary Sources)[1].

Temperature and barometric pressure measurements were recorded during the sampling program. These measurements were first recorded from instruments located in a warehouse approximately a quarter mile from the test sites. This location was changed, however, to the actual sampling site, where the data would be representative of the testing environment.

This section presents detailed descriptions of the sampling locations for AN-A, particle size distribution, gas composition, scrubber pressure drop and opacity observation measurements.

4.2 Cooler Inlet

The AN-A sampling ports on the cooler scrubber inlet are located in the duct which vents the exhaust gases from the rotary drum cooler to the cyclone scrubber. The inner duct diameter at this sampling location was measured as 29.88 inches. Two ports, located 99 inches (3.3 duct diameters) downstream of a bend in the duct and 91 inches (3.0 duct diameters) upstream of a bend in the duct, were

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[1] All test methods cited in this report are taken from, "Standards of Performance for New Stationary Sources, Appendix A," Federal Register, Volume 42, No. 160, August 18, 1977.

used for sampling. A total of 24 traverse points (12 in each port), were sampled for 3 minutes each, resulting in a total test time of 120 minutes (Figure 7).

Particle size distribution samples were obtained at Point A6. Sampling was conducted for 1 hour for the first test and 2 hours for tests 2, 3, and 4. Static pressure measurements were recorded every 15 minutes at the AN-A ports during the tests.

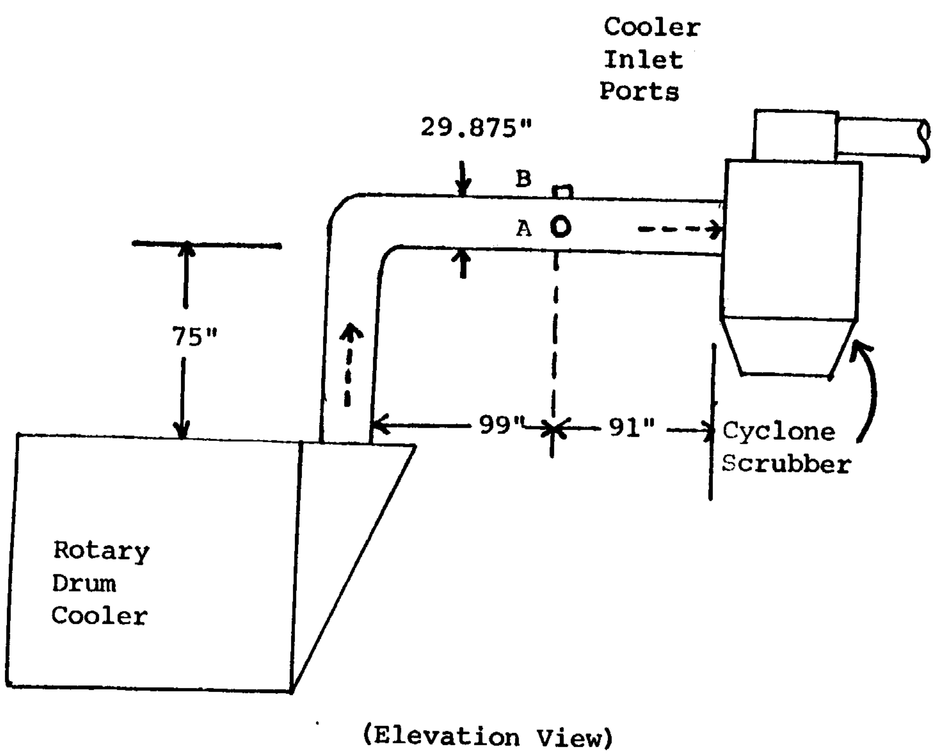
4.3 Evaporator - Pan Granulator

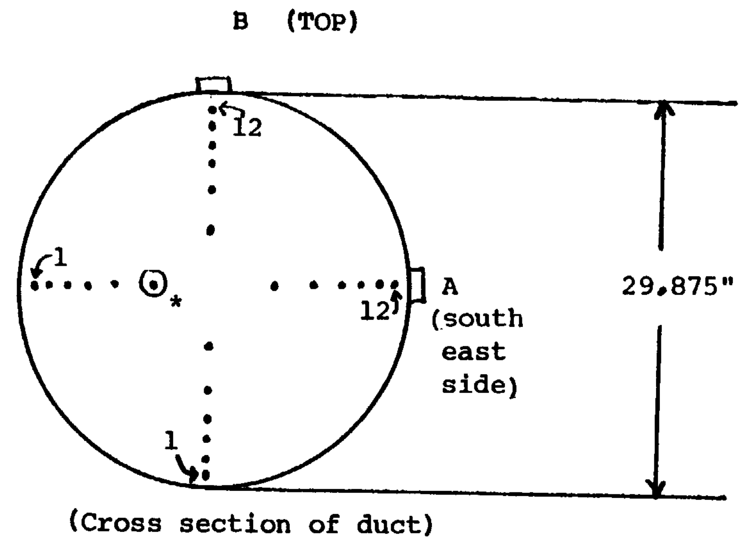
The AN-A sampling ports for the evaporator-pan granulator process are located in the duct which vents the exhaust from the evaporator and pan granulator to the venturi scrubber, and in the duct which vents the exhaust from the separator to the stack (Figure 8). There were three sampling locations: i) evaporator inlet, ii) combined evaporator-pan granulator inlet, and iii) the combined evaporator-pan granulator outlet.

i) Evaporator Inlet

The vertical duct at the evaporator inlet AN-A sampling location was determined to have an inner diameter of 21.75 inches. Two ports, located 133 inches (6.1 duct diameters) downstream of a bend in the duct and 109 inches (5.0 duct diameters) upstream of the inlet duct from the pan granulator, were sampled at 16 traverse points, 8 in each port. Each point was sampled for 6 minutes, resulting in a total test time of 96 minutes (Figure 9).

A grab sample of the flue gas was taken at point A4 in the evaporator inlet and was analyzed for CO_2, and O_2 with an Orsat Analyzer. (Refer to Section 5.6, "Gas Composition", for further details.



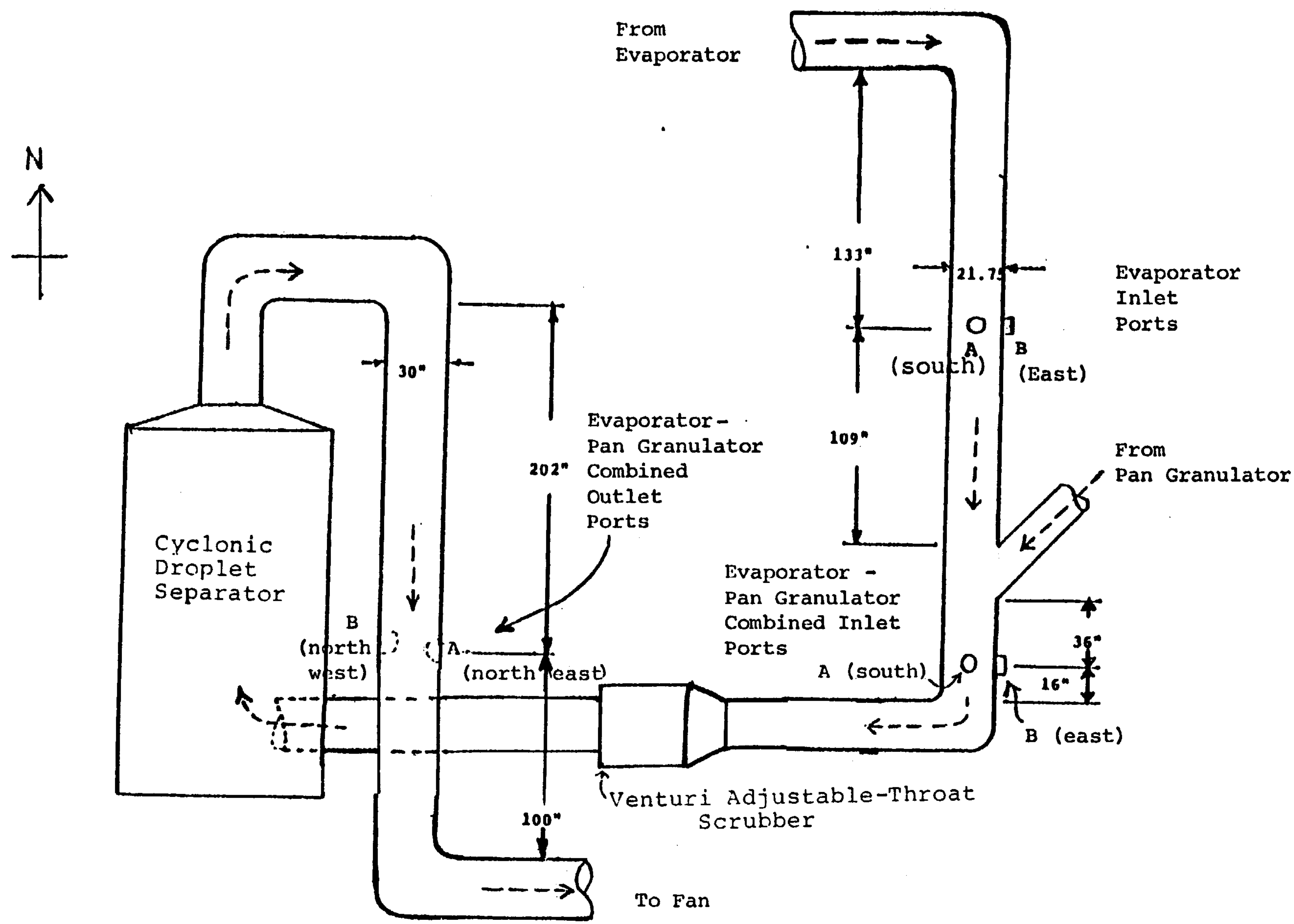


SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	2.00
3	3.53
4	5.29
5	7.47
6	10.64
7	19.24
8	22.41
9	24.59
10	26.35
11	27.88
12	28.88

* A6 - particle size sampling location

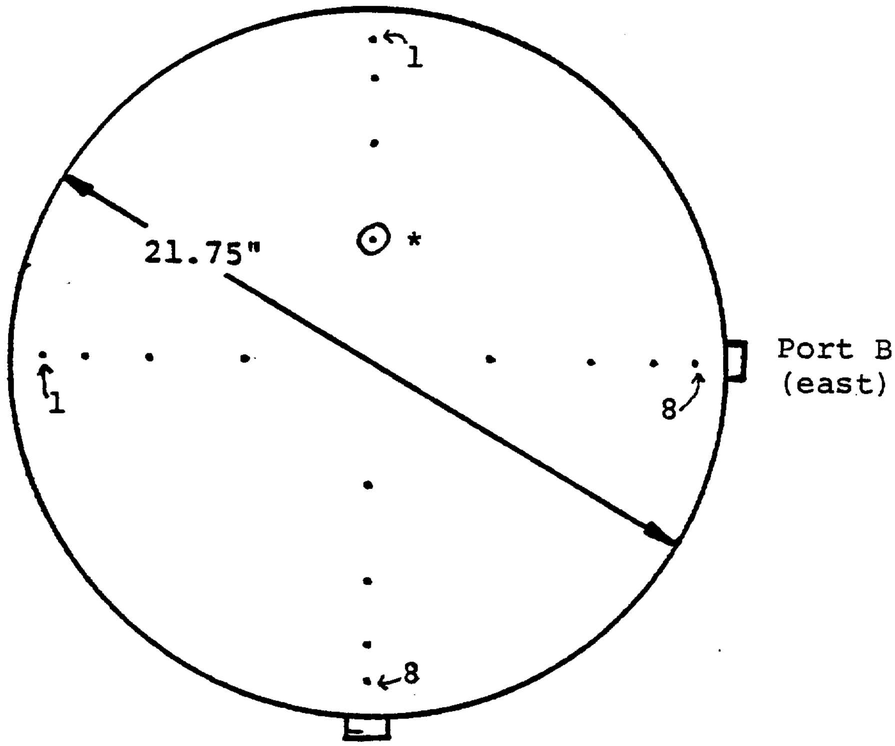
COOLER INLET PORT AND SAMPLING POINT LOCATIONS

FIGURE 7



EVAPORATOR - PAN GRANULATOR PORT LOCATIONS

FIGURE 8



SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	2.28
3	4.22
4	7.03
5	14.72
6	17.53
7	19.47
8	20.75

* A4 - Gas Composition Sampling Point

EVAPORATOR INLET SAMPLING POINT LOCATIONS

FIGURE 9

ii) Combined Evaporator-Pan Granulator Inlet

Two ports, located 36 inches (1.7 duct diameters) downstream of the pan granulator inlet duct and 15 inches (0.9 duct diameters) upstream of a bend in the duct, were sampled with a total of 32 traverse points. Sixteen traverse points were sampled in each port, across a measured inner duct diameter of 21.75 inches. Each point was sampled for 3 minutes, resulting in a total test time of 96 minutes (Figure 10).

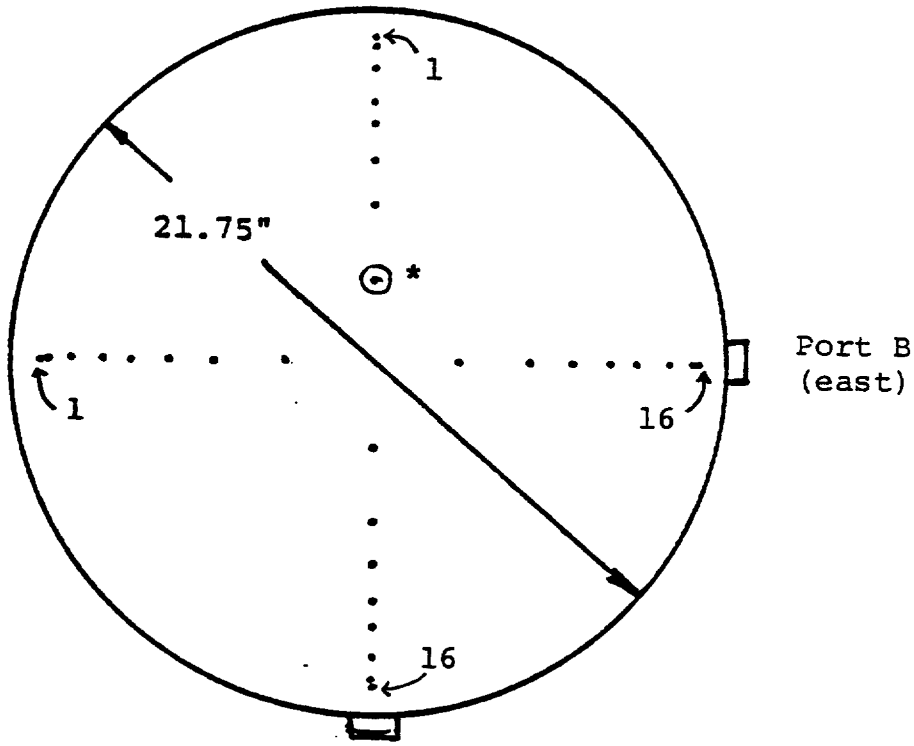
A grab sample of the flue gas was obtained at point A-8, and was analyzed for CO_2, and O_2 with an Orsat Analyzer.

iii) Combined Evaporator-Pan Granulator Outlet

The diameter of the vertical duct at the combined evaporator pan granulator outlet was determined to be 30 inches. Two ports, located 202 inches (6.7 duct diameters) downstream of a bend in the duct and 100 inches (3.3 duct diameters) upstream of a bend in the duct, were used for sampling. Twenty-four traverse points, twelve in each port, were sampled for 5 minutes each, resulting in a total test time of 120 minutes (Figure 11).

The pressure drop across the venturi scrubber was recorded by the operator at this location. The inlet pressure was obtained at the combined evaporator-pan granulator inlet port and the outlet pressure was obtained at the combined evaporator-pan granulator outlet port. (Refer to Section 5.3, "Auxiliary Test Data").

Visible emissions observations were recorded on the combined evaporator-pan granulator controlled emissions. Figure 12 indicates the relative positions of the observation sites. These locations were determined in accordance with EPA Method 9 (Visual Determination of the Opacity of Emissions from Stationary Sources). The observer stood on a rooftop which was east of the stack. He was positioned either southeast or northeast of the stack, depending upon the location of the sun.

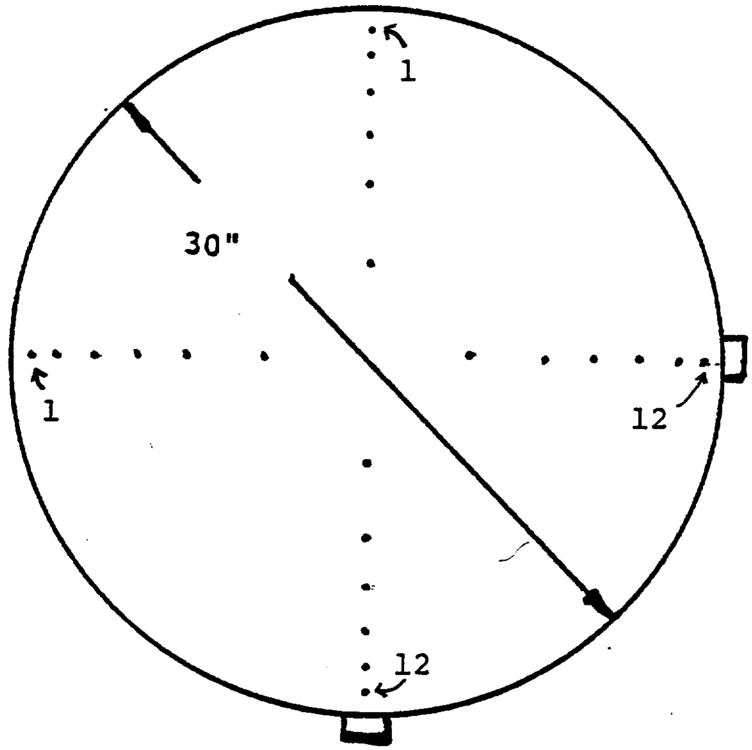


SAMPLING POINT	DISTANCE FROM STACK WALL (IN.
1	1.00
2	1.07
3	1.85
4	2.72
5	3.68
6	4.79
7	6.16
8	8.16
9	13.59
10	15.59
11	16.69
12	18.07
13	19.03
14	19.90
15	20.68
16	20.75

* A8 - Gas Composition Sampling Point

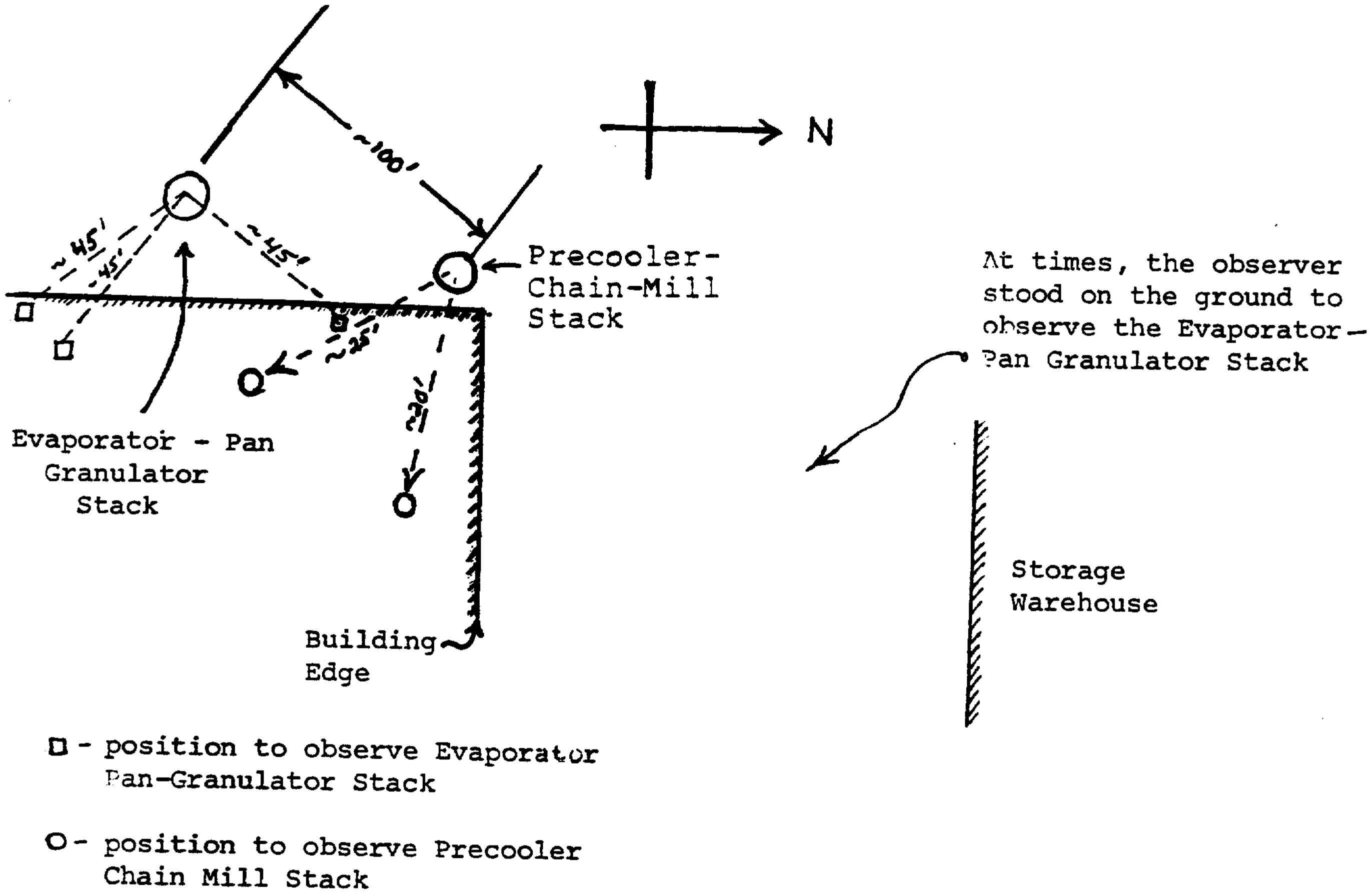
Evaporator-Pan Granulator Combined Inlet Sampling Point Locations

Figure 10

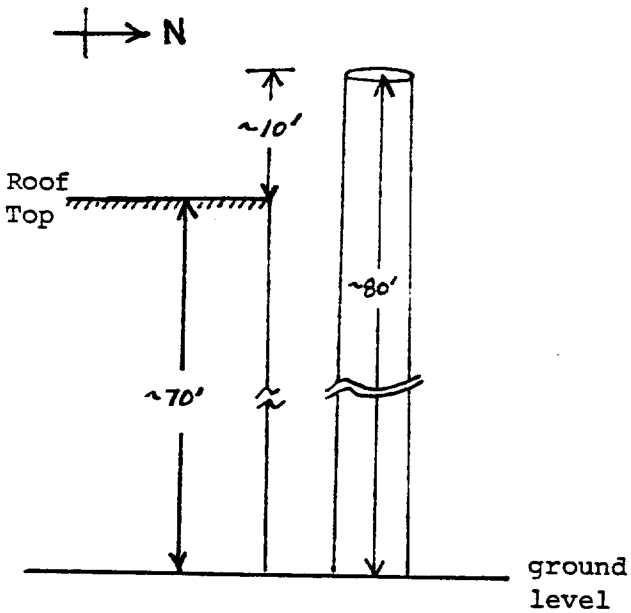


SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	2.01
3	3.54
4	5.31
5	7.50
6	10.68
7	19.32
8	22.50
9	24.69
10	26.46
11	27.99
12	29.00

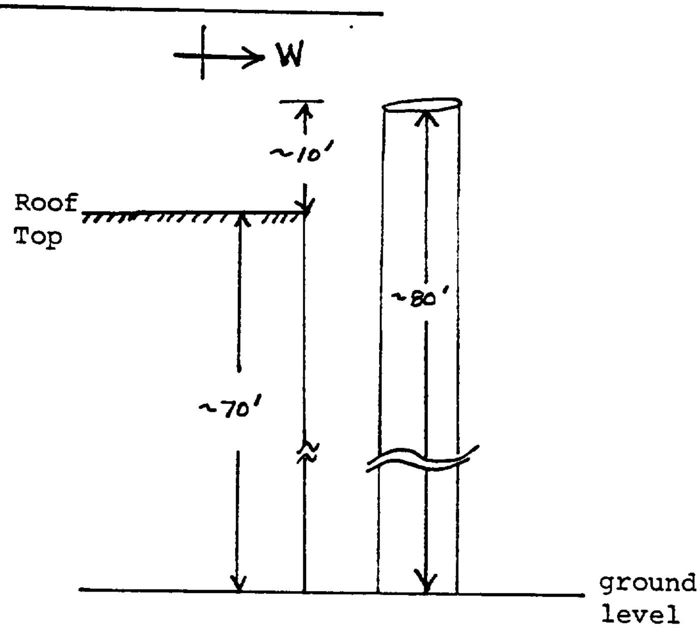
Evaporator-Pan Granulator Combined Outlet
Sampling Point Locations
FIGURE 11



VIEW FROM TOP



Elevation View
Precooler - Chain Mill Stack



Elevation View
Evaporator-Pan Granulator Stack

RELATIVE POSITIONS OF OBSERVER FOR VISIBLE
EMISSION MEASUREMENTS

FIGURE 12

At times, the observer evaluated the emissions from the ground, at a position approximately northeast of the stack.

4.4 Precooler-Chain Mill

The AN-A sampling ports for the precooler-chain mill process are located in the ductwork which vents the exhaust from the rotary drum precooler and the chain mill to the Buffalo Forge Scrubber, and the duct which vents the exhaust from the scrubber to the atmosphere (Figure 13). Sampling was performed at three locations: i) the precooler inlet, ii) the chain mill inlet, and iii) the combined precooler-chain mill outlet.

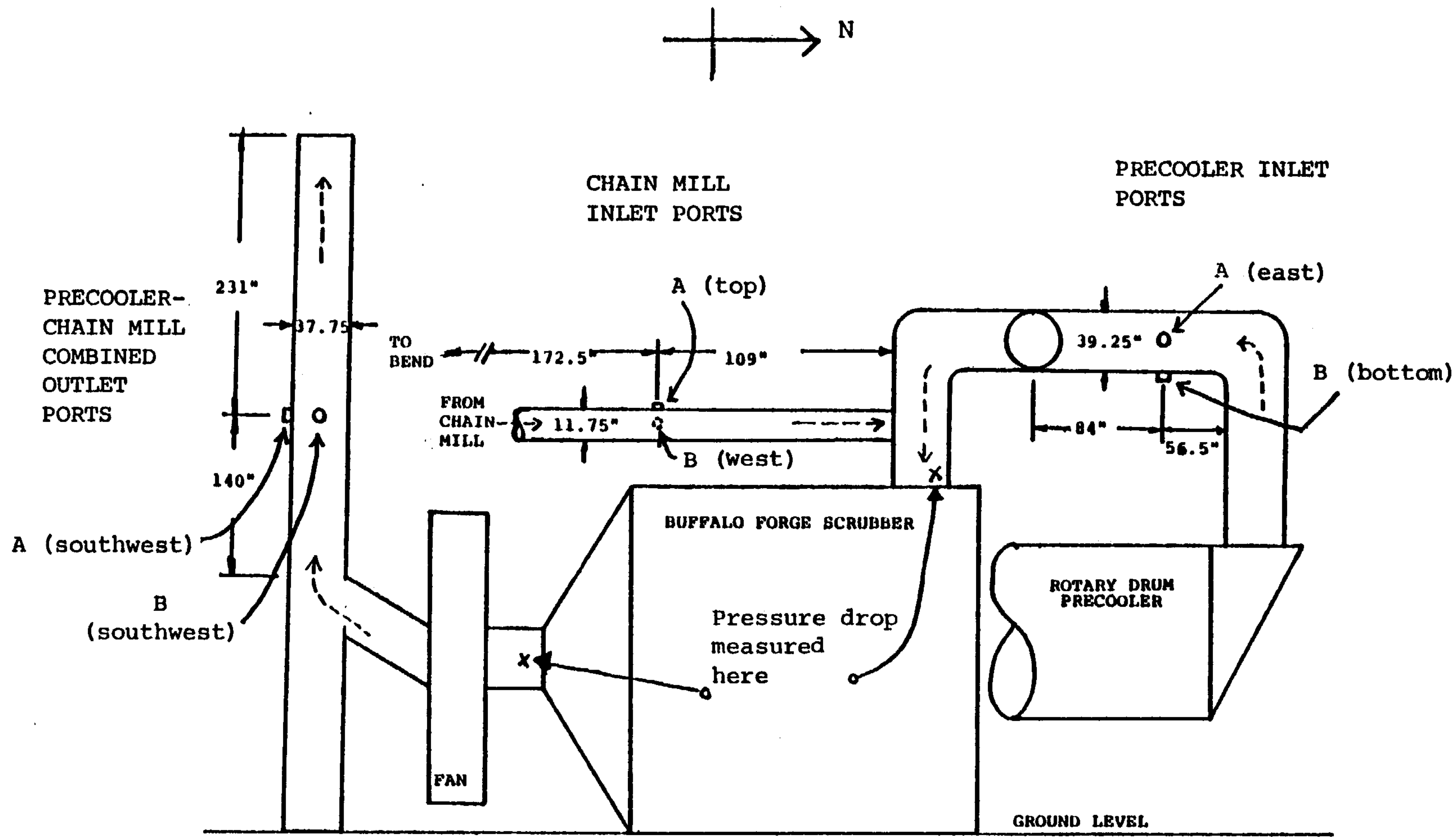
i) Precooler Inlet

The inner duct diameter of the precooler inlet sampling location was measured as 39.25 inches. Two ports, located 56.5 inches (1.4 duct diameters) downstream of a bend in the duct and 84 inches (2.1 duct diameters) upstream of a bend in the duct, were used for sampling (Figure 14). A total of 48 traverse points, 24 in each port, were sampled for 3 minutes each, resulting in a total test time of 144 minutes. Particle size distribution samples were obtained at point A7.

ii) Chain Mill Inlet

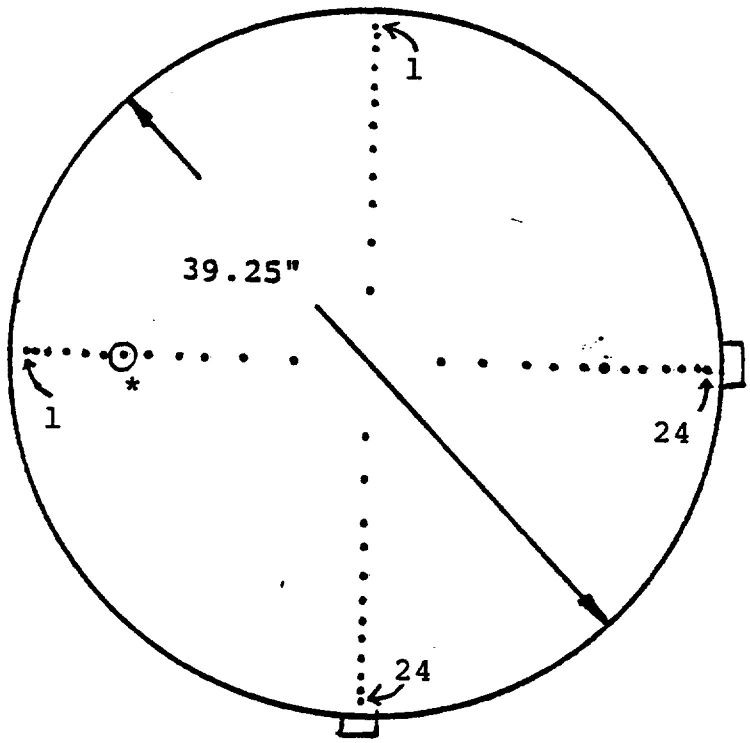
The inner duct diameter at the chain mill inlet AN-A sampling location was measured to be 11.75 inches. Two ports had been installed 172.5 inches (14.7 duct diameters) downstream of a bend in the duct and 109 inches (9.3 duct diameters) upstream of a bend in the duct. Eight traverse points, 4 per port, were sampled at this location. Each point was sampled twice for 8 minutes, with a total test time of 128 minutes (Figure 15).

The operator at this location also recorded the pressure drop across the Buffalo Forge scrubber. Figure 13 indicates the



PRECOOLER - CHAIN MILL PORT LOCATIONS

FIGURE 13

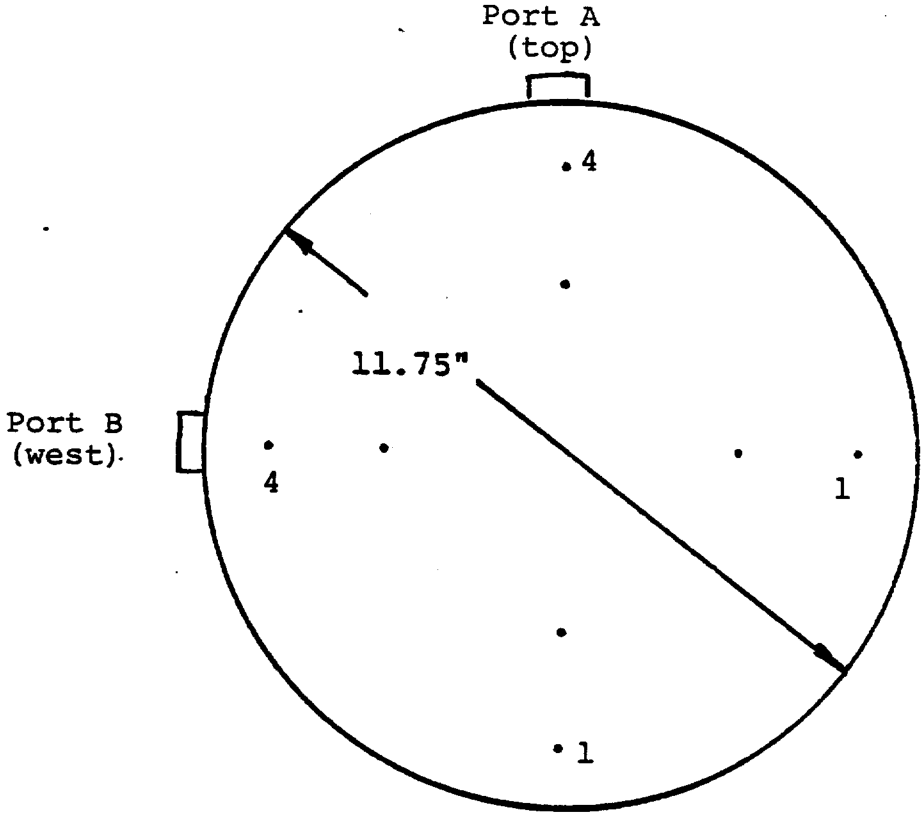


SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	1.25
3	2.16
4	3.10
5	4.12
6	5.18
7	6.32
8	7.61
9	9.03
10	10.68
11	12.68
12	15.62
13	23.63
14	26.57
15	28.57
16	30.22
17	31.64
18	32.93
19	34.07
20	35.13
21	36.15
22	37.09
23	38.00
24	38.25

* A7 Particle Size Sampling Point Location

PRECOOLER INLET SAMPLING POINT LOCATIONS

FIGURE 14



SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	2.94
3	8.81
4	10.75

Chain Mill Inlet Sampling Point Locations

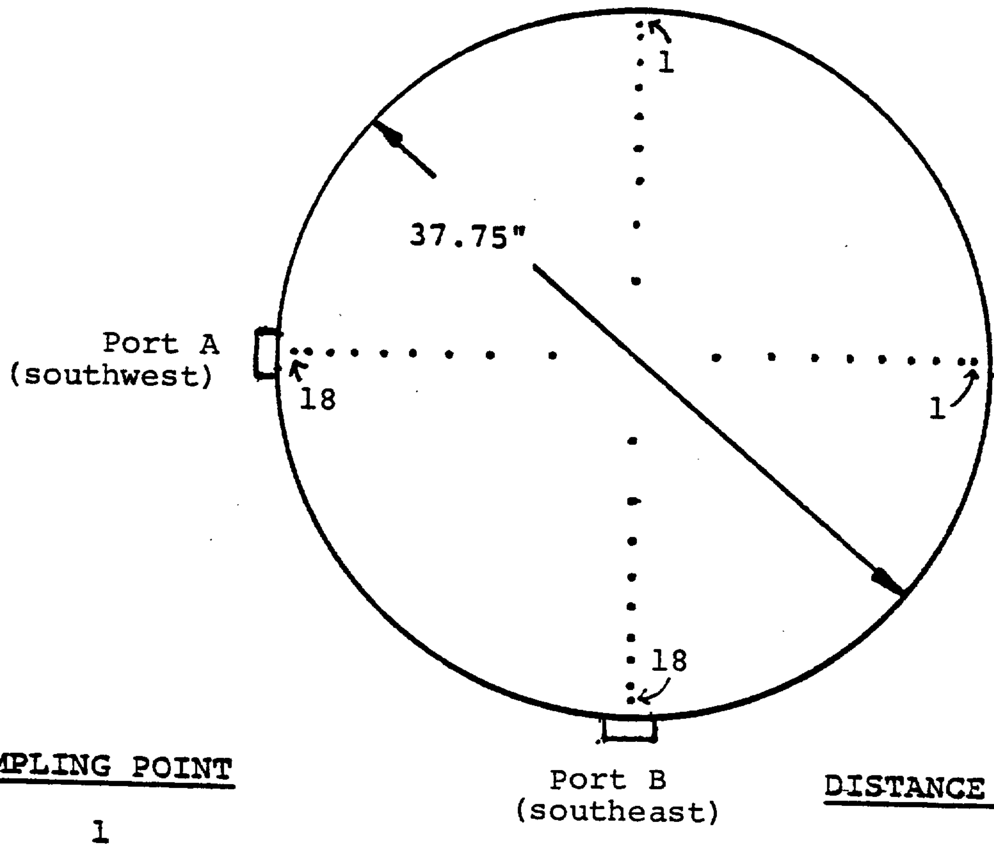
FIGURE 15

positions where the inlet and outlet pressure measurements were taken (refer to Section 5.3, "Auxiliary Test Data" for further details).

iii) Combined Precooler Chain Mill Outlet

The inner duct diamter at the combined precooler-chain mill outlet AN-A sampling location was measured to be 37.75 inches. Sampling was performed in two ports located 140 inches (3.7 duct diameters) downstream of the fan inlet and 231 inches (6.1 duct diameters) upstream of the stack outlet. At this location, 36 traverse points, 18 per port, were required. Each point was sampled for 4 minutes, resulting in a total test time of 144 minutes (Figure 16).

Visible emissions observations were recorded from the roof of a building located to the southeast of the stack. The observer stood either due east or southeast of the stack to measure the emissions. (Figure 12).



SAMPLING POINT	DISTANCE FROM STACK WALL (IN.)
1	1.00
2	1.66
3	2.83
4	4.11
5	5.51
6	7.10
7	8.91
8	11.71
9	14.42
10	23.33
11	26.58
12	28.84
13	30.65
14	32.24
15	33.64
16	34.92
17	36.09
18	36.15

Precooler-Chain Mill Combined Outlet Sampling Point Locations

FIGURE 16

5.0 SAMPLING AND ANALYTICAL PROCEDURES

5.1 Introduction

This section describes the sampling and analytical procedures used by YRC at N-ReN Corporation, Cherokee Division, Pryor, Oklahoma during a test program conducted in November 1978. Brief descriptions of modifications and standard procedures are presented in this section, details are outlined in Appendices 6.10 through 6.14.

5.2 Preliminary Measurements

A. Gas Velocity and Temperature

Velocity and temperature were measured at each test location in accordance with guidelines outlined in EPA Method 2 (Determination of Stack Gas Velocity and Volumetric Flow Rate). Using a pitot tube and thermocouple, measurements were made and recorded at each traverse point.

B. Moisture Determination

The moisture content of the stack gas at each test location was determined in accordance with guidelines outlined in EPA Method 4 (Determination of Moisture Content in Stack Gases).

5.3 Auxiliary Test Data

A. Scrubber Pressure Drop Measurements

The pressure drop across the venturi scrubber was measured and recorded every 15 minutes by the operator at the scrubber outlet. The legs of a U-tube manometer were attached to stainless steel tubes which were attached to taps at the combined Evaporator-Pan Granulator Inlet and scrubber outlet.

The pressure drop across the Buffalo Forge scrubber was measured and recorded every 15 minutes at the Chain Mill Inlet. At this location the legs of a U-tube manometer were attached to taps at the inlet and outlet of the scrubber.

The pressure drop across the Cyclone scrubber could not be measured because a tap could not be installed at the scrubber outlet. However, the static pressure was measured at the cooler inlet every 15 minutes during sampling.

B. Ambient Air Temperature, Relative Humidity, and Barometric Pressure Measurements

Ambient air temperatures, in degrees Fahrenheit, were measured with a wet-bulb/dry-bulb thermometer. The dry bulb thermometer was used to measure the ambient air temperature. Relative humidity values were obtained by using a table which correlates wet-bulb and dry-bulb temperatures to percent relative humidity. Barometric pressure was measured on a barometer in inches of mercury. These values were measured and recorded every 10-15 minutes during sampling. However, only those temperature measurements taken outside were considered representative of the test site conditions (see Table 38).

C. Process Samples

Grab samples of the product, melt, and clay were taken. The samples and results of the analyses (see Section 5.10) were left with N-ReN personnel because of confidentiality.

5.4 Ammonium Nitrate

A. Sampling

The sampling apparatus at each location consisted of a probe, teflon line, impingers, vacuum pump and dry gas meter (Figure 17).

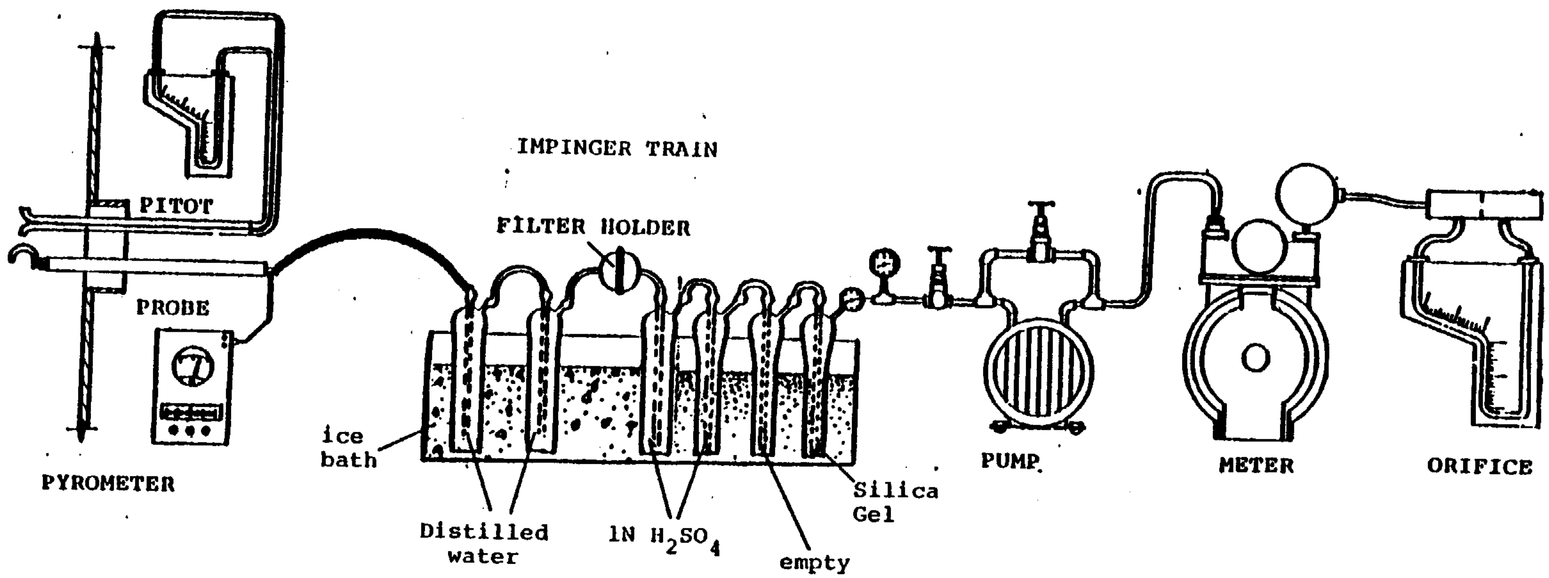
The sampling probe was glass-lined with a ball joint at one end and wrapped with heater tape. A button hook nozzle, of appropriate diameter, was attached to the probe by means of a stainless steel coupling. A pre-calibrated, S-type pitot tube and thermocouple were rigidly attached to the probe.

The correct nozzle size was determined from the velocity traverse and moisture test. The probe was connected to the first impinger with a flexible teflon sampling line. The first and second impingers each contained 100 ml of distilled water. A tared fiber glass filter, heated to 100°F, was located between the second and third impingers. The third and fourth impingers contained 100 ml of 1N H_2SO_4. The fifth impinger was empty and the sixth contained 300 grams of indicating type silica gel. The first, second, fourth and fifth impingers were of the modified type (see Figure 17).

From the impinger train, sample gas 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 at the end of the train was used to measure instantaneous flow rates. An inclined, vertical manometer graduated in hundredths of an inch of water from 0 to 1.0 inch and in tenths of an inch of water from 1 to 10 inches was used to measure orifice and velocity pressure drops.

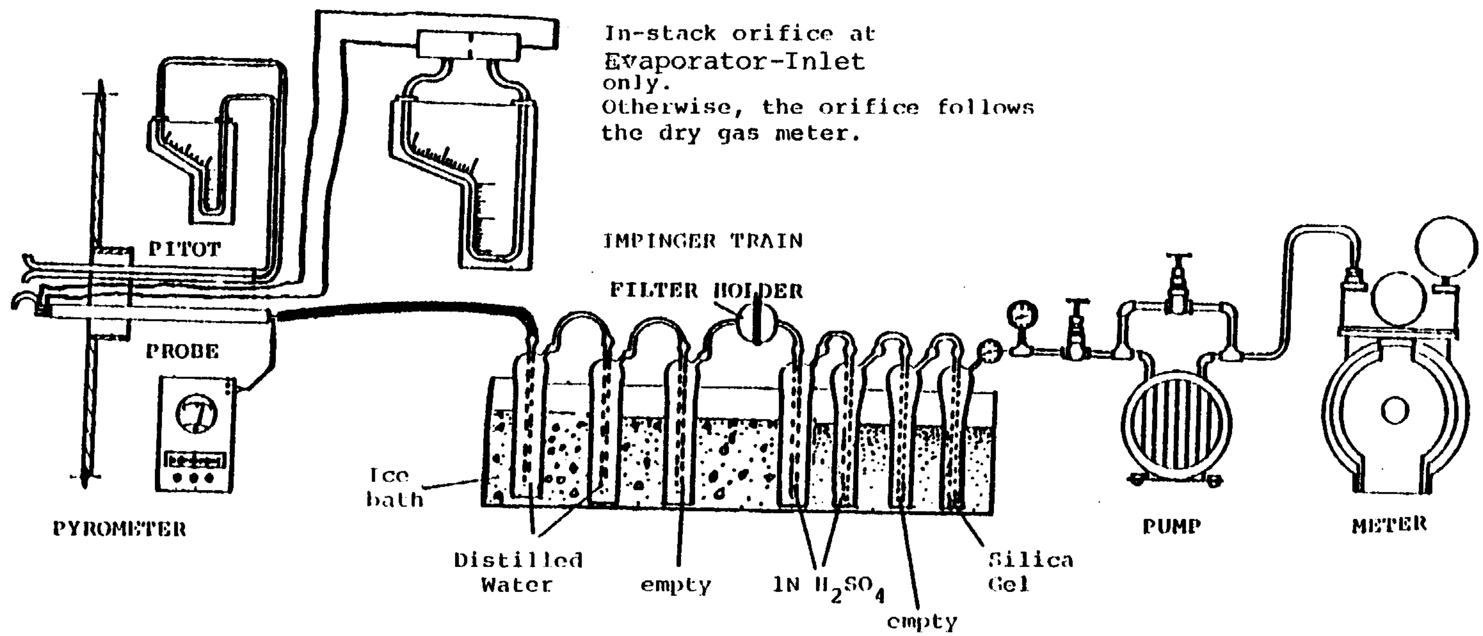
The stack condition at the Evaporator-Pan Granulator locations necessitated some modifications in the sampling trains. Due to the extremely high (>35%) moisture content of the gas stream, an additional empty impinger was placed in the train at the Evaporator Inlet and Pan Granulator Inlet. The scrubber outlet train did not change. An in-stack orifice was also placed after the nozzle at the Evaporator Inlet and Pan Granulator Inlet sampling locations (see Figures 18 and 19). The orifice was precalibrated at several representative flow rates. This in-stack orifice was used at the Evaporator Inlet for Tests 1, 2 and 3, but was only used for Test #1 at the Pan Granulator Inlet location. It was removed at this location when plugging resulted from the excessive moisture and ammonium nitrate loading.

For tests 2 and 3, the probe being used at the Pan-Granulator Inlet was wrapped with an additional heater tape



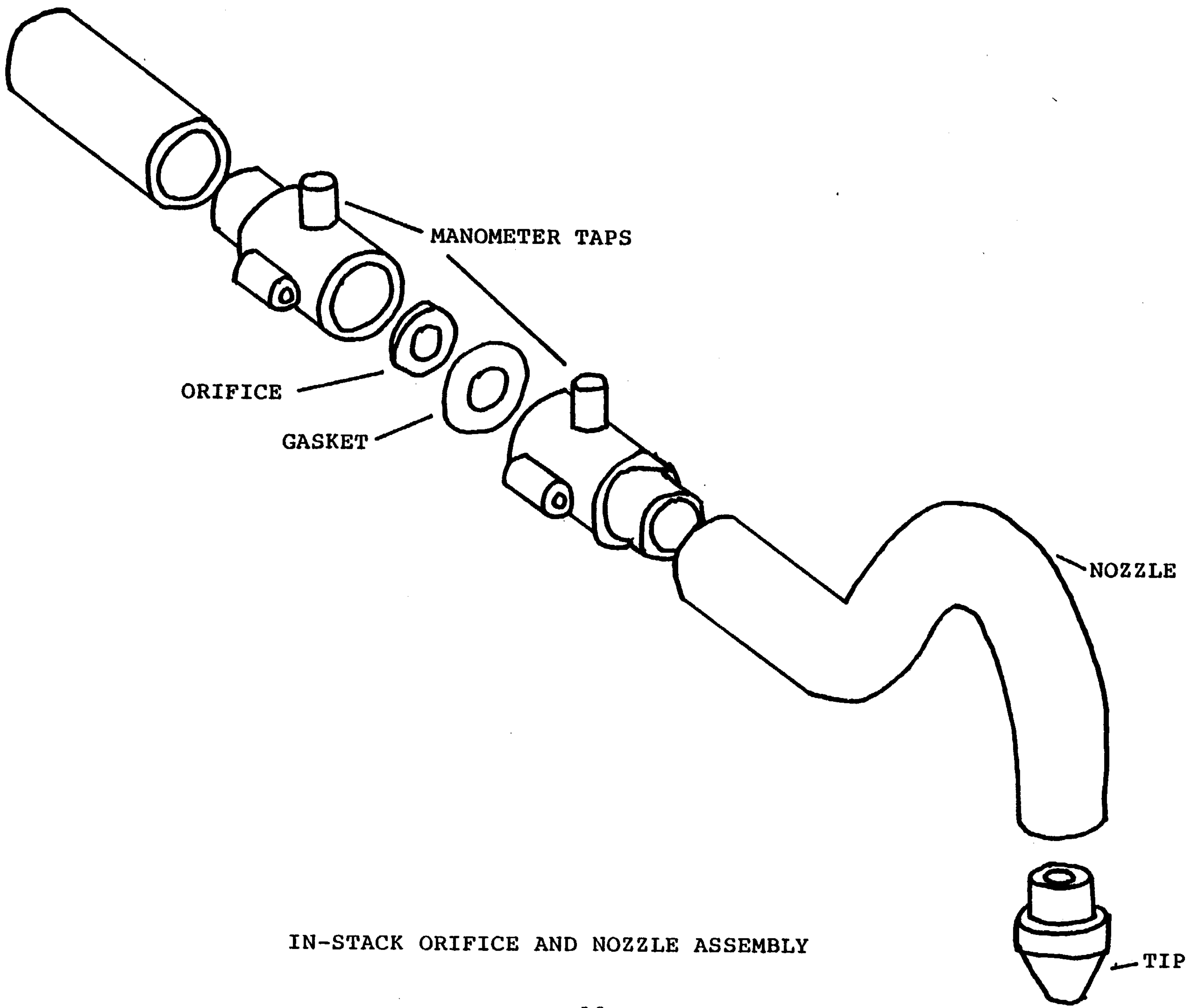
AMMONIUM NITRATE SAMPLING TRAIN

FIGURE 17



MODIFIED AMMONIUM NITRATE SAMPLING TRAIN FOR Evaporator-Pan Granulator Inlet Sampling Locations

FIGURE 18



IN-STACK ORIFICE AND NOZZLE ASSEMBLY

FIGURE 19

and insulated with aluminum foil to minimize the effects of the high moisture. The probe temperature at the inlet and outlet sampling locations was maintained at approximately $10^{o}F$ plus the stack temperature (T_s+$10^{o}F$), and did not exceed $160^{o}F$ throughout the test program.

During tests 2 and 3 at the Pan Granulator Inlet, 100 ml of distilled water was added to the empty impinger before the filter and 100 ml of 1N H_2SO_4 was added to the 1N H_2SO_4 impinger number five. This was done to prevent crystals from forming in the impingers.

During each test run the following readings were taken and recorded 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 temperatures at meter inlet and outlet (^{o}F)
- Vacuum gauge reading (in. Hg)
- Dry gas temperature at the exit of last impinger (^{o}F)
- Stack temperature (^{o}F)

The relationship of the Δp reading 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

The operator was able to sample isokinetically using a nomograph showing a direct relationship between Δp and ΔH. At the Pan Granulator Inlet the pitot tubes became clogged during tests 1 and 2, and the operator had to assume Δp values from velocity traverse data until the lines were cleared.

Sometime during test #1 at the cooler inlet, the glass probe lining cracked. This was evident when the post-test leak check failed to meet the requirements of the method (0.02 cfm). This test was voided and another was run in its place.

B. Sample Recovery

At the completion of each test the train was separated between the probe and teflon sample line. The probe and impinger train, with the teflon line attached, were carried to an onsite warehouse that YRC used as a field laboratory.

The samples were placed in glass sample jars with teflon lined caps. The jars were labeled with date, test location, test number, contents, and sample number which was logged into a laboratory notebook.

The total volume of deionized, distilled water in the first set of impingers was measured and recorded. Deionized, distilled water was used to wash the front half (i.e., all glass before the filter) of the train and the teflon sample line. The probe and nozzle were rinsed with deionized, distilled water and brushed three times. The brush was also rinsed.

The total volume of 1N H_2SO_4 in the last set of impingers was measured and recorded. The back half (i.e., all glass after the filter except for the silica gel impinger) of the train was rinsed with 1N H_2SO_4.

The silica gel was weighed on a platform balance and the weight was recorded. The silica gel was returned to its original container.

The filter from the train was returned to its original container.

Each test had a total of 6 samples:

1 - Untreated portion of the distilled water sample
2 - Treated portion of the distilled water sample ($pH \leq 6$)
3 - Filter used to filter the distilled water sample (funnel filter)
4 - Total 1N H_2SO_4 sample
5 - Silica gel
6 - Train filter

One problem occurred during recovery of the Pan Granulator inlet and outlet samples. In test #1 at the inlet, crystals formed in two of the front-half and two of the back-half impingers. Fifty milliliters of the appropriate reagent were added to each impinger. They also had to be warmed to room temperature with a heater tape before the crystals dissolved.

Prior to testing, a cleanup evaluation was performed of the probe, teflon line, front half of the impinger train, and back-half of the impinger train. Details of the analysis are presented in Appendix 6.14.

C. Sample Preparation

The water portions were combined and filtered through a tared, glass fiber filter using a vacuum. The filtrate was divided and one half was treated with concentrated H_2SO_4 until the pH was 6 or less.

All sample containers were sealed with tape. Liquid levels were marked and the samples were transported to the YRC laboratory in Stamford, Connecticut for analysis.

D. Sample Analysis

The total volume of the sample was measured. A 100 ml aliquot was treated with ionic strength and pH adjusted reagents. The nitrate molarity of the sample was then determined using a standardized Specific Ion Electrode and Meter with several dilutions of stock ammonium nitrate standard. The weight of the ammonium nitrate in the sample was determined by the following equation.

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

where: Wn = 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 blank, ml
C_b = Nitrate molarity of blank, gm-moles/liter
0.08 = Grams of $NH_4 \ NO_3$ per milliequivalent (meg.) where $(V_t \ C_t - V_b \ C_b)$ = meg. 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 deionized, distilled water. The liquid sample was then analyzed for nitrate molarity using the above procedure.

5.5 Ammonia

A. Sampling and Recovery

The sampling and sample recovery of ammonia samples were identical to those used for ammonium nitrate. Aliquots of the same sample were used for the ammonia analysis.

B. Sample Preparation

The water portions were combined and filtered through a tared, glass fiber filter using a vacuum. The filtrate was divided and one half was treated with concentrated H_2SO_4 until the pH was 6 or less.

All sample containers were sealed with tape. Liquid levels were marked and the samples were transported to the YRC laboratory in Stamford, Connecticut for analysis.

ANDERSEN STACK SAMPLER

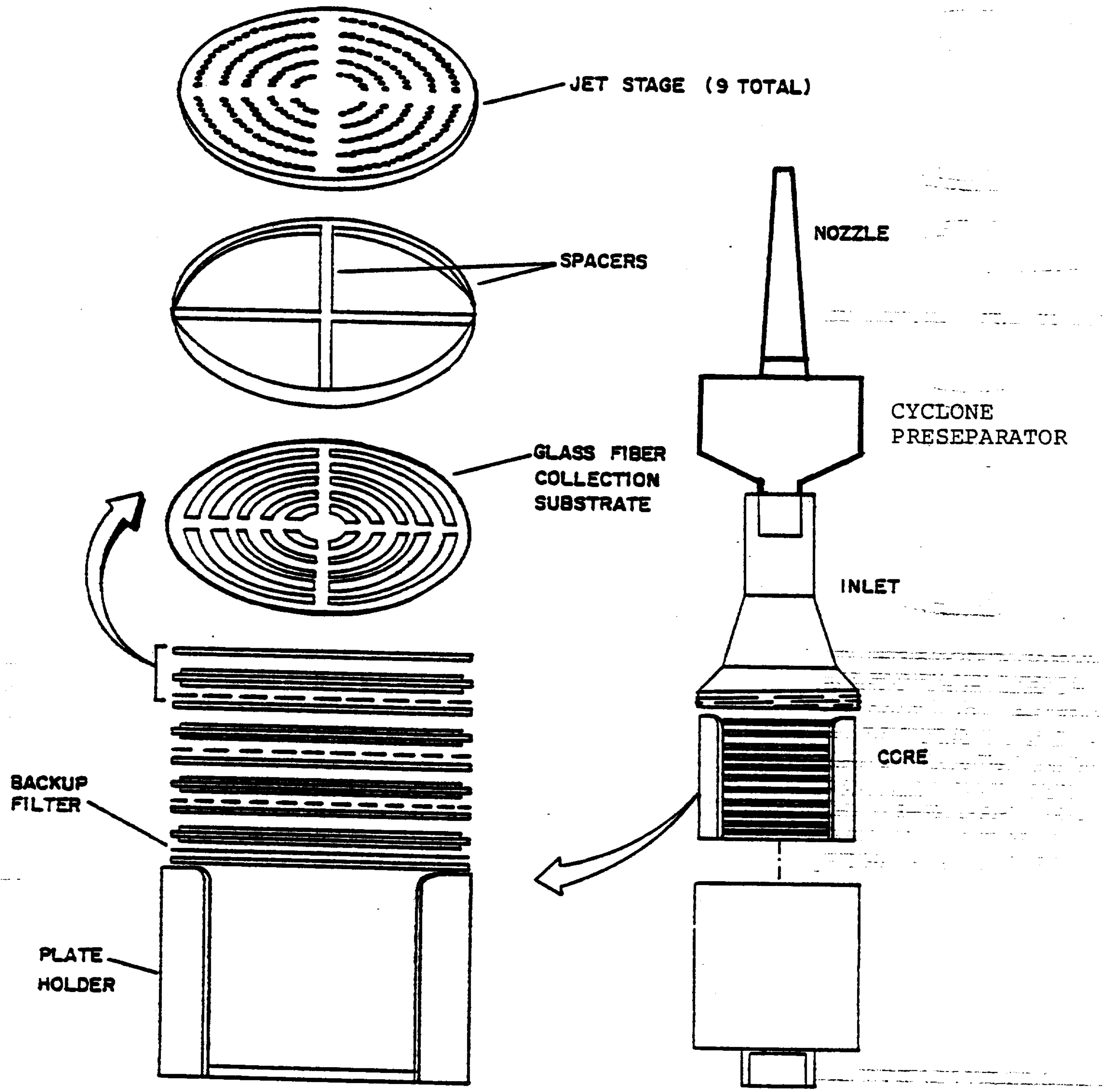


FIGURE 20

ANDERSEN SAMPLING TRAIN

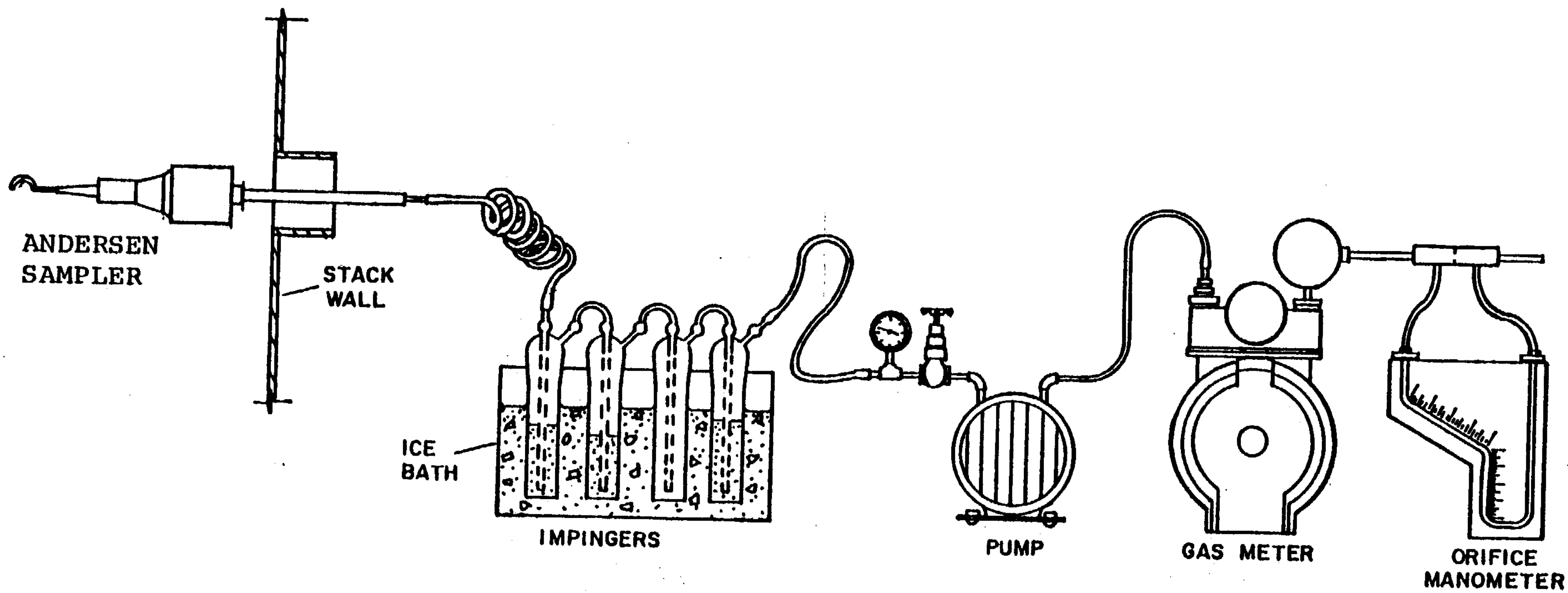


FIGURE 21

B. Sample Recovery

The contents of the preseparator and a distilled water wash were placed in a sample jar after each test. The level was marked and the container was sealed with tape. The glass fiber substrate filters were returned to their original containers and sealed.

All samples were transported to the YRC laboratory in Denver, Colorado for analysis.

C. Analysis

The glass substrate filters were desiccated 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 water was evaporated by heating. The beaker was desiccated and weighed to a constant weight. The net weight gain was recorded to the nearest 0.01 mg.

5.8 Visible Emissions

A. Field Measurements

Visible emissions measurements were conducted at the Pan-Granulator stack and the Precooler stack by a certified visual emission evaluator in accordance with EPA Reference Method 9. (Visual Determination of the Opacity of Emissions from Stationary Sources). Readings were taken at 15 second intervals.

The Pan Granulator outlet had a steam plume. The observations were made of the plume between the stack outlet and the detached steam plume. The length of the steam plume and visible emissions after dissipation of the steam plume were observed. These observations were taken every 10 to 15 seconds.

B. Summary of Data

The field measurements were averaged over six minute intervals and are presented in Table 28 and Table 29.

5.9 Scrubber Solution Samples

A. Sampling

During testing at the Evaporator-Pan Granulator and Pre-cooler-Chain Mill Duct locations, scrubber solution samples were taken. Samples of the influent and effluent solution were collected every 30 minutes during the respective tests. There were 3 separate sampling locations (Figure 22). The time of collection, temperature and pH of the sample were recorded immediately after collection.

B. Analysis

At the end of each test the samples of one location were combined. Approximately one half of the total sample was then treated with concentrated H_2SO_4 to a pH of 6 or less; the remaining portion was untreated.

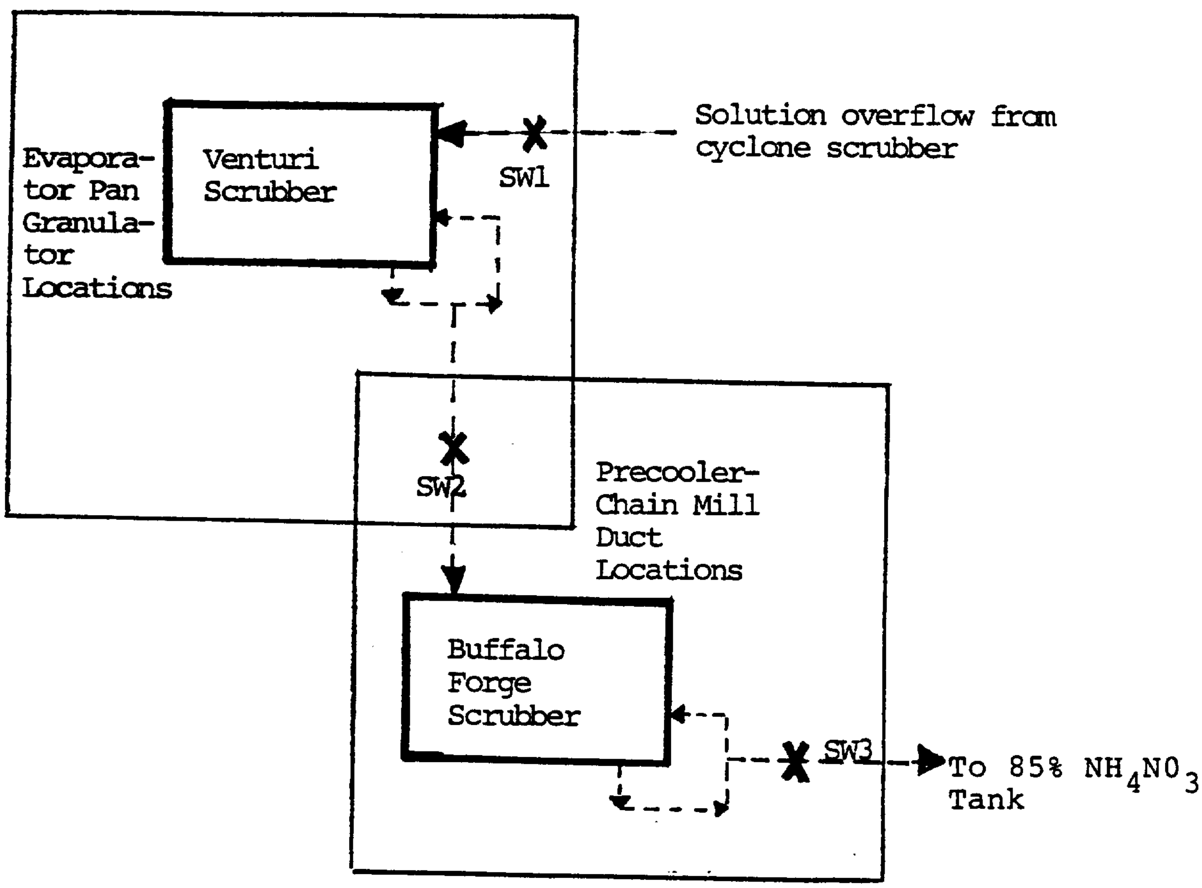
Each sample was analyzed in Stamford, CT for ammonium nitrate and ammonia (see methods above, i.e., 5.4 Ammonium Nitrate Analysis and 5.5 Ammonia Analysis). Each sample was also analyzed for percent solids. An aliquot of sample was transferred to a tared beaker. The water was evaporated at 103°C. The beaker was desiccated and weighed to a constant weight. The percent solids was calculated.

5.10 Bulk Density and Particle Size of Product

A. Sampling

Product samples were taken from each test location. Samples taken from conveyor belts were collected in 1 quart jars by scooping the jar across the flow. Three scoops were made to fill the jar. Samples from free flowing vents were taken by placing a jar in the vent directly in the stream of product flow.

SCHEMATIC OF SCRUBBER SOLUTION FLOW
AND SAMPLING LOCATIONS



---- - flow of solution
X - sampling point
SW1 - influent solution, venturi scrubber
SW2 - effluent solution, venturi scrubber and influent solution, Buffalo Forge scrubber
SW3 - effluent solution, Buffalo Forge scrubber

Figure 22

B. Analysis

The analyses were performed in the N-ReN laboratory by YRC and N-ReN personnel. The results are confidential.

Bulk Density:

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

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

Particle Size:

The particle size of the product is estimated by means of a sieve analysis. A sieve shaker, timer, balance, sample splitter, (sieves 4, 6, 8, 10, 12, 14, 16, 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 weighed to the nearest 0.2 gram. The sieves were 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 next 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:

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